PHYSICS
TEST – 6

11th physics	myF-6	<hggay;
	myF-7	gUgnghUsd; gzGfs;
	myF-8	ntggKk; ntgg ,af;ftaYk;
	myF-10	miyTfs;
	myF-11	miyfs;

11TH ,awgay;
njhFj–II
myF 6 - <hggay;

mwKfk;

xsUk thdjijg ghhjJ ehk vgnghOJk taffdNwhk. fofNf #had #had cjggJVd? NkwNf kiwtJVd? thykd tzzy tiueJnrytJvggb? tzkdfs ,utiy fzrklLtJVd? ,J Nghdw Nfstfs gyekfFs vOeJnfhzNl ,Uffdwd. gzilafhyenjhlNl tznts ahdJ ek Mhtjij J}zLk fskhfNt ,UeJtUfwJ. eyT›Nfhsfs kwWk tzkdfs tzzy vtthW ,aqftUfdwd? mit ,aqFtjwfhdfhuzk ahJ? vdtaggilfNwhk. tzzy ,aqFtjwfhd fhuzk ahJ? vdtaggilfNwhk. tzzy thdnghUsfsd ,affjijAk mjd fhuzjijAk GheJnfhsskfr rwejrejidahshfshd mh]lhlby Kjy]Bgd `hfq tiuKadwdh.

17 Mk E}wwhzbd ,Wjay eA+lld cUthffa<uggay nfhsifahdJ› thd kwWk Gtay Yss nghUsfsd ,affk gwwAk mJFwjJ vOej gy Nfstfs FfFk tilfisj jejJ. flej %dW E}wwhzLfshfj njhlheJthday MaTfs gyeilngwWssNghJk› ,dwsTk <hggay JiwahdJ ,awgayy MaTfs kf mjfkhfefOk fskhfNt cssJ. 2017 Mk Mzby ,awgaYffhd Nehgy ghR›‘<hggay miyfs’(Gravitational Waves) fzLgbgGfF toqfggllJ. ,ej<hggay miyfs FwjJfUjjstiy 1915 Mk MzbNyNa Id]Bd Kddwtigenrajiejhh. Nfhsfsd ,affk FwjjGhjy› tzkdfs kwWk tzkd $llqfs cUthFk tjk›fUeJisfs kwWk mtwwd thofifr Rowr Mfait njhlhghd gy MaTfs flejr E}wwhzLfshfNkwnfhssgglLtUfdwd.

Gtikaf; nfhs;if–jhyk;:

,uzlhk E}wwhz ilr Nrhejf NuffNuhkhd athday mwQh fshba] jhykthd nghUsfshd #had›eyh›nrttha›tahod Nghdwtwwd ,affjijtsfFtjwfhfxUnfhsifiacUthffdhh. ,kkhjhNaGtikaf nfhsifvdmioffgglJ.

jhykpad Gtpikaf nfhsifggbGtpNagugQrjjpd ikak. #hpad>epyhclglgugQrjjpy cssmidjJthd nghUsfSk Gtpiaikakhff nfhzLRwwptUfpdwd.

Gtpikaf nfhsifahdJntWk fzfshy thidcwWNehffpLk NghJehk czUk gyepfoTfSld edFnghUeJfpdwJ. #hpad kwWk epyhtpd ,affjijXusTrhpahfjhykpad nfhsiftpsffpaNghJk>nrttha>tpahod NghdwNfhsfspd gpdNdhfF ,affjij(Retrograde motion) tpsff ,aytpyiy.

15-k E}wwhzby NghyeJehlLthdpay mwpQh epfNfhy] Nfhgghdpff] (1473 – 1543) #hpa ikaf nfhsifapid(Heliocentremodel) Kd nkhopejhh. ,fnfhsifggb #hpa FLkgjjpd ikakhf #hpad cssJ. #hpaid ikakhff nfhzLGtpclglmidjJNfhsfSk tllgghijapy RwwptUfpdwd. midjJthdpay nghUsfspd ,affqfisAk ,fnfhsifntwwpfukhftpsffpaJ.

mNjfhyflljjpy Gfo ngww ,jjhypa ,awgpay mwpQh fypyNah(Galileo)GtpfFmUfpy NkypUeJfo tpOk nghUsfs midjJk GtpapidNehffprktjjjpy KLffkilfpdwdvdfzlwpejhh.

,jwfpilapy ilNfhgpuhN` (1546 – 1601) jd thoehs KOtijAk tpzkdfs kwWk Nfhsfs Mfpatwwpd epiykwWk ,affk FwpjJntWk fzfshy fzlwpeJgjpTfs nratjpy nrytopjjhh. gpuhN` NRfhpjjthdpay juTfismtuJcjtpahsh N[hfd nfgsh (1571 – 1630) gFjjhaTnraJNfhsfspd ,affk gwwpatpjpfisfzlwpejhh.

,ttpjpfs Nfhsfspd ,affjjpwfhdnfgsh tpjpfs vdmioffgglld.

Nfhspfspd; ,afpfjpjpwpfhdnfgpsh tpjpfs;

nfgshpd tpjpfisfoffzlthW $wyhk

1. **RwpWg; ghijfSf;fhd tpjp:**

   #hpaid xUFtpag Gsspapy nfhzLxtnthUNfhSk #hpaid estllgghijapy RwwptUfpwJ.

Nfhs; elspl;lgghijapy; #hpaid RwwptUjy;

#hpaDfFkpfmUfpy Nfhs cssepiy(P) mzikepiy(Perihelion) vdggLk. #hpaDfFngUkj njhiytpy Nfhs cssepiy(A)Nraikepiy(Aphelion) vdf. estlljjpd miunellrR‘a’kwWk miuFwwrR‘b’vdggLfpdwd. Nfhghdpffrk jhykpAk Nfhsfs tllgghijapy ,aqFfpdwdvdf fUjpdh. Mdhy Nfhsfs estllgghijapy ,aqFfpdwdvdgijnfgsh fzlwpejhh.

gugGtpjp(Law of Area)

#hpaidAk xUNfhisAk ,izfFk Mu ntfluhdJrkfhy ,ilntspapy rkgugGffisVwgLjJk.

Nfhs xdW #hpaid rwwptUk NghJΔtvdwrpwpa Neu mstpy Muntflh VwgLjjpagugGΔA>ntzzpwkhffhllgglLssJ. estlljjpd ikajjpy #hpad ,yiy. vdNtNfhs #hpaDfFmUNfnryYkNghJkpfmjpfNtfjjpYk> #hpadplkpUeJ ezlnjhiytpy nryYk NghJFiwejjpirNtfjjpYk nryYk. ,jd %yk rkfhymstpy rkmsTgugGfisfleJnryfpwJ. Nfhsfspd Ntfk khWgLtijjuTfs %yk mwpejnfgsh mjd mbggilapy gugGtpjpiafzlwpejhh.

RwpWfhyq;fspd; tpjp:

estllghijaiy #haid RwWk Nfhsid RwWffhyjjid ,Ukb›mejestlljjid miunellrrid KkkbfFNehjftiy ,UfFk. fofzlthWvOjyhk.

$$T^2 \mu a^3$$

$$\frac{T^2}{a^3} = khwiyi$$

,qFTvdgJRwWffhyk›avdgJmiunellrrid esk MFk. ,rrkdghlbyiUeJ›ehk mweJnfhstJ #hadyiUeJ cssnjhiyTmjifhifFkNghJ›RwWfhyKk mjifhifFk. Mdhy mjifhgGtjk khWgLk vdmwiayhk.

#haidr Rwwi tUk Nfhsfsid RwWfhyqfSk›mitRwWk estllgghijaid miunellrRkjigGfSk juggllssd. mlltizaiyiUeJ $\frac{T^2}{a^3}$ Vwjjhokhwiyiahf ,Uggijfhzyhk. ,Jnfgsh %dwhk tijiiacWjiggLjJfwJ.

#haidr; RwWk; Nfhs;fsid; RwWfhyq;fSk; (T)mtwwd; milnel;lr;R(a)msTfSk;

Nfhs	a (10^{10} m)	T (MzLfs)	$\frac{T^2}{a^3}$
Gjd	5.79	0.24	2.95
ntssi	10.8	0.615	3.00
Gti	15.0	1	2.96
nrttha	22.8	1.88	2.98
tiahod	77.8	11.9	3.01
rdi	143	29.5	2.98
ANuNd]	287	84	2.98
negbA+d	450	165	2.99

nghJ<hggiay; tiji:

Nfhsfsid ,affk gwwinfgsh tijifs tsffi $wiaNghJk›mfNfhsfsid ,affjjiwFfhuzkhd tirfisgwwitsffKbatiyiy. nfgsh tijfisAk fyiyiNahtid MaTfisgFgghaTnraje+lld mtwwid mbggilaiy <hggiay tijiajUtjjhh.

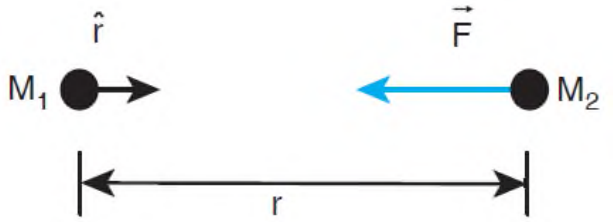
Meiwcilajfs›mzljjiy cssmidjJJfsfisAk Fwiggilltirald <hffiwJ. mej<hgGtiraid tyikahdJ›mtwwid eiwfsid ngUffwgyDfFNehjjftiYk›mtwWfF ,ilNaahdnjhiytid ,UkbfFvjhjjftiYk ,UfFk vdgNje+lldid <hggiay tijiahFk.

fzjtiay tbtiy <hggiay tiraiidfofzlthWvOjyhk.

$$\vec{F} = -\frac{GM_1M_2}{r^2}\hat{r}$$

,qFM1yiUeJM2Nehffinryk myFntflh $\hat{r}$ MFk.

G<hggiay khwi: G d kjigG6.67 × 10^{-11} Nm^2kg^{-2}. r-vdgJeiwfs M_1kwWk M_2,ilNacssnjiyT. eiwM_1MdJeiwM_2 My czUk <hggiay tiria $\vec{F}$ ntflh Fwiffiw J. vjhFwiahdJ<hggiay tirvgnghOJk <hfFk jdikcilaJvdgijFwiffiwJ. <hggiay tirahdJvgNghJk ,U eiwfisAk ,izfFk NehfNfhlbd toiNanraygLk.

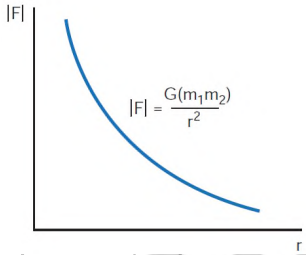


,Uepiwfs; xd;iwxd;W<hj;jy;:

fhhBrpad Ma mrRfspy ‘r’vdwnjhiytd ,Ukb $r^2 = (x^2 + y^2 + z^2)$ vdFwpffggLk

<hggpay; tpiraid Kf;fpagz;Gfs;:

<hggpay tpirahdJ r^2 fFvjphj jftpy csshy ,U epiwfSfF ,ilNaahdnjhiyTmjfhpfFk NghJ<Hggpay tpiraid typikFiwfpwJ. MfNtjhd #hapdlk;UeJGtpiatplmjfnjhiytpy cssANud] Gtpaidtplf;iwejmsT<hggpay tpiraidczhfpwJ.



njhiyitg;nghUj;J<uggpay; tpirkhWgLjy;

- ,UJfsfSfF ,ilNanraygLk <hggpay tpirvgnghOJk nray vjphrnray (action – reaction) ,izahfNtmikAk. Gtpkj #hpad VwgLjJk <hggpay tpir #hpaid NehffpnraygLk. mNjNghy #hpad kJGtpVwgLjJk <hggpay tpirGtpiaNehffpnraygLk. ,Jvjphrnray tpir(Reaction force) MFk. ,Utpirfsk ntt NtWnghUsfspd kJnraygLfpdwd.

- #hpad <hgGtpiraidhy Gkpaid kJVwgLk jpUgGtpirahdJfNojugglLssJ.

$$\vec{t} = \vec{r} \times \vec{F} = \vec{r} \times \left(-\frac{GM_sM_E}{r^2}\hat{r}\right) = 0$$

Vnddwhy $\vec{r} \times \hat{r} = 0$

$\vec{t} = \frac{d\vec{L}}{dt} = 0$ vdNt ,jypUeJmwtJvddntdwhy Gkpaid Nfhz cejk $\vec{L}$ #hpaidg nghWjJxUkhwhntfluhFk ,J midjJf NfhsfSfFk nghUeJk.,dDk nrhytnjdwhy ,ejNfhz cejkhwhj jdikjhd nfgshpd ,uzlhk tpjpiaVwgLjJfpwJ.

- $m_1$kwWk $m_2$epiwfs Gsspepiwfs vdwmDkhdjjpd mbggilapNyNa $\vec{F} = \frac{Gm_1m_2}{r_2}\hat{r}$ rkdghLgadgLjjggLfpwJ. #hpadpd <hgGtpiraid fhuzkhfGtpahdJ #hpair RwwptUfpwJvDkNghJehk #hpaidAk GtpiaAk GsspepiwfshffujfpNwhk. #hpaDfFk GtpfFk ,ilNacssnjhiytpidmtwwpd tpljJld xggpLk NghJmtwiwGsspepiwfshffUJtjpy jtwpyiy. xOqfwwkwWk

elbffggILssxggLk NghJmtwiwGss e iwfshffUJtjy jtwyiy. xOqfwwkwWk elbffggILssgugGila(Irregular and extended) nghUsfSfFgadgLjj ,ayhJ.mggbggllnghUsfSfF ,ilNacss<hgGtirad fzffILKiwfiscah tFgGfsy fwNghk.

· xNuxUrwgGNehty klLk ,U nghUsfs kfmUfy ,UejhYk>Gss eiwvdwmDkhdjijgadgLjjyhkl.

ruhdmlhjjAk eiwM Kk cilacsslwwNfhsjjwFk>mfNfhsjjwFnts Nacss Gss eiwmfFk ,ilNacss<hggay tiriafzffLk NghJ> ,it ,uzLk Fiwejnjhiytiy cssNghJk Nfhsjij Gss eiwvdfUj<hggay tirrkdghlilgadgLjjyhk. csslwwNfhsjjwFgjyhfeiwM cilaGss eiwahdJmfNfhsjjd ikagGssay cssjhff fUJNthk. gdG ,ttUGss eiwfSfFk ,ilNacss<hggay tiriafzffLyhk. ,ejkjgGcsslwwNfhsjjwFk Gss eiwfFk ,ilNaahd<hggay tirfFrkk MFk. csslwwNfhsjjd nkhjjeiwAk mjd ikagGssay ,UggJNghyNjhdWk.

ekikftuf$bakwnwhUKbTk cssJ. eiwM cilacsslwwNfhsk xdiwfUJNthk. csslwwNfhsjjd clGwk eiwm l itgNghk. eiwmczUk.<hggay tirRoMFk. ,jwfhdtsffjijcah tFgGfsy fwNghk.

edFgOjjkhqfd>kujjyUeJfNotOtjwFk>eyhGtiaRwWtjwFk fhuzk xNu<hggay tirjhd vdWtsffaNj<hggay tjjad ntwwahFk.

eA+l;ldd; vjhj;jfT ,Ukbtjj:

eA+lld xUvsikahdfzffILffhfNfhsfs tllgghijay ,aqFtjhffUjdhh. rMuKilatllgghijay ,aqfdhy ikagGssiaNehffnraygLk ikaNehfFKLffk

$$a = \frac{v^2}{r}$$

,qFv–jirNtfk kwWk r–tllgghijad ikagGssay UeJNfhsd J}uk MFk.

njhejmsTfs rkwWk TMfatwwd mbggilay jirNtfk

$$a = \frac{2pr}{T}$$

,qFTvdgJNfhsd RwWffhyk MFk. vd kjgig

$$a = \frac{\left(\frac{2pr}{T}\right)^2}{r} = -\frac{4p^2r}{T^2}$$

,eja– d kjgige A+lld ,uzlhk tjjF=markdghlby gujail ,qFmvdgJNfhsd eiwMFk.

$$F = -\frac{4p^2mr}{T^2}$$

nfgsh %dwhk tjjggb

$$\frac{r^3}{T^2} = k \text{ (khwy)}$$

$$\frac{r}{T^2} = \frac{k}{r^2}$$

t¡irffhdrkdghLg¡uj¡a¡lekfF<hgg¡ay t¡j¡ffhdrkdghLf¡lLk

$$F = \frac{4p^2mk}{r^2}$$

,tt¡irahdJfthrr¡t¡irvdgijAk t¡irahdJikajijNehff¡nraygLk vdgijAk vj¡hfFw¡czhjJf¡wJ. Nfhs¡d e¡iw m MdJnts¡ggilahfteJssJ. Mdhy e¡A+lld jdJ %dwhk t¡j¡ggbGt¡ahdJ #h¡adhy <hffggLf¡wJvd¡y #h¡aDk Gt¡ahy <hffgglNtzLk vdcWj¡ahfekg¡dhh. vdNt #h¡ad¡y e¡iwM Kk nts¡ggilahf ,lkngwNtzLk vde¡A+lld fUj¡dhh. MfNtjd csczht¡dgb $4p^2k$ fFgj¡yhfGM vdrkdghlby g¡uj¡a¡llhh. mjd%yk <hgg¡ay t¡j¡rkdghL

$$F = -\frac{GM_m}{r^2}$$

vdg ngwggllJ.

<hgg¡ay t¡irahdJfthrr¡vdgijvj¡hfFw¡kzLk ekfFczhjJf¡dwJ. Nkw$w¡at¡thjjj¡y›Nfhs tllgghija¡y ,aqFf¡wJvdehk vLjJnfhzNlhk. Mdhy Nfhsfs #h¡aid estllgghija¡y Rww¡tUf¡dwdvdgNjczikahFk. Ma¡Dk Nfhsfs¡d ghijahdJ›tllgghija¡y¡UeJr¡wjsNtkhWglLcssd. NkYk ngUkghyhdNfhsfs¡d ghijf¡lljjlltllkhfNtcssJvdgjhy Nkwfz lfUJNfhs rh¡Na

Gt¡fFk e¡yTfFk ,ilNacssnjhiyTkwWk Gt¡a¡d Muk Mf¡atww¡d kj¡gGfs¡d %yk Nkwfzlfz ffLmikeJssJ.

2400 MzLfSfFKddh f¡Nuff E}yfh (vulNlh]jd]) (Eratosthenis) Gt¡a¡d Muj ijfzff¡llhh. mNjNghyf¡Nuffthd¡ay mw¡Qh `¡gghhff] Gt¡fFk e¡yTfFk ,ilNacssnjhiyitf fzlw¡ejhh.

Rthur¡akhdt¡~ak vddntdwhy ,jnjhiyTfisf fzff¡l ,tthdt¡ay mw¡Qhfs gadgLjj¡atbt¡ay kwWk KfNfhzt¡ay ,dWehk cahe¡iygss¡tFgGfs¡NyNafwf¡Nwhk. thd¡ay gFj¡a¡y ,Jgww¡at¡tguqfs juggllssd.

<hgg¡ay; khw¡y¡:

<hgg¡ay khw¡y¡'G'a¡d kj¡gG><hgg¡ay t¡j¡a¡y Kff¡agqfhwWf¡wJ. #h¡aDfFk Gt¡fFk ,ilNacss<hgGt¡irk¡fmj¡fkhf ,UggJk›e¡iwFiwthdk¡frr¡w¡anghUsfSfF (vLjJffhllhf ,U kd¡jhfSff¡ilNaahd) t¡irGwffz¡ffjjffmst¡y k¡ffFiwthf ,Uggjd fhuzjijG d kj¡gGt¡sfFf¡wJ.

Gt¡gugg¡y csse¡iwmczUk t¡ir

$$F = -\frac{GM_E m}{R_E^2}$$

,qFM$_E$–Gt¡a¡d e¡iw›m–nghUs¡d e¡iw›R$_E$–Gt¡a¡d Muk MFk.

e¡A+lld ,uzlhk t¡j¡ggb›F = - mg,
,jidxgg¡l›

$$-mg = -\frac{GM_E m}{R_E^2}$$

$$g = \frac{GM_E}{R^2}$$

Gtpad ikajjpyUeJrnjhiytpy csse piwMcz Uk tpir

$$F = -\frac{GM_E M}{r^2}$$

GM_Eapd kjpgigNkNy cssrkdghlby gpujpapl›

$$F = -gM\frac{R_E^2}{r^2}$$

,jd %yk ekfFj njhptJvddntdwhy›g ,d kjpgGnjhpejhNytpiriavspjpy fzffplyhk. ,jwF'G' ,d kjpgGNjit ,yiy.

1798y n`dwpfhtzb~ KWfFjuhR(Torsion balance) fUtpapd %yk G = 6.75 × 10^{-11} N m^2 kg^{-2}vdf fzlwpejhh. ,dWetdnjhopyElgjjpd %yk G ,d kjpgGkpfj Jyypakhffzlwpaggl LssJ. jwNghJG = 6.67259 × 10^{-11} N m^2 kg^{-2}vdwkjpgGVwWf nfhssggl LssJ.

<hgGGyKk><hgGjdpdpiyMwwYk;
<hgGggGyk;

mbggilapy ,U nghUsfSfF ,ilahd ,iltpidNatpirMFk. ,ejcwtpd jdikiag nghWjJtpirahdJ (1) njhLtpir(2) njhlhtpirvd ,UtifggLk.

,UnghUsfs xdWld xdWnjhlLf nfhzbUfFk NghJVwgLk tpirnjhLtpirMFk. tpiriaVwgLjJk fhuzpAk nghUSk xdWfnfhdWnjhLtjd %yk VwgLk njhLtpirahy nghUspd ,affkhdJVwgLfpwJ.

#hpaid GtpRwwptUtijfUJNthk. #hpaDk GtpAk xdiwxdWnjhltpyiyvdwhYk mitxdiwnahdW ,iltpidGhpfpdwd. mjd fhuzkhfGtpahdJ#hpadpd <hgGtpiriaczhfpwJ. ,ttif<hgGtpirxUnjhlhtpirMFk.

Gtpapy UeJkpfmjpfj njhiytpy #hpad cssNghJk ,uzLk xdWfnfhdW ,iltpidGhpfpdwdvdgJekfFtpagghfNjhdWk. ekkhy NeubahfghhffnthmyyJczuNthKbtjhy jsSjy ,Ojjy Nghdwnjhltpirfspd typikiaekkhy fzffplKbAk. Mdhy nttNtWnjhiyTfspy nraygLk njhlhtpirapd typikiavtthWfzffpLtJ? njhlhtpirapd typikiaGhpeJnfhssTk kwWk fzffplTk><hgGg Gyk vdwfUjJmwpKfggLjjggLfpwJ.

epiw'm_2'kJepiw'm_1'VwgLjJk <hggpay tpir

$$\vec{F}_{21} = \frac{Gm_1m_2}{r^2}\hat{r}$$

,qF $\hat{r}$ vdgJepiw $m_1$kwWk m_2 it ,izfFk NfhLtopNanraygLk myFntflh MFk.

epiw $m_1$ypUeJrnjhiytpy cssGsspapy <hgGGyrnrwpT($\vec{E}_1$)vdgJ'XuyFepiwapdhy czuggLk <hgGtpir"vdtiuaWffggLfpwJ. <hgGyrnrwpthdJ $\frac{\vec{F}_{21}}{m_2}$ vdwtpfjjjhy Fwpffggl fpwJ.

,qFepiw m_2kJnraygLk tpir $\vec{F}_{21}$ MFk.

vdNt $\vec{E}_1 = \frac{\vec{F}_{21}}{m_2}$ gpujpapl

$$\vec{E}_1 = \frac{Gm_1}{r^2}\hat{r}$$

<hgGyrnrwT (,dNky <hgGGyk vdWmioffggLk) xUntflh $\vec{E}_1$ MFk. ntflh ,d jire iwm$_1$ l Nehff mikAk. NkYk ,Je iwm$_2$ itr rhhejJmyy.

nghJthf>e iwM My rnjhiyt y VwgLk <hgGGyk>g dtUkhWFw ffggLf wJ

$$\vec{E} = \frac{Gm}{r^2}\hat{r}$$

<hgGGyk nraygLk gFj a y cssGss P a y e iw'm'itffggLf wJ. e iw'm'MdJ<hgGGyk $\vec{E}$ iac zhtjhy xU<hgGt irVwgLf wJ.

e iwM My e iwmc zUk <HgGt irg dtUkhWvOjggLf wJ.

$$\vec{F}_m = m\vec{E}$$

,ejr rkdghlile A lld d ,uzlhk t j rkdghlNlhLxgg Lk NghJ>ekfFf ilggJ.

$$ma = m\vec{E}$$
$$\vec{a} = \vec{E}$$

mjhtJxUGss a y ,UfFk <hgGGykhdJmgGss a y cssxUJfs c zUk KLffjjwFrkk MFk. Mdhy vzkjgGk j irAk xdwhfmikejhYk a kwWk $\vec{E}$ Mf a ,uzLk nttNtW ,awg ay msTfs MFk. <hgGGyk $\vec{E}$ vdgJ %y e iwa d (Source mass) fhuzg gzG. KLffk a vdgJ<hgGGyk $\vec{E}$ y itffgglLssNrhjide iwc zUk t isTg gzghFk.

xdiwnahdWnjhlhj ,U e iwfs ilNaeilngWk ,ilt idia"<hgGgGyk"vdwfUjj y %yk ,gNghJehk t sffKbAk.

1. e iwM id t lLt yf r nryy<hgGgGyjj d ty ikFiwAk. njhiyTrmj fh fFk NghJ $\vec{E}$ a d vdkjgGFiwAk. Gss fs P, Q kwWk R y <hgGGykhdJ $|\vec{E}_P| < |\vec{E}_Q| < |\vec{E}_R|$ vdvOjyhk. Gss fs P, Q kwWk Rffhdt irntflhfs d esqfisxgg Ltjd %yk ,jidGh eJnfhssyhk.

2. <hgg ay t iriafzff Ltjwfhf"<hgGg Gyk"vdwfUjJmw KfggLjjggllJ. g dG<hgGGyk xU,awg ay msTvdWk mJnts a y (Space) MwwiyAk cejjijAk ngwWssJvdWk fzlw aggllJ.

,dDk nrhyygNghdhy k dD}llqfs ,aqFf dwKiwiaGh eJnfhssGyfnfhsifahdJjt hffKbahjxdwhft sqf wJ.

3. <hgGGyjj d myFe A lld /f Nyhf uhk (N/kg) myyJms^{-2}

<hgGGyj j d Nkw nghUe Jjy jj Jtk

m$_1$, m$_2$, ...m$_n$ e iwAila'n' Jfsfs d eiyntflhfs KiwNa $\vec{r}_1, \vec{r}_2, \vec{r}_3$...vdf. Gss a y njhFgad <hgGgGykhdJjd jjd eiwfshy vwgLk jd jjd <hgGg Gyjj d ntflh $LjYffFrkk. ,jjjJtk <hgGGyqfs d NkwnghUeJjy jjJtk vdggLk.

$$= \vec{E}_{nkhjjk} = \vec{E}_1 + \vec{E}_2 + ...\vec{E}_n$$
$$= = -\frac{Gm1}{r_1^2}\hat{r}_1 - \frac{Gm_2}{r_2^2}\hat{r}_2 - ... - \frac{Gm_n}{r_n^2}\hat{r}_n$$

$$= -\sum_{i=1}^{n} \frac{Gm_i}{r_i^2}\hat{r}$$

jd;jjd;e;iwfSfFgj;yhfnjhlhrr;ahfgut;Assnkhjje;iwM – I fUj;dhy Gss;P a;y <hgGGyj ijnjhifalLKiwa;y (integration method) fz ff;lyhk.

<hgGe;iyMwwy; (Gravitational Potential Energy):

e;iyMwwy gww;afUjJk ,awg;ay rhhejmjd nghUs gww;Ak Kd ghlqfs;y fwWsNshk. <hgg;ay t;irxUMwwy khwwht;irahFk. vdNt ,ejMwwy khwwht;ira;d GyjJld njhlhGila<hgGe;iyMwwiyehk g;d tUkhWtiuaiwnraayhk.

$m_1$kwWk $m_2$vdw ,U e;iwfs Mukgjj;y r'njhiyt;y cssd. m_1e;iwahdJe;iyahfcssJvdf. e;iwm_2 I r' e;iya;y ,UeJre;iyfFfhlbAssgbefhjjNtiynraaNtzLk.

e;iwm_2 I k;fr r;wanjhiyTdrmjhtJry;UeJ$r+dr$efhjjntsa;UeJNtiynraaggLNtzLk.

,ejk;frr;waNtiy g;d tUkhWvOjggLf;wJ.

$$dW = \vec{F}_{ext}.d\vec{r}$$

,ejNtiyahdJ<hgg;ay t;irfFvj;uhfnraaggLsJ. vdNt<hgg;ay t;ir

$$\left|\vec{F}_{ext}\right| = \left|\vec{F}_G\right| = \frac{Gm_1m_2}{r^2}$$

g;uj;a;l

$$dW = \frac{Gm_1m_2}{r^2}\hat{r}.d\vec{r}$$

vdgijehk mw;Nthk.

$$\therefore \quad dW = \frac{Gm_1m_2}{r^2}\hat{r}.(dr\hat{r})$$

(,qF $\hat{r}.\hat{r} = 1$. Vnddwhy $\hat{r}$ xUmyFntflh)

$$\therefore \quad dW = \frac{Gm_1m_2}{r^2}dr$$

r'y ,UeJJfisrfF ,lk ngaur nrajnkhjjNtiy

$$W = \int_{r'}^{r} dW = \int_{r'}^{r} \frac{Gm_1m_2}{r^2}dr$$

$$W = -\left[\frac{Gm_1m_2}{r}\right]_{r'}^{r}$$

$$W = -\frac{Gm_1m_2}{r} + \frac{Gm_1m_2}{r'}$$

$$W = U(r) - U(r')$$

,qF $U(r) = \frac{Gm_1m_2}{r}$

,ejNtiy(W) ahdJ$m_1$kwWk m_2e;iwfs KiwNarkwWk r' njhiyt;y cssNghJmtt ikgg;d <hgGe;iyMwwyfs;d NtWghlilj;Uf;wJ.

e;iy1 :vd;y

<hgg;ay t;irxUfthrr;t;irvdgjhy e;iwm2e;iwm1 my ftuggLf;wJ. vdNte;iwm2l>ry;UeJr'fFefhjjntsgGwjj;y;UeJNtiynraaNtzbaNjit ,yiy. ,qFmikgghdJjdJMwwiynryto;jJNtiynraf;wJ. vdNtnraaggllNtiyvj;hfFw;ngWk.

e;foT 2 : r<r'vd;y

r y;UeJr' fFm2e;iwiaefhjj<hgGt;irfFvj;uhfNtiynraaNtzLk. vdNtntsgGwjj;y;UeJNtiyahdJnraaggllNtzLk. MfNtnraaggllNtiyNehfFw;kj;gigg ngWf;wJ.

"e;iyMwwy khWghL"vdgNj ,awg;ay;y Kff;ajJtk cilaJ. jwNghJ<hgGe;iyMwwiyedFtiuaWffxUMjhugGss;iaNjhenjLgNghk.

mejMjhug Gss;r=¥ Kbt;y vdf.

,jd gb ,uzlhk gFj;Ro;MFk.

vdNt

$$W = \frac{Gm_1m_2}{r} + 0$$

rnjhiyt;y mikeje;iwfs $m_1$kwWk $m_2$cilamikgg;d <hgGe;iyMwwyhdJ>e;iwm1e;iyahfcssNghJ>e;iwm2 it rnjhiyt;y;UeJKbt;yhj njhiyTfFnfhzLnryynrajNtiyfFrkk vdehk tiuaWffyhk MfNt<hgGe;iyMwwy vd $U(r) = \frac{Gm_1m_2}{r}$ Fw;ffggLf;wJ.

rnjhiyt;y mikeje;iwfs $m_1$kwWk $m_2$cilamikgg;d <hgGe;iyMwwyhdJ>Kbt;yhj njhiyTkwWk rnjhiyt;y ,eje;iwfs;d mikgGcssNghJngwWss<hgGe;iyMwwyfs;d NtWghlbwFrkk vdgJk Fw;gg;ljjffJ.

mjht J $U(r) = U(r) - U(¥)$

Mdhy ,qF $U(¥) = 0$ vdMjhugGss;iaehk NjhenjLjJcsNshk.

<hgGe;iyMwwyhdJvgnghOJk vj;hf Fw;kj;gGngWk. Vnddy Kbt;yhj njhiyt;y;UeJe;iwfs (mikgG) xdiwnahdWnkJthfneUqf;tUkNghJmikgghy Ntiynraaggf;wJ.

<hgGe;iyMwwy U(r) d myF [{y (joule).NkYk ,J]Nfyhh msTMFk. <hgGe;iyMwwyhdJe;iwfisAk mtwWfF ,ilNaahdnjhiyt;idAk rhhejJ.

Gt;a;d; gugGf;FmUNf<hgGe;iyMwwy;

Gt;a;y;UeJcaujj;wFnfhzLnryyggle;iwm ,y e;iyMwwy 'mgh'Nrk;ffgglLssJvdgijt;thj;jJsNshk. ,rrkdghlil><hgGe;iyMwwy to;NaAk jUt;ffyhk.

Gt;ikajj;y;UeJrnjhiyt;y csse;iwmkwWk Gt;iaAk NrhjJxUmikgghff fUJNthk.
,ejmikgg;d <hgGe;iyMwwy

,rrkdghlil><hgGe;iyMwwy to;NaAk jUt;ffyhk.

Gt;ikajj;y;UeJrnjhiyt;y csse;iwmkwWk Gt;iaAk NrhjJxUmikgghff fUJNthk.

,ejmikggd <hgGepiyMwwy

$$U = -\frac{GM_e m}{r}$$

,qFr = R_e + h NkYk R_eGtpapd Muk MFk.

$$U = -G\frac{M_e m}{(R_e + h)}$$

foffz lthWkhwwpmikffyhk.

$$U = -G\frac{M_e m}{R_e(1 + h/R_e)}$$

$$U = -G\frac{M_e m}{R_e}(1 + h/R_e)^{-1}$$

,qFh<<$R_e$vdNt <UWgGj Njwwjij(Binomial theorem) gadgLjjptpTgLjjpgpdGcah mLfFcWgGfisGwffzpjjhy>ehk ngWtJ

$$U = -G\frac{M_e m}{R_e}\left(1 - \frac{h}{R_e}\right)$$

Gtpapd guggpy epiwmcssNghJ>

$$G\frac{M_e m}{R_e} = mgR_e$$

vdgJehk mwpejNj>

gpujpal

U = -mgR_e + mgh

Nkwfzlrkdghlby KjyNfhit(first term) cauk h l rhhejJmyy. cjhuzkhf>h_1 caujjpy ,ueJh_2 caujjpwFnghUs vLjJr nryyggLfpwJvdf.

h_1 caujjpy <hgGepiyMwwy

U(h_1) = - mgR_e + mgh_1

h_2 caujjpy <hgGepiyMwwy

U(h_2) = -mgR_e + mgh_2

$h_1$kwWk h_2 ,ilNa<hgGepiyMwwy NtWghL

U(h_2) – U(h_1) = mg (h_2 – h_1)

cssmgR_eNfhit><hgGepiyMwwy khWghLfhzgjpy vttpjkhwwjijAk VwgLjjtpyiy. vdNtrkdghLKjy Nfhitiaffzpffyhk. myyJRopvdvLjJf nfhssyhk. MfNtGtpguggpypUeJhcaujjpy csse piwm ,y NrkpffgglLss<hgGepiyMwwy U = mghvd $wyhk.

Gtpgguggpy h = 0>vdgjhy U = 0

,qFehk ftdpffNtzbaJepiw‘m’ l Gtpguggpy ,UeJehk ‘h’ cauk cahjjnrajNtiyNa‘mgh’MFk. ,ejNtiyepiw‘m’ ,y <hgGepiyMwwyhfNrkpffgglLssJ. czikapy ‘mgh’vdgJepiw‘m’kwWk Gtpiaf Nrhjj<hgGepiyMwwy MFk. Mapdk ,ej‘mgh’ l epiw‘m’ ,d <hgGepiyMwwyhfNtvLjJf nfhsfpNwhk Vnddpy epiw‘m’ cauk ‘h’fFnryYkNghJGtpepiyahfNt cssJ.

<hgGjd;dpiyMwwy; (Gravitational Potential) *V(r)*

<hgGGyk $\vec{E}$ ahdJ>mgGyjijcUthfFk epiw‘m’ I klLNkrhheJssJvdtpsffgglLssJ. ,JxUntflh msthFk. ,NjNghy epiw‘m’ I klLNkrhhej<hgGjddpiyMwwy vdw]Nfyhh msitAk ehk tiuaWffyhk.

xUepiwapyUeJrnjhiytpy cssGsspay <hgGjddpiyMwwyhdJ>xuyFepiwiaKbtpyhj njhiytpyUeJmgGsspfFnfhzL tur nrajNtiyMFk. ,J*V(r)*vdFwpffggLk. NkYk r njhiytpy cssGsspay <hgGjddpiyMwwy vdgJmgGsspay xuyFepiwffhd<hgGepiyMwwYfFr rkk vdWk tiuaWffyhk. <hgGjddpiyMwwy xU]Nfyhh msT. ,jd myFJ/kg.

<HgGepiyMwwypUeJ<hgGjddpiyMwwiyehk tiuaWffKbAk.
rnjhiytpy mikej ,Uepiwfs $m_1$kwWk $m_2$fisfUJNthk. ,ttikggpd <hgGepiyMwwy $V(r) = -\frac{Gm_1m_2}{r}$

epiwm_2l xuyFepiw(m_2 = 1 kg) vdf nfhzLepiwm_1 My VNjDk xUgsspPay VwgLk <hgGjddpiyMwwy kjpggpidngwyhk.

rnjhiytpy epiwm_1 My VwgLk <hgGjddpiyMwwy

$$V(r) = -\frac{Gm_1}{r}$$

<hgGtpirAk <hgGGyKk ntflh msTfs.

<hgGtpirAk <hgGGyKk ntflh msTfs. <hgGepiyMwwYk <hgGjddpiyMwwYk]Nfyhh msTfshFk. ntflh msTfistpl]Nfyhh msTfisgadgLjjpJfsfspd ,affjijgFjjhaTnrajy vspjhFk. cjhuzkhfMggps fNotpOtijfUJNthk.

Gtpapd <hgGtpirapd fhuzkhf<hffgglLMggps jhdhffNotpOtijfhlLfpwJ. <hgGjddpiymwwy *V(r)*JizAld ,jidtpsffKbAk.

Gtpggugpy;UeJhcaujjpy cssGsspay

<hgGjddpiyMwwy

$$V(r = R + h) = -\frac{GM_e}{(R+h)}$$

Gtpggugpy <hgGjddpiyMwwy

$$V(r = R) = -\frac{GM_e}{R}$$

Nkwfzlrkdghlfspy;UeJ

$$V(r = R) < V(r = R + h)$$

GtpggugGfFmUNfhcaujjpy <hgGepiyMwwy mghvdgijehk Kd gFjapay tpthjjNjhk. mgGsspay <hgGjddpiyMwwy *V(h) = U(h) / m = gh*. Gtpapd guggpy hRopvdgjhy Gtpggugpy<hgGjddpiyMwwy RopMFk. vdNtjhd Mggpshdjmjpf<hgGjddpiyMwwy cssgFjpapy;UeJFiwej<hgGjdikMwwy cssgFjpiaNehffptpOfpwJ. nghJthfepiwahdJ<hgGjddpiyMwwy kpFejgFjpapy;UeJ<hgGjddpiyMwwy FiwejgFjpfFr nryYk.

Gtpapd; <hgGKLf;fk;

nghUsfs Gtpapd kJtpOkNghJ> ,it Gtpapid Nehffp KLffkiltijfhzfpNwhk. epAilld ,uzlhk tpjpggbGwtpirnraygllhy klLNKxUnghUs KLffkilAk vdmwpNthk. ,qFGtpapd <hgGtpirahy nghUsfs KLffkilfpdwd. Gtpapd mUNf ,ttpirmidjJnghUsfs kJk khwhjKLffjijVwgLfpwJ. NkYk,kKLffkhdJnghUsfspd epiwfisrhhejJmyy. Gtpgug GfFmUNfcsse piwmkJGtpapdhy VwgLk <hgGtpir

$$\vec{F} = -\frac{GmM_e}{R_e^2}\hat{r}$$

,ej<hgGtpiriaepAilldpd ,uzlhk tpjpAld rkggLjj

$$m\vec{a} = -\frac{GmM_e}{R_e^2}\hat{r}$$

vdNt>KLffk

$$\vec{a} = -\frac{GM_e}{R_e^2}\hat{r}$$

Gtpg gugGfFmUNfcssnghUSfFGtpapd <hgGGyjjhy VwgLk KLffkhdJ><hgGKLffk vdggLfpwJ. ,JgvdwFwpallhy Fwpffgglfpwj.

<hgGKLffjjpd vz kjpgG

$$|g| = g = \frac{GM_e}{R_e^2}$$

,rrkdghlbypUeJ<hggpd KLffkhdJKLffkilAk nghUspd epiwiarhhejjyyvdmwpfpdNwhk. gd kjpgghdJGtpapd epiwiaAk Mujijak rhheJssJ. "Gtpapid Nehffptpok midjJnghUsfSk rkkhfKLffkilfpwJ"vdgijfypyNah 400 MzLfSfFKdNggyMaTfs %yk fzlwpejhh.

Gtpapd Gkjjpa Nuifg Fjpapy <hggpd KLffk g = 9.8 ms^{-2} vdfzlwpaggllssJ.

Fj;Jauk> Mok; kw;Wk; FWf;Ff;NfhLMf;atw;iwr; rhhe;J<hgg;d; KLf;fk; khWgLjy;

Gtpgugg pypUeJhcaujjpy csse piwm I fUJNthk. Gtpapd <hgGtpirahy mgnghUs czUk KLffk

$$g' = \frac{GM}{(R_e + h)^2}$$

$$g' = \frac{GM}{R_e^2\left(1 + \frac{h}{R_e}\right)^2}$$

$$g' = \frac{GM}{R_e^2}\left(1 + \frac{h}{R_e}\right)^{-2}$$

h<<R_e vdpy <UWgGNjwwjjpidgadgLjjpgdGcah mLfFfisg Gwffzpjjg gpd tUkhWvOjyhk.

$$g' = \frac{GM}{R_e^2}\left(1 - 2\frac{h}{R_e}\right)$$

$$g' = g\left(1 - 2\frac{h}{R_e}\right)$$

,jy UeJg' < g vdehk fhzf Nwhk. ,jd nghUs FjJauk hmjfhfFk NghJ<hgGKLffk gFiwfwJvdgjhFk.

Mojijg nghWjJgkhWgLjy;

Gtad Mo Ruqfk xdwy cjhuzkhf› (neaNtyeyffhr Ruqfk) dMojjy eiwmcssJvdf.

Ruqfjjd Mok dvdf. dMojjy g'kjgigfzffIfoffzlfUjJfisftdjjy nfhsNthk. eiwmilAk KLffjjy Gtad (Re – d) fFNkNycssGtad gFjahdJ ,ejKLffjjwFVJk gqfsgGnratjyiy. KeijagFjay e&gffgglIKbtdgb›

dMojjy <hggd KLffk

$$g' = \frac{GM'}{(R_e - d)^2}$$

(Re – d) cilaGtgFjad eiwM'MFk.Gtad mlhjjρ ruhfmidjJgFjaYk ruhf(uniform) cssJvdf fUjNdhk. vdy›

$$r = \frac{M}{V}$$

,qFM–Gtad eiwkwWk
V–Gtad gUkd MFk
NkYk mlhjjruhfcssjhy

$$r = \frac{M'}{V'}$$

$$\frac{M'}{V'} = \frac{M}{V} \text{ MfNt } M' = \frac{M}{V}V'$$

$$M' = \left(\frac{M}{\frac{4}{3}\pi R_e^3}\right)\left(\frac{4}{3}\pi(Re - d)^3\right)$$

$$M' = \frac{M}{R_e^3}(R_e - d)^3$$

gujaLf.

$$g' = G\frac{M}{R_e^3}(R_e - d)^3.\frac{1}{(R_e - d)^2}$$

$$g' = GM\frac{R_e\left(1 - \frac{d}{R_e}\right)}{R_e^3}$$

$$g' = GM\frac{\left(1 - \frac{d}{R_e}\right)}{R_e^2}$$

vdNt $g' = g\left(1 - \frac{d}{R_e}\right)$

,qFk g' < g.

Mok mjpfhpffFk NghJg'kjpgGF iwfpwJ. vdNtGtpapd Nkwgugpy <hggpd KLffk ngUkkhf ,Uffpwf. Mdhy gugGfF caNunrdwhNyhmyyJGtpapd Mojpwfnrdwhnyh<hggpd KLffk FiwAk.

FWfpFfpNfhlpilg; (Latitude)nghUjpJgkhWjy;

RoYk Fwpggha jjpy ,aqFk nghUsfspd ,affjijehk gFjjhAk NghJikatpyfFtpiriaAk ehk fUjjpy nfhssNtzLk. nghJthfGkpapidepiykfFwpgghakhffUJNthk. Mdhy czikapNyNaGkpxURoYk Fwpgghak. Vnddpy Gkpahd JjdJmrirggwwpRoyfpwJ. vdNtGtpgguggpy xUnghUs cssNghJ>m Jika tpyfFtpirapidczUfpwJ. mttpirahdJGtpapd FWfFfNfhlLkjpgigrhheJssJ. GtpRoytpyiyvdpy nghUspd kjhdtpirmgMFk. Mdhy GtpRowrpapd fhuzkhfnghUs $LjyhfikatpyfFtpirapidczhfpwJ.

ikatpyfFtpir= mω²R'

R' = R cos λ

,qFλ vdgJ FWfFNfhlbd kjpgG

nghUspd kJgfFvjphjpirapy nraygLk ikatpyfFKLffjjpd $W

$$a_{PQ} = w^2 R' \cos l = w^2 R \cos^2 l$$

Vnddpy R' = R cos λ

vdNtg' = g – ω² R cos² λ

Gtpikafnfhlby λ = 0, vdNt g' = g – ω² R. Gtpikafnfhlby <hggpd KLffk g MdJ rpWkk MFk.

JUtggFjpapy λ= 90°vdNt>g' = g

MfNt JUtg gFjpapy <hggpd KLffk ngUkk MFk.

tpLgLNtfk; kwWk; Rwwpafpfntfk;

gpugQrjjpy ngUksTfhzggLk jdpkqfs i`lu[d kwWk `ypak MFk. Mdhy Gtpapd tspkzlyjjpy ielu[Dk Mfrp[DNkmjpfmstpy cssd. Gtpapd tspkzlyjjpy i`lu[Dk `ypaKk kpffFiwthf ,Ufffhuzk ahJ? ,jid ,ggFjpapy MuhaNthk.

nghUnshdiwNkyNehffpvwpejhy Fwpggpllcauk mileJgpdGfoNehffptpOk. ,jidf fhZk NghJxUnghUisvddNtfjjpy nrqFjjhfvwpejhy>mgnghUs GtpgguggpwfkzLk tuhky>Gtpapd <hggpypUeJjggpr nryYk vdwNfstpvOfpwJ.

tpOk.,jidf fhZk NghJxUnghUisvddNtfjjpy nrqFjjhfvwpejhy>mgnghUs GtpgguggpwfkzLk tuhky>Gtpapd <hggpypUeJjggpr nryYk vdwNfstpvOfpwJ.

Gtpgguggpyepiwmcilaxunghuisfujnthk. Mukgntfk *v*apy nghUs NkyNehffpvwpaggLfpwJvdpy nghUspd Mukgnkhjj Mwwy

$$E_i = \frac{1}{2} M v_i^2 - \frac{GM_E}{R_E}$$

,qFME - Gtpapd epiw: RE - Gtpapd Muk. NkYk $\frac{-GMM_E}{R_E}$ vdgJ epiwM d <hgGepiyMwwy MFk.

nghUs Gtpiatplltyfpntfj}uk nrdWtpllJvdpy mjnjhiyitKbtpyhj njhiyTvdfUJf. ,eepiyapy <hgGepiyMwwy Ropl[U(¥)=0]MFk. NkYk ,affMwwYk Ropl. vdNtnghUspd nkhjjMwwYk Ropahfpwj.

$$E_f = 0$$

Mwwy khwhtpjpapd gb

$$E_i = E_f$$

gpujpapl

Nfhspd <hggpay Gyjjpy pUeJtplglLj jggpr nryy›nghUs vwpaggllNtzbarpWkNtfk $v_e$vdf. vdNt$v_i$gjpyhf$v_e$vdgpujpapl

$$\frac{1}{2}Mv_i^2 - \frac{GMM_E}{R_E} = 0$$

$$\frac{1}{2}Mv_i^2 - \frac{GMM_E}{R_E}$$

$g = \frac{GM_E}{R_E^2}$ rkdghlilgadgLjjpdhy

$$v_e^2 = 2gR_E$$

$$v_e = \sqrt{2gR_E}$$

Nkwfzlrkdghlbypy pUeJtplglLNtfkhdJ<hggpd KLffk›Gtpapd Muk Mfpa ,Ufhuzpfisrhhe JssJvdgijmwpfpNwhk. tplglLNtfkhdJnghUspd epiwapidrhhejJmyy. g (9.8 ms^{-2}) kwWk R_e = 6400 km kjpgGfisgpujpaplGtpapd tplglLNtfk V_e = 11.2 kms^{-1}MFk. tplglLNtfk nghUs vwpaggLk jpiriarhhejJmyy. nrqFjjhfNthmyyJfpilkllkhfNthmyyJFwpggpllNfhzjjpy nghUs vwpaggllhNyhGtpapd <hgGtpirapy pUeJtplglLnrytjwfhd tplglLNtfk khwhJ. ,JfhllggllLssJ.

ipa`lu[d kwWk `ypak NghdwNyrhd %yf$Wfs GtpggugigtplljggpnryYtjwFNghJkhdNtfk nfhzLssd. Mdhy ielu[d kwWk Mfp]p[d Nghdwfdkhd %yf$Wfs jggpr nryyNghJkhdNtfk cilaitmyy. (thAffspd ,affttpay nfhsifiatpthjpFk NghJipa`lu[d kwWk `ypak mZffspd Ntfjijgtpapd tplglLNtfjJld xggLnraJghhgNghk)

Jizf; Nfhs;fs; - Rww;waf;fNtfKk; RW;Wf;fhyKk;

ehk thotJetdAfk. cyfpd vggFjpapy csstfSlDk njhlhGnfhstjwfhdmjpetdnjhopyElgfUtpfs ekkpilNacssd. ,kKdNdwwjjpwFfhuzk #hpa FLkgmikgigehk edFGhpejnfhzlNjMFk. Gtpapidtyk tUk JizfNfhsfNsjwNghJnrajpj njhlhGfFnghpJk cjTfpdwd. #hpaidf Nfhsfs RWWtJNghyJizfNfhsfs Gtpiar Rww;tUfpdwd. vdNtnfgshpd tpjpfs kdpjd cUthffpanrawifj JizfNfhsfSfFk nghUeJfpdwd. epiwMcilaJizfNfhs Gtpiar Rww;tUtjwFj Njitahdika NehfFtpiriaGtpapd <hgGtpirjUfpwJ.

$$\frac{Mv^2}{(RE+h)} = \frac{GMM_E}{(R_E+h)^2}$$

$$v^2 = \frac{GM_E}{(R_E+h)}$$

$$v = \sqrt{\frac{GM_E}{(R_E+h)}}$$

cauk hmj;fh;fFk NghJ›J i z fNfhs;d Rww;a f fNt fk FiwAk.

J i z f;Nfhs;d; RwWf; fhyk; :

xUKOr Rww;d NghJJ i z fNfhs flfFk njhiyT2p (R_E + h) fFr rkk. NkYk xU KO RwWfFMFk fhymsNt J i z fNfhs;d RwWf fhyk TMFk.

$$\text{Rww;a f fNt fk } v = \frac{\text{f l e j njhiyT}}{\text{fhyk}} = \frac{2p(R_E + h)}{T}$$

y;UeJ v fFg;uj;a;l

$$\sqrt{\frac{GM_E}{(R_E + h)}} = \frac{2p(R_E + h)}{T}$$

$$T = \frac{2p}{\sqrt{GM_E}}(R_E + h)^{3/2}$$

,UGwKk ,UkbvLf f

$$T^2 = \frac{4p^2}{GM_E}(R_E + h)^3$$

,qFkhw;y;= $\frac{4p^2}{GM_E}$ vdgJ xUkhw;y;. vdNt ,ijcvdf.

$T^2 = c (R_E + h)^3$

Nfhsfs;d ,affk gww;anfgsh t;j;a;y $wggl Lssfhyk kwWk njhiyTf fhdnjhlhg;idNaGt;a;idr RwWk J i z fNfhSk nfhzLss Jvdgijehk mw;ayhk. Gt;fFmUNfRwWk J i z fNfhS fFGt;a;d Muk R_E c l d xgg;Lk NghJhk;fr r;w;aJvdgjhy hGwf f z;f f j j f fJ. vdNt

$$T^2 = \frac{4p^2}{GM_E}R_E^3$$

$$T^2 = \frac{4p^2}{g}R_E$$

,qF $GM_E / R_E^2 = g$

$$T = 2p\sqrt{\frac{R_E}{g}}$$

$R_E = 6.4\ 10^6$ m kwWk g = 9.8 m/s^2, kj;gGf i s g;uj;a;l

J i z fNfhs;d Rowr; fhyk T @85 e;k;lqfs vdg ngwggLf;wJ.

Gt;ia RwWk; J i z f;Nfhs;d; Mwwy;

Gt;ggugg;y;UeJ h caujj;y Gt;a;idr tyk tUk J i z fNfhs;d nkhjj Mwwy foffzl Kiwa;y fzff;lggLf;wJ. J i z fNfhs;d nkhjj Mwwy mjd ,aff Mwwy kwWk e;iy Mwwy;d $lLjnjhifahFk.

J i z fNfhs;d e;iy Mwwy

$$U = -\frac{GM_s M_E}{(R_E + h)}$$

,qF M_s– J i z fNfhs;d e;iw›

M_E - Gtpad epiw>
R_E - Gtpad Muk.
Jizf Nfhspd ,aff Mwwy

$$K.E = \frac{1}{2} M_s v^2$$

,qF v vdgJ Jizf Nfhspd Rwwpaff Ntfk NkYk ,jd kjpgG ,kkjpgig gupapl

$$v = \sqrt{\frac{GM_E}{(R_E + h)}}$$

Jizf Nfhspd ,aff Mwwy

$$K.E = \frac{1}{2} \frac{GM_E M_s}{(R_E + h)}$$

vdNt Jizf Nfhspd nkhjj Mwwy

$$E = \frac{1}{2} \frac{GM_E M_s}{(R_E + h)} - \frac{GM_s M_E}{(R_E + h)}$$

$$E = - \frac{GM_s M_E}{2(R_E + h)}$$

,qFvjhfFwpahdJJizf Nfhs GtpAld gpizffgglLssJvdgijAk Jizf Nfhs Gtpapd <hgGGyjjpyUeJjggpr nryy ,ayhJvdgijAk vLjJffhlLfpwJ.

Kbtpy kjpgig(∞) neUqFk NghJ>nkhjjMwwy Ropianeuqfk. ,jd nghUs vddntdwhy>Jizf Nfhshd JGtpapd <hgGGyjjpd jhffjjpypUeJKwwpYk tpLglLssJ. NkYk kpfmjpfnjhiyTcssNghJJizf Nfhs GtpAld gpizffgglt pyiyvdgjhFk.

Gtpepiyj pJizf Nfhs kwWk JUtj pJizf Nfhs:

Gtpapidr Rwwptuk Jizf Nfhsfspd RwWfhyqfs mtwwpd RwWgghijMujijg nghWjJmikfpdwd. RwWfhyk 24 kzp Neuk cilaJizf Nfhspd RwWgghijMujijfzffpLNthkh?

nfgshpd %dwhk tpjpiag gadgLjjp ,ejRwWg ghijapd Mujijfzffplyhk.

$$T^2 = \frac{4p^2}{GM_E} (R_E + h)^3$$

$$(R_E + h)^3 = \frac{GM_E T^2}{4p^2}$$

$$R_E + h = \left(\frac{GM_E T^2}{4p^2} \right)^{1/3}$$

Gtpapd epiw>Muk kwWk RwWffhyk T (= 24 kzp= 86400 tpdhbfs) Mfpatwwpd kjpgGfisgupapL>fzffplh d kjpgG 36>000 kmvdf fpilffpwJ. ,ttifJizf Nfhsfs Gtpepiyj Jizf Nfhsfs (geo-statinary satellites) vdggLfpdwd. Vnddwhy Gtpaypue Jghhf Fk NghJ ,it epiyahf ,UggJNghyj NjhdWk.

,ejpahnrajpnjhlhGfFg gadgLjJk Gtpepiyj Jizf Nfhsfshd ,drhl (INSAT) tifJizf Nfhsfs mbggilapy Gtpepiyj Jizf NfhsfNs. Gtpapd gugpypUeJ 500 Kjy 800 km caujjpy Gtpapidtlf F–njwFjpirapy kwnwhUtifJizf Nfhsfs Rwwptufpdwd. Gtpapd tl–njd JUtqfs Nky nryYk RwWgghijapy Gtpapid Rwwptuk ,ttifJizf Nfhsfs JUtj Jizf Nfhsfs vdggLfpdwd. JUtjJizf Nfhsfspd Rowrpfhyk 100

e¤klqfs. vdNtxUehs¤y gyKiwGt¤a¤idRww¤tUf¤dwd. xURww¤dNghJGt¤a¤d tlJUtk Kjy njd JUtk tiuxUr¤w¤ae¤yggugig(Strip of area) fleJnryYk. mLjJj Rww¤d NghJNtWe¤yggugGgFj¤Nky fleJnryYk. Vnddwhy Kjy RwWfhyms t¤y Gt¤ahdJxUr¤w¤aNfhzmsTRodW ,UfFk. ,tthWmLjjLjjRwWfs¤d %yk JUtJizfNfhshdJGt¤a¤d KO e¤yggugigAk flffKbAk.

vila¤d¡iknghUs¤d¡ vil:

Gt¤a¤y cssxtnthUnghUSk›Gt¤a¤d <hgGt¤irahy ftuggLf¤dwd. ‘m’e¤iwcilanghUs¤d kJnraygLk <hgg¤ay t¤irmgMFk. ,tt¤irahdJvgnghOJNkfoNehff¤Ak›Gt¤a¤d ikak Nehff¤Ak nraygLk. jiua¤d Nky ehk e¤wFk NghJ›ekkJ ,U t¤irfs nraygLf¤dwd.

xdW›foNehff¤nraygLk <hgGt¤irkwnwhdWjiua¤dhy ekkJnrYjjggLk NkyNehff¤anrqFjJt¤ir. ,tt¤irNaekikxaTe¤iya¤y itjj¤Uff¤wJ. xUnghUs¤d vil $\vec{W}$ MdJfoNehff¤at¤irahFk. ,ejvila¤d vz kj¤gghdJmgnghUisjiuiag nghWjJxaT–
e¤iya¤Nyhmyy Jkhwhjj¤irNtfjj¤Nyhitjj¤Uffnr YjjNtzbaNkyNehff¤at¤ira¤d vz kj¤gGfFrkk MFk. vila¤d j¤irAk›Gt¤ahgGt¤ira¤d j¤ira¤NyNaFw¤ffggLf¤wJ. vdNtxUnghUisjiua¤y xaTe¤iya¤y itjj¤Uffjiuahd J‘mg’msTsst¤iriaNkyNehff¤nrYjJf¤wJ.

vdNtvila¤d vz kj¤gGW = N = mg MFk. vila¤d vz kj¤gGmgMf ,UejhYk›vilAk nghUs¤d kJnraygLk <hgGt¤irAk xdwyyvdgijehk ftdjj¤y nfhssNtzLk.

k¤d¡ cah¡j¡j¤fs¤y¡ Njhww vil:

k¤d cahjj¤ ,aqfMukg¤fFk NghJk›e¤WjjggLk NghJk k¤d cahjj¤a¤Ds ,Uggthfs xUFYqfiy(Jerk) czhthfs. Vd mtthWe¤fof¤wJ? ,eje¤foittsfFtjwF›vila¤d fUjjhffjijGhe¤JnfhsSjy Kff¤akhdxdwhFk. foffzl #oyfs¤y xUkd¤jh k¤d cahjj¤a¤y e¤wf¤dwdhh vdf.

k¤d cahjj¤a¤y e¤wFk kd¤jh kJ ,U t¤irfs nraygLf¤dwd.

1. foNehff¤nraygLk <hgGt¤ir. ehk nrqFjJj¤ira¤idNeh mrRj¤irvdvLjJfnfhzlhy›mejkd¤jh kJnraygLk <hgg¤ay t¤ir $\vec{F}_G$ - $mg\,j$
2. k¤d cahjj¤a¤d j sjj¤dhy kd¤jh kJnrYjjggLk NkyNehff¤anrqFjJt¤ir $\vec{N} = N\,j$

e¤foT(i)k¤d¡ cah¡j¡j¤xaTe¤iya¤y¡ cs¡sNghJ

kd¤jh¤d KLffk Ro¤MFk. vdNtkd¤jh kJnraygLk nkhjjt¤irAk Ro¤ahFk. e¤A¡lld¤d ,uzlhk t¤j¤ggb

$$\vec{F}_G + \vec{N} = 0$$
$$-mg\,j + N\,j = 0$$

ntflh $Wfisxgg¤llhy ehk ngWtJ

$$N - mg = 0 \text{ (myyJ)} N = mg$$

vdNtvilW = N vdgjhykd¤jh¤d Njhwwvilmth¤d czikvilfFr rkk.

e¤foT(iii)k¤d¡ cah¡j¡j¤Nky¡Neh¡f¡f¤KL¡f¡fggLk¡ NghJ

Nky Nehff;aKLfffjJld ($\vec{a} = a\hat{j}$) k;d cahjj; ,aqFf;wJvd;y jiuiag nghWjJ (e;iykf Fw;gghak) e;A+lld;d ,uzlhk t;j;iagadgLjj;dhy>ekfFf;ilggJ

gadgLjj;dhy>ekfFf;ilggJ

$$\vec{F}_G + \vec{N} = m\vec{a}$$

Nkwfzlrkdghlilnrq Fjjj;ira;d myFntflhfisgadgLjj;vOJNthk.

$$-mg\hat{j} + N\hat{j} = ma\hat{j}$$

ntflh $Wfisxgg;l

$$N = m(g + a)$$

vdNtkd;jh;d Njhwwvilmth;d czikviliat;lmj;fk.

e;foT(iv)k;d; cahj;j;jf;foNehf;f;aKLf;fggLk; NghJ

k;d cahjj;ahdJ foNehff;aKLffjJld ($\vec{a} = -a\hat{j}$), aqFf;wJvd;y e;A+lld;d ,uzlhk t;j;iagadgLjj;ehk ngWtJ

$$\vec{F}_G + \vec{N} = m\vec{a}$$

Nkwfzlrkdghlilnrq Fjjj;ira;d myFntflhfisgadgLjj;vOJNthk.

myFntflhfisgadgLjj;vOJNthk.

$$-mg\hat{j} + N\hat{j} = -ma\hat{j}$$

ntflh $Wfis ,UGwKk xgg;lehk ngWtJ

$$N = m(g-a)$$

vdNtkd;jh;d Njhwwvil{W = N = (m(g-a)} mth;d czikviliat;lFiwT.

jhNdfNot;Ok; nghUs;fs;d; vila;d;ik:

jhNdfNot;Ok nghUsfs <hgg;ay t;iriaklLNk czhf;dwd. jila;dw;jhNdt;Otjhy mitvejgugGlDk njhlhG ,yyhky cssd. (fhww;d cuhaTt;irGwffz;ffggLf;wJ). vdNtnghUs;d kjnraygLk nrqFjJt;irRo;ahFk. nghUs;d foNehff;aKLffk Gt;a;d <hgGKLffjj;wFr rkk. mjhtJa=g vdNtrkdghL ,UeJ

$$/\ N = m(g - g) = 0$$

,jidNavila;dike;iyvdf;Nwhk. k;d cahjj;fo Nehff;aKLffk (a = g) y t;OkNghJ>k;d cahjj;a;d csNs ,UfFk kd;jh vila;dike;iyiamyyJjhdhfNtfNot;Ok e;iyiaczhthh.

t;zntsf; fyj;j;y; vila;d;ik:

Gt;iaRww;tUk t;zntsffyjj;y csst;zntstuhfs kJvtt;j<hgg;ay t;irAk nrayglhJvdwxUjtwhdfUjJe;yTf;wJ. czika;y Gt;a;d gugGfFmUNfGt;a;idtyk tUk t;zntsfyk Gt;a;d <hgGt;irfFclgLkl. mNj<hgg;ay t;iriat;zntsfyjj;y csst;zntstuhfSk czhthhfs. ,jd fhuzkhfmthfs fyjj;d jiu kJvtt;jt;iriaAk nrYjJtJ ,yiy. vdNtfyjj;d jiuAk mthfs kJvtt;jnrqFjJt;iriaAk nrYjJtJ ,yiy. MfNtt;zntsfyjj;y csstuhfs vila;dike;iya;y cssdh. t;zntstuhfs klLkyy. t;z fyjj;y cssmidjJnghUsfSk vila;dike;iya;y cssd. ,jidjhdhffNot;Ok e;iyAld xgg;lyhk.

thd;ay; gww;ambgg;ilf; fUj;Jfs;:

kd;jFytuyhww;y Njhdw;ak;fg gioamw;t;ay g;h;Tthd;ay MFk. Kwfhyjj;y ,awg;ay;y ,UeJg;h;jJg ghhffKbahjgFj;ahfthd;ay ,UejJ. 16 Mk E}wwhzLtiu ,awg;ay;y thd;ay;d gqfs;gGk;fmj;fk. `;gghhff]>mh;] lhhf]>jhyk;Nfhghe;f]

kwWk ilNfhguhN` Mf Nahhfshy gy E}wwhzLfshfjullgglthd ay juTfs d mbggila y jhd nfgsh t j fSk e A lld d <hgg ay t j fSk cUthffgglld> cWj nraaggllld. ilNfhguhN` - t d thd ay juTfs cjt a dw nfgsh t j fs cUthf ,UffhJ. nfgsh t j fs d cjt a dw e A lld <hgg ay t j i acUthff ,UffKbahJ.

ghlMukgjj y Nfhghe f] d #h a ikaf nfhsifahdJjhyk a d Gt ikaf nfhsiffFgj yhfmikejJvdgghhjNjhk. vdNtGt ikaf Nfhlghlbd Fiwfisehk gFjjhaeJt sfFtJKff akhdjhFk.

Gt ikaf; nfhs;ifAk; - #h a ikaf; nfhs;ifAk;

njhlheJr ykhjqfSfF ,ut y ntWqfzfshy Nfhsfs d ,affqfiscwWNehff Ndhk vd y Nfhsfs f ofFj ira y ga z jJg dGg dNdhff NkwFj ira y ,aqf kzLk f ofFj ira y ga z ggijfhzyhk. ,jwF“Nfhsfs d g dNdhfF ,affk”(Retro grade motion) vdWngah. nrttha d g dNdhfF ,affjijfhzyhk.

Xh MzLfhyjj wFnrttha Nfhs d ,affjijcwWNehfFk NghJmJKjy y f ofFj irNehff (g guth Kjy [{d) nryYk. g dGg dNdhff ([{i y> Mf] L> nrglkgh) nryYk. g wFmfNlhgh Kjy kzLk f ofFj ira y nryf wJ. Kwfhyjj y thd ay mw QHfs fz ZfFGydhFk midjJNfhsfs d g dNdhfF ,affjijgj TnraJmjidt sffKawr nrajdh. #h ad kwWk midjJNfhsfSk Gt iaikakhff nfhzLtllgghija y Rww tUf dwdvdmh] lhlby $w dhh. mtthWtllgghija y Nfhsfs ,aqf dhy FWf afhyjj wFVd Nfhsfs g dNdhff ,aqFf dwd? vdgijt sffKbat yiy.

vdNtjhyk ,ejGt ikaf Nfhlghby”ngUtlljj d Nky mikAk r WtllrRowr ”(Epicycle) vdwfUjj idKdnkho ejhh. ,ffUjj dgb> Gt a idf Nfhs tllg ghija y RwWk mNjNtisa y kwWk xUtllgghij ,affjj wFk csshFk. mjwFngUtlljj d Nky mikAk r WtllRowr vdg ngah. tllgghija y Gt a idRwWk ,affjijAk> ngUtlljj d Nky mikAk r Wtll ,affjijAk xdw izfFk NghJGt a idxUnghUjJNfhsfsg dNehff nrytJNghyNjhdWk ,affjijjUf wJ. mh] lhlby d Gt ikaf fUjJld ,affjijjhyk ,izjjhh.

Mdhy jyhk a d ,ejr Wtllr Rowr t sffkhdJk fTk fbdkhf ,UejJ. 15Mk E}wwhzby NghyeJehlLthd ay mw Qh Nfhghe ff] > ,ejr ffiyvs aKiwa y jhfFk t jkhf #h a ikaf nfhsifiaKdnkho ejhh. ,fnfhsifggb> #h a FLkgmikgg d ikak #h aNd. midjJNfhsfSk #h aidr Rww tUf dwd. Gt a idr rhheJNfhsfs d rhhG ,affjj d fhuzkhfNfhsfs “g d Nehff nrytJNghdw ,affjij”(Retrograde motion) ngWf dwd. #h a ikaf nfhsifa d mbggila y Nfhsfs d ,ejg dNehff nrytJNghdw ,affk fhllgglLssJ.

Gt ahdJnrttha Nfhist lt iuthf #h aid Rww tUf wJ. Gt fFk nrtthaNfhSfFk ,ilNaahdrhhG ,affjj d (Relative motion) fhuzkhf[{iyKjy mfNlhgh t iunrttha Nfhs g dNehff nrytJNghyNjhdWf wJ. ,NjNghyg wNfhsfs d g dNdhfF ,affqfisAk Nfhgh ef] d #h a ikaf nfhsifahy t sffKbejJ. ,ejvs ikj jdika d fhuzkhfNt #h a ikaf nfhsifGt ikaf nfhsiffFgj yhfgbggbahfVwWf nfhssgglIJ. ,awife foTfSfFxdWfFNkwgllt sffqfs juggLk NghJ> vs ikahdt sffNkmyyJkhjh NanghJthfVwWfnfhssggLk. Nkw$w afUjJklLkyyhJ> jhyk a d nfhsiffFgj yhfNfhghe f] nfhsifVwWf nfhssgglljwfhdt h thdt sffjijthd ay E}yfs y fhzyhk.

nfg;shd; %d;whk; t j;Ak; thd ay; njhiyTfSk;

nfgsh jdJ %dWtpjpfisAk jUtpggjwFilNfhgpuhN`tpd thdpay juTfisKOikahfg gadgLjjpdhh. jdJ %dwhk tpjpay #hpaDfFk NfhSfFk ,ilNaahdnjhiyTfFk›Nfhspd RwWf fhyjjpwFk cssnjhlhgpidjUtpjjhh. thdpay mwpQhfs tbtpay kwWk KfNfhztpaypd cjtpAld xUNfhSfFk #hpaDfFk ,ilNacssnjhiytpidGtpfFk #hpaDfFk ,ilNacssnjhiytpd (thdpay myF) klqfhff fzlwpejhhfs. ,qF #hpadpypUeJ Gjd kwWk ntsspad njhiyTfzlwpaggllt pjjijfhzNghk. Gjd kwWk ntsspNfhsfs cs Nfhsfs vdggLfpdwd. Gkpapypuejghhf FkNghJ #hpaDfFk ntsspf NfhSfFk ,ilNacssmjpfglrNfhzk 46˚MFk. mNjNghyGjd NfhSfFk #hpaDfFk ,ilNacssmjpfglrNfhzk 22.5˚MFk.

Gtpiag nghWjJntsspfNfhs ngUkelrpeiyapy (46˚)cssNghJ› #hpaDfFk›ntsspfFk cssNfhlLfFk›ntsspfFk Gkpf Fk cssNfhlLfFk ,ilNacssNfhzk 90˚MFk. ,jd %yk Gtpf Fk #hpaDfFk ,ilNacssnjhiyTfhzyhk. Gtpf Fk #hpaDfFk cssnjhiyTxUthdpay myF(1 AU)vdWvLjJf nfhssyhk.

jphpNfhzkpjpnfhs ifggbcssnrqNfhz KfNfhzjjpy

$$\sin q = \frac{r}{R}$$

,qFR = 1 AU

$$r = R\sin q = (1AU)(\sin 46°)$$

sin 46˚ = 0.72vdgjpypUeJntsspl #hpadpypUeJ 0.72 AUnjhiytpy cssJvdfzffplggllJ. ,NjNghy θ = 22.5˚vdgpujpalLGjDfFk #hpaDfFk cssnjhiyT0.38 AUvdfzffplggllJ. ntspfNfhsfshdnrttha kwWk tpahod NghdwNfhsfspd njhiythdJrwWkhWgllKiwapy fzlwpaggllld. #hpaDfFk NfhsfSfFk cssnjhiyTfs jugglLssd.

nttpNtWNfhspfSf;fhd $\frac{a^3}{T^2}$

Nfhspfs;	RwWgghijMuk; (a)	RwWf;fhyk; T (ehlfs;)	A^3/T^2
Gjd	0.389 AU	87.77	7.64
ntssp	0.724 AU	224.70	7.52
Gtp	1,000 AU	365.25	7.50
nrttha	1.524 AU	686.98	7.50
tpahod	5.200 AU	4332.62	7.49
rdp	9.510 AU	10,759.20	7.40

,jpypUeJnfgsh tpjpiar rhpghhffcahepiyg gsspapy fwFk tbtpay kwWk KfNfhztpay fUjJffNsNghJkhditvdgJedFnjhpfwJ.

Gtpapd; Mujijmsjjy;

fp.K. 225 y mNyf]hzlhpah(Alexandria) tpy thoejfpNuff E}yfh vulNlh]jd] (“EratosThenes”) Gtpapd MujijKjd Kjypy msejhh. jwNghJetdKiwapy fzlwpaggllkjpgGld xggpl ,kkjpgGfplljjllJyypakhfmikeJssJ. vulNlh]jd] gadgLjjpafzfflLfFNjitahdfzpjk ,dWcahepiytFggpy nrhyypj juggLfpwJ. Nfhil #hpa jpUgGKfepiyapy (#hpad jd ,affjpiriakhwWk ehs) (Solstice) ezgfypy ird (Syene)efhpy #hpa xspepoy VwgLjjhijf fzlhh. mNjNeujjpy

irnad efhyUeJ 500 iky njhiytpy cssmnyf]hzlhahefhy nrqFjJj jpirfF7.2°rhathf #ha xspeoy tOfwJvdf fzlhh.
vdf fzlhh.
7.2 bfhNtWghLVwglf fhuzk Gtpapd NkwgugGtiseJfhzggLtNjvd czhejhh.

,ejNfhzk $7.2^\circ = \frac{1}{8}$ Nubad

ird kwWk mnyfrhzbhahefUfF ,ilNaahdtlltpyypd esk Svdf.
NkYk Gtpapd Muk Rvdpy

$S = R\theta = 500$ iky

Gtpapd Muk $R = \frac{500}{q}$ iky

$R = \frac{500}{\left(\frac{1}{8}\right)}$ iky

R = 4000 iky

1 iky = 1.609 km. vdNtmth Gtpapd Muk R = 6436 km vdf fzffplhh. tpaggspFk tzzk ,kkjpgGjwNghJfzlwpaggllkjpgghd6378 km fFkfmUNfcssJ.

3Mk E}wwhzby fNuffehlLthdpay mwpQH `pgghhff] GtpfFk epyTfFk cssnjhiytpidfzlwpejhh.

tpagGplLk thdpay; cz;ikfs;:

1. **rejpfpufzk; kwWk; Gtpapd; epoypd; Muk; mstpLjYk; :**

2018 [dthp 31>mdW KO rejpfpufzk eilngwwijjkpofk clglgy ,lqfspy cwWNehffpgjpTnraaggllJ. epyhGtpapd epoiyf flfFkNghJ> ,gGtpepoypd Mujijmstpnraayhk.

Gtpapd fUepoy gFjpapy epyhcssNghJrptgGepwjjpy epyhnjhpAk. Gtpapd fUepoy gFjpapidtplLepyhntspNawpaclNdmJgpiwepyTNghyNjhdWk.
mtthWepyhntspNaWk NghJGtpfUepoypd NjhwwMuk kwWk epyhtpd NjhwwMuk Mfpatwiwmsffyhk. gpdGmtwwpd jfTfzffplyhk.

epowgljjpy Gtpapd fUepoypd NjhwwMuk (apparent radius) = R_s = 13.2 cm
epowgljjpy epyhtpd NjhwwMuk (apparent redius) = R_m = 5.15 cm

,ejMuqfspd jfT $\frac{R_s}{R_m} \approx 2.56$

Gtpapd fUepoypd Muk $R_s = 2.56 \times R_m$
epyhtpd Muk $R_m = 1737\ km$
Gtpfuepoypd Muk

$R_s = 2.56 \times 1737\ km @ 4446\ km$

Mujjpd rhahdmsT= 4610 km

fzfflby rjtjg gpio

$= \frac{4610 - 4446}{4610} \times 100 = 3.5\%$

cahjpwd njhiyNehffp %yk glqfs vLffgglhy gpioapd msTFiwAk. vspafzpjnrayghlbd %yk ,ejfzffLnraaggLssJvdgJftdpffjjffJ.

rej‰uf‰uf z jj‰d NghJe‰yht‰d kJt‰Ok Gt‰a‰d e‰oy‰d tbtjijcwWNehff‰Gt‰ahdJNfhsftbtKilaJvdthd‰ay mw‰QHfs ntFfhyjj‰wFKdNge‰&g‰jjdh.

2. xtnthUkhjKk #h‰a f‰uf z k kwWk rej‰uf‰uf z k ,uzLNkNjhdWtj‰yiyVd? KO e‰yTehs‰d NghJe‰yt‰d RwWgghijAk Gt‰a‰d RwWgghijAk xNujsjj‰y mikejhy rej‰uf‰uf z k NjhdWk. mNjNghy mkhthirmdWk mikejhy #h‰a f‰uf z k NjhdWk. Mdhy e‰yht‰d RwWghijahdJGt‰a‰d RwWgghijjjsjj‰y‰UeJ5°rhaeJfhzggLf‰wJ. ,ej5°rhaTcssjhy›Mzbd xUFw‰gg‰llfhyjj‰y klLNk #h‰ad›Gt‰kwWk e‰yTMf‰aitxNuNehNfhlby mikf‰dwd. mtthWmikAk nghOJklLNk ,k%dw‰d e‰iya‰idg nghWjJrej‰uf‰uf z NkhmyyJ #h‰a f‰uf z NkhVwgLk.

3. Gt‰a‰y gUtfhyqfs NjhdWtJVd?
#h‰aid Gt‰estllgghija‰y RwWf‰wJ. vdNt #h‰aDfFmzika‰y Gt‰cssNghJNfhilfhyKk Nraika‰y cssNghJFs‰hfhyKk NjhdWf‰wJ"vdgJjtwhdfUjjhFk. czika‰y Gt‰ahdJ #h‰aid 23.5° Nfhzrhatld Rww‰tUtjhNyNagUtfhyqfs NjhdWf‰dwd.
23.5°rhat‰d fhuzkhfGt‰a‰d tlNfhsggFj‰#h‰aDfF ntFnjhiyt‰y cssNghJ›Gt‰a‰d njdNfhsggFj‰ #h‰aDfF mUf‰y mikAk. vdNttlNfhsggFj‰a‰y Fs‰hfhykhfcssNghJ›njdNfhsggFj‰a‰y Nfhilfhykhf ,UfFk.

4. t‰zkd‰d Njhww ,affKk Gt‰a‰d Rowr‰Ak:

,uTNeuqfs‰y t‰zkdfs efhtJNghJNjhdWtijcwWNehfFtjd %yk Gt‰jdidjjhNdRoyf‰wJvde‰&gffyhk. Gt‰a‰d jwRowr‰fhuzkhfNtJUtt‰zkidkwwt‰zkdfs tllgghija‰y Rww‰tUtJNghyNjhdWf‰wJ

Gt‰a‰d Rowr‰mrRfFNeuhf Jut t‰zkd mikeJssjhy mtt‰zkd e‰iyahdjhfNjhdWf‰wJ. Nghyhh‰] t‰zkd (Polaris) JUtt‰zkd MFk.

thd‰ay; kwWk; <h‰gg‰ay‰y; rkgj;j‰atshr;r‰fs;

19 Mk E}wwhzLtiuthd‰ayhdJntWk fzfshy myyJnjhiyNehff‰%yk cwWNehffggLjiyrhheJ ,Uejj. 19 Mk E}wwhzbd Kbt‰y k‰dfhejmiyfs‰d e‰wkhiyfzlw‰agg‰llTld g‰ugQrjijg gww‰aekJGh‰jy ngUkst‰y mj‰fh‰jjJ. 19 Mk E}wwhzbd ,Wj‰a‰y Vwgll ,ejtshrr‰ahy e‰A‹lld‰d <h‰gg‰ay t‰j‰ahy r‰ye‰foTfs kwWk KuzghLfist‰sffKbat‰yiyvdfzlw‰agg‰llJ. <h‰gg‰ay Jiwa‰y 20 Mk E}wwhzbd k‰fr r‰wejnfhsiffs‰y xdwhd"nghJrhhg‰ay jjJtk"Myghl ld]Bdhy cUthffgg‰llJ.

,Ughjk E}wwhzby thd‰aYk <h‰gg‰aYk xdw‰izejd. NkYk gyklqFtshrr‰milejd. t‰zkd NjhwwKk kiwTk vtthWvwgLf‰wJvdgJedFGh‰eJnfhssgg‰llJ. thd ,awg‰ay kwWk <h‰gg‰ay Jiwfs‰y ,ej‰a ,awg‰ay mw‰QHfs Kff‰agqfs‰gGfs ms‰jj‰Uff‰dwdh. fUeJiskwWk t‰zkd‰d kiwTgww‰anfhsifa‰idRgg‰ukz‰ad rej‰uNrfh cUthff‰dhh. ,jwfhf 1983 ,y Nehgy gh‰Rngwwhh. ,ej‰athd‰ay mw‰QHfs‰y Fw‰gg‰ljjfftuhdNkfehl rhfh(Meghanadsaha) t‰zkdfs‰y eilngWk mad‰ahffjj‰wFch‰arkdghlilfzLg‰bjjhh. ,J'rhfht‰d mad‰ahffr rkdghL"vdggLk. ,rrkdghLt‰zkdfistifggLjjcjTf‰wJ. mky Fkhh nrsjh‰(Amal kumar Ray - Choudhuri) cUthff‰a"uha - nrsjh‰rkdghLk"<h‰gg‰ay JiwfFk‰fr‰wejgqfs‰gghFk. ,dndhUKff‰a ,ej‰athd‰awg‰ayuhdn[aej t‰. ehy‰fh

(Jayand V. Narlikar) thd;awg;ay;y KdNdhbahdgygqfs;gGfisjeJsshh. NkYk thd;ay kwWk thd;awg;ay gww;aMhtjijj J}zLk E}yfs gyvOj;Asshh.

IUCAA (Inter University Center for Astronomy and Astrophysics)vdwMuharr;e;Wtdk Nguhr;h;ah n[aej t;. ehy;fuhy Mukg;ffggllJ. ,ee;Wtdk %yk thd;ay kwWk <hgg;ay Jiwfs;y gyNtWMaTfs eilngwWtUf;dwd. khz thfs ,jJiwfs;y VwglLsstshrr;fs gww; E}yfk nrdWNkYk mwpeJnfhssNtzLk.

11TH , awgpay;
myF 7
gUgnghUspd; gzGfs; Properties of Matter

mwpKfk;

cyfjpy css goikahd mizfspy xdW jpUrrpay; mikeJss fyyiz MFk. fyyiz fhtph; Mwwd FWfNf ghrdjjwfhf fllgglIJ. fhtph; Mwwy mjpf ntssg ngUffpdNghJ ehpd Ntfk nghJthf kpf mjpfkhf ,UfFk. fyyiz apd cWjpjjdikAk> mjd gadghLk> ,jid 2 Mk E}wwhzbNyNa tbtikjj jkpohfspd csSzhTss mwtpay Ghpjiy ntspggLjJfwJ. Kwfhyjjpd mwpTg Ghtkhd flLkhdqfSfF kwnwhU cjhuzk vfpgjpy css gpukpLfs MFk. jwfhyjjpy cyfk KOtJk Nkkghyqfs kwWk ghyqfs Vuhskhf cssd. fduf thfdqfspd ,affjjhy> ghyqfs vgnghOJk jifTfF clgLfpdwd. jFjpahd nghUsfisf nfhzL Kiwahf tbtikfftpyiy vdpy ghyqfs kwWk Nkkghyqfs cWjpahf ,UffhJ. gUgnghUspd gyNtW tbtqfis (jpzkk> jputk kwWk thA) GhpeJ nfhstjd %yk kdpj ehfhf tshrrp mikeJssJ.

gUgnghUspd gzGfisf fwgJ> xU Fwpggpll gadghlbwfhf vej xU nghUisAk NjhT nraa kpfTk Njitahd xdwhFk. cjhuzkhf> njhopyElgjjpy tpzntspgadghLfspy gadgLjJk nghUsfs vil Fiwthdjhf Tk Mdhy cWjpahdjhf Tk ,Uff NtzLk. nrawif kdpj cWgG khwWk epfoTfspy gadgLjjggLk nghUsfs jpR ,zffkhdjhf ,Uff NtzLk. kUjJtjjpy fjpaff rpfprir Kiwfspy jpRffSfF khwwhf nrawif cly jputqfs gadgLjjggLfpdwd. ghakqfs caTgnghUshfg gadgl mit rpy gzGfisf nfhzbUff NtzLk. ,ej Nghpayhd gzGfs> gUgnghUSfF csNsNa eilngWk Ezzpa epfoTfshy KbT nraaggLfpwJ. ,ej myF jpzkqfs kwWk ghakqfspd gzGfs kwWk gUgnghUspd nrayghlilf ifahSk tpjpfis tpsfFfpwJ.

gUgnghUspd; gyNtW epiyfspd; Ezzpa Ghpjy;

gUgnghUspd gyNtW tbtqfshd jpl czT> jputkhd eh kwWk ehk Rthrpfk fhwW Mfpait flej gyyhapuk MzLfshf mdwhl thofif Kiwapy ghprrakhf ,UejhYk jpzkqfs> jputqfs kwWk thAffspd Ezzpa Ghpjy 20 Mk E}wwhzbNyNa epWtgglIJ. mzljjpy css midjJk mZffshy Mdit. mtthW ,Uff>Vd xNu nghUs %dW epiyfspy cssJ? cjhuzkhf euhdJ jplkhd gdpfflb> jputkhd eH kwWk thA epiyapy euhtp Mfpa %dW epiyfspy cssJ. gdpfflb> eh kwWk euhtp Mfpait xNu tifahd mZffshy cUthfpdwd. mjhtJ ,U i`lu[d mZffs kwWk xU Mf]p[d mZ NrheJ xU eh %yf$W cUthfpwJ. ,ej ,awifapd moif Ezzpa klljjpy Muha ,awgpay ekfF cjTfpwJ. mZffs myyJ %yf$WfSfF ,ilNa css njhiythdJ mJ jpzkk> jputk myyJ thA Mfpatwwpy vej epiyapy cssJ vdgijj jhkhdpffpwJ.

jpzkqfs;

jpzkqfspy mZffs myyJ %yf$Wfs ,Wffkhf nghUjjgglLssd. jpzkk cUthFkNghJ mZffs gyNtW tifahd gpzgGfs %yk xdwhf gpizffgglLssd. mZffSfF ,ilNa css ,iltpid fhuzkhf mit xU Fwpggpll mZtpil njhiytpy jhqfshfNt epiy nfhzLssd. gpizffggll epiyapy css mZffspd ,ej epiyahdJ mZffspd eLepiy vdggLk.

jputqfs;

jpzkgnghUSfF ntggk Nghdw vej Gw MwwYk mspffgglhj NghJ mZffSfF ,ilNa css gpizggpd fhuzkhf mJ njhlheJ jpzkkhfNt ,UfFk. ntggggLjjpdhy jpzkjjpy css mZffs ntgg Mwwiyg ngwW mtwwpd eLepiyfis nghWjJ mjphTWfpdwd. jpzkkhdJ mjd cUFepiyfF Nky

ntggggLjjggllhy› ntgg Mwwy mZffsd gizgig KwjJtLk kwWk ,Wjahf mZffs NghJkhd Mwwiyg ngwW Rwwj jhAk. ,eeiyaYk %yf$WfSfF (myyJ mZffSfF) ,ilNa css tirfs Kffakhdjhf mikfdwd. Mdhy %yf$Wfs NghJkhd Mwwiyfnfhz L efhtjhy ,jd tbtk ,aqff $bajhf Mfwj.

thAf;fs;

xU jutkhdJ khwh mOjjjjy mjd nfhjeiyfF ntggggLjjggllhNyh› myyJ xU khwh ntggeiyay mjd mOjjk Fiwffggllh Nyh mJ thAthf khWk. jutkhdJ thAthf khWk ,ejr nray Kiw Mtahjy vdggLk. thA %yf$Wfs kfTk tYtww gizgGfisf nfhzbUfFk myyJ gizgGfNs ,UffhJ. vdNt thAthdJ mjd nfhsfydd tbtjjwF ,zqf thtileJ nfhsfyid eugGk. jzkjjyUeJ jutk kwWk jutjjyUeJ thA eiyfF Gw Mwwy khWghlLld eiykhwwk miltijg jll tiuglkhf fhzgffggllLssJ.

gUgnghUsd %dW ,ayG eiyfSld (jzkk› jutk kwWk thA) Nrhj J mjj #oeiyfsy› gUgnghUshdJ gw eiyfshd gsh]kh› Ngh] - Id]Bd thAggzG Mfa eiyfsYk cssJ. $Ljy eiyfshd Fthhf - FSthd gsh]kh Nghdw eiyaYk cssjhff fUjggLfwJ. mzljjy css mZffshy Md gUgnghUsd ngUkgFjahdJ ntgg gsh]khthf› mhjhd tzkd jus kwWk mlhjjahd tzkdfisf nfhzLssJ.

eAlldd ,aejutaiyf fwgjy (njhFj 1) ehk nghUsfisg Gss eiwfshfNth myyJ xOqfhd jzkg nghUsfshfNth (Gss eiwfsd njhFgG) fUjNdhk. ,it ,uzLNk ,ylra khjhfs. jzkg nghUsfsy› nghUsfsd tbtjjy VwgLk khwwqfs Gwffzffjjff mstwF kffFiwthf ,UfFk. czikahd nghUsfsy› nghUsd kJ xU tir nrYjjggllhy› cUfFiyT VwgLk. cUfFiytfFk tir nrYjjggllhy nghUsfs vtthW khwwkilAk vdgij mweJ nfhss Ntzba J kf Kffakh Fk.

nghUs;fsd; klr;rggz;G:

xU jzkgnghUsy mZffSfF ,ilNa css tirfshdJ ,uzL myyJ mjwF Nkwgll mZffis xdwhfg gizjJssJ› kwWk mZffs cWjr rkeiyffhd ,lqfsy mikejUfFk. nghUsd kJ cUfFiytfFk tir nraygLk NghJ› mZffs neUffkilfdwd myyJ tyffkilfdwd. cUfFiytfFk tir effggllTld mZffSfF ,ilNaahd fthrr myyJ tyfF tir mZffis mjd rkeiyfSfF ksf nfhzL tUk. xU nghUshdJ cUfFiytfFk tir effggllTld mjd njhlff tbtk kwWk mstid ksgngwwhy mJ klrgnghUs MFk. kwWK ,ggzG klrggzG (Elasticity) vdggLk. nghUsd msT myyJ tbtjij khwwa tir cUfFiytfFk tir vdggLk.

vLjJffhlLfs: ,uggh› cNyhfqfs› v/F faWfs.

klr;raww gz;G (Plasticity):

xU nghUshdJ cUfFiytfFk tir effggllTld jdJ njhlff tbtk kwWk msit ksg ngwtyiy vdy mgnghUs klraww nghUs MFk. ,ggzG klraww gzG vdggLk.

vLjJffhlL: fz zhb

jifT kwWk; jhG (Stress and strain):

jifT:

xU tpir nrYjjggllhy mZffs myyJ %yf$Wfspd rhhG epiyfspy VwgLk khwwjjpdhy nghUspd msT myyJ tbtk myyJ ,uzLk khwyhk. ,ej cUfFiyit ntWk fzzhy fhz ,ayhtpllhYk mgnghUspDs cUfFiyT ,UfFk. xU nghUs cUfFiytpfFk tpirfF clgLjjggllhy› kstpir vdggLk mftpir mjDs cUthfpwJ. xuyF guggpy nraygLk tpir jifT vdggLk.

$$\text{jifT } s = \frac{\text{tpir}}{\text{gugG}} = \frac{F}{A}$$

jiftpd SI myF Nm^{-2}myyJ gh]fy (Pa) kwWk mjd ghpkhzk ($ML^{-1}T^{-2}$] MFk. jifT xU nldrh (Tensor) MFk.

1. **elrpjjifT kwWk rWfFgngahrrpj jifT** (Longitudinal stress and shearing stress): XU ngUisf fUJNthk. gy tpirfs mikggpy (nghUspy) nrayglhy epiwapd ikak khwhky ,UfFk. vdpDk ,ej tpirfshy nghUs cUfFiyeJ mjdhy mftpirfs NjhdWfpdwd. nghUspd FWfFntlLggugG ΔA vdf. cUfFiytpd fhuzkhf ΔA ,d ,U gffqfspYk css nghUspd gFjp $\ddot{F}$ kwWk -$\ddot{F}$ vdw mftpirfis xdWfnfhdW nrYjJfpdwd. tpiria ΔA guggpwF nrqFjjhf F_n kwWk ΔA guggpd njhLtiu jpirapy F_t vdw ,U $Wfshfg gFffyhk. guggpd topNa nrqfjJjjifT myyJ elrpjjifT (σ_n) MdJ.

$$s_n = \frac{F_n}{\Delta A}$$

vd tiuaWffggLfpwJ. ,JNghdNw guggpd topNa njhLtiu jifT myyJ rWfFg ngahrrpj jifT (σ_t)

$$s_t = \frac{F_t}{\Delta A}$$

vd tiu aWffggLfpwJ.

elrpjjiftpid ,Otpirjjif T kwWk mKffjjifT vd ,U tifahfg ghpffyhk.

1. **,Otpirjjif T** (Tensile stress):

   ΔA ,d ,U gffqfspYk mftpirfs xdiwnahdW ,Offyhk. mjhtJ mJ rkkhd vjpnujpuhd tpirfshy ,OffggLfpwJ. ,ej elrpjjifT ,Otpirjjif T vd mioffgglfpwJ.

2. **mKf;fj;jif** (Compressive stress):

   ΔA ,d ,U gffqfspYk nraygLk tpirfs xdiwnahdW jsspdhy› mjhtJ mjd ,U Kidfspyk rkkhd vjpnujpuhd tpirfshy jssggLfpwJ vdwhy ΔA mJ mOffjjpwF clgLfpwJ. jwNghJ elrpjjifthdJ mKffjjifT vd mioffggLfpwJ.

3. **gUkj; jifT** (Volume stress):

   xU nghUspd kJ mjd guggpy css midjJg gFjpfspYk guggpwFf Fjjhf tpirfs nrayglhy Nkwguggpy tpirapd msthdJ guggpwF Nehjftpy mikfpwJ. cjhuzkhf› xU jpzkg nghUshdJ xU ghakjjpy %ofpdhy› nghUspd kJ nraygLk mOjjk Pvdpy vej xU gugG ΔA ,y nraygLk tpir

   $$F = P \Delta A$$

   ,qF›F MdJ guggpwF nrqFjjhf cssJ. vdNt› XuyF guggpy nraygLk tpir gUkjjifT vdggLfpwJ.

$$s_v = \frac{F}{A}$$

,J mOjjjjwFr rkkhFk.

jhG (Strain):

jhG vdgJ tir nraygLjjggllhy xU nghUs ellggLk myyJ cUfFiyAk msthFk. nghUsd msty rwa khwwk VwgLtij jhG ifahsfwJ. mjhtJ cUfFiyAk msit jhG mstLfwJ. cjhuzkhf› xU ghkhz efotpy /esKss xU fkgiaf fUJf. mJ Δlesk ellgllhy

$$\text{jhG } e = \frac{\text{ghkhz khwwk}}{\text{cz ikahd ghkhzk}} = \frac{Dl}{l}$$

,J ghkhzkww kwWk myF mww msT MFk. jhghdJ %dW tiffshf tifggLjjggLfwJ.

elr;rj;jhG (Longitudinal strain):

/vdw esk nfhzl xU fkgahdJ rkkhd› vjnujh jirfspy nraygLk tirfshy ,OffggLk NghJ› mjd elrjjhG

$$e_1 = \frac{\text{fkgay mjfhffFk esk}}{\text{fkgad cz ikahd esk}} = \frac{Dl}{l}$$

elrjjhG ,U tifggLfwJ.

1.

i. **,Otirj;jhG** (Tensile strain): ,ayghd mstyUeJ esk mjfhffggllhy mJ ,Otirjjhg vdggLk.

ii. mKffjjhG (Compressive strain): ,ayghd mstyUeJ esk Fiwffggllhy mJ mKffjjhG vdggLk.

2. **rWf;Fg; ngahrr;rj;jhG** (Shearing strain):

xU fd rJujijf fUJf. nghUshdJ ,lngahrr kwWk Rowr rkepiyapy cssjhff fUJNthk. ,y fhlbAsthW fdrJuk cUfFiyAkhW AD topNa F vdw njhLtay tiria nrYjJNthk. vdNt rWfFgngahrrjjhG myyJ rWfFgngahrr (*e*$_s$)

$$e_s = \frac{AA'}{BA} = \frac{x}{h} = \tan q$$

rwa Nfhz kjggwF› $\tan q \approx q$

vdNt rWfFgngahrrj jhG myyJ rWfFg ngahrr

$$e_s = \frac{x}{h} = q = \text{ rWfFg ngahrr Nfhzk}$$

gUkj;jhG (Volume strain):

xU nghUshdJ gUkjjifTfF clgLjjggllhy mjd gUkd khWk. nghUsd njhlff gUkd jifTfF Kd V vdTk jiftdhy ,Wj gUkd V+ΔV vdTk nfhsf. gUkdpy VwgLk rwa khWghlil mstLk gUkj jhit fofzlthW Fwggplyhk.

$$\text{gUkj jhG› } e_v = \frac{DV}{V}$$

kl;rp vy;iy (Elastic Limit):

cUfFiytfFk tirfs effggll gwF nghUshdJ mjd njhlff msT kwWk tbtjij ksg ngwf$ba jiftd ngUk kjgG klrp vyiy vdggLk.

cUfFiyt‰fFk t‰ir klr‰ vyiyia t‰l mj‰fkhdhy› nghUshdJ e‰ueju cUfFiyit milAk. cjhuzkhf› ,uggh glil k‰f mj‰fkhf ,Offggllhy mjd klr‰ggz ig ,off‰wJ. mjd msT khw‰t‰Ltjhy kzLk gadgLjj jFj‰awwjhf‰wJ.

`{f; t‰j‰ kw‰Wk; mjd; Nrhjid Kiw rh‰ghh‰gG

`{ft‰j‰: "r‰w‰a mst‰yhd cUfFiyt‰wF› jifT kwWk j‰h‰G xdWfnfhdW Neht‰f‰jjj‰y cssJ'. ,jid O vdw e‰iyahd Gss‰a‰y njhqft‰lggll LesKk›A vdw ruhd FWfF ntlLggugGk nfhzl xU nkyy‰a fkg‰ia elr‰ailar (RUst‰y NghdW elr‰ailAk) nratjd %yk vs‰ikahfr rh‰ghhffyhk. fkg‰a‰d kwnwhU Kida‰y xU jlL kwWk xU Fw‰Ks ,izffgglLssd. fkg‰a‰y cUthFk elr‰ xU nthd‰ah msTNfhy mikgg‰idg gadgLjj‰ mst‰lggLf‰wJ. Nrhjida‰y‰UeJ nfhLffggll F vdw xU gSt‰wF fkg‰a‰y cUthd elr‰ ΔL MdJ mjd njhlff esk LwF Neht‰f‰jjj‰Yk mjd FWfFntlLg gugg‰wF (A) vj‰ht‰f‰jjj‰Yk cssJ. F I X– mrr‰Yk›ΔL - I Y– mrr‰Yk nfhzL xU tiuglk tiuaggLf‰wJ. mJ fhlbAssthW Mj‰gGss‰ to‰Na nryYk xU Neh NfhlhFk.

vdNt›

$$\Delta L \text{ (rhaT) F}$$

V = AL vdw gUkdhy ngUffTk› tFfffTk nraa

$$F \text{ (rhaT)} = \frac{AL}{AL} DL$$

khww‰aikff ehk ngWtJ

$$\frac{F}{A} = \text{æ} \frac{L}{\text{rhaT}} \text{ö} \frac{DL}{L}$$

vdNt›$\frac{F}{A} \mu$ æ$\frac{DL}{L}$ ö

rkdghLfs kwWk xgg‰l ehk ngWtJ

$$s \mu e$$

mjhtJ klr‰ vyiya‰y jifthdJ j‰h‰GfF Neht‰f‰jjj‰y cssJ.

jifT – j‰h‰G t‰tugglk; (Stress – Strain Profile):

jifT – j‰h‰G t‰tugglk vdgJ xtnthU gS kj‰gg‰wFk jifT kwWk j‰h‰G mst‰lggll j‰h‰ia X– mrr‰Yk› jifit Y– mrr‰Yk nfhzL tiuaggll xU tiuglk MFk. nghUsfs‰d klr‰ggzGfis jifT – j‰h‰G t‰tuggljj‰y‰UeJ gFgghaT nraayhk.

1. **gFj‰** OA

,ejg gFj‰a‰y jifthdJ j‰h‰GfF Nehjjft‰y ,UfFk tifa‰y jifthdJ k‰fTk Fiwthf cssJ. mjhtJ `_f t‰j‰fF clgLf‰wJ. Gss‰ A MdJ t‰f‰j vyiy vdggLk. Vnddwhy ,ej Gss‰fF Nky `_f t‰j‰ nghUejhJ. OA Nfhlbd rhaT fkg‰a‰d aq Fzfk MFk.

2. **gFj‰** AB

jifthdJ k‰f Fiwthd msT mj‰fh‰ffggllhy ,ejg gFj‰ milaggLf‰wJ. ,ejg gFj‰a‰y jifthdJ j‰h‰GfF Neujjft‰y ,yiy. Mdhy› elr‰ t‰ir effggllhy fkg‰ahdJ mjd njhlff esjj‰wFj j‰UkGk. ,ejg gzG BGss‰a‰y Kbtilf‰wJ. vdNt B Gss‰ t‰isTgGss‰ (klr‰ vyiy) vdggLk. jifT – j‰h‰G tiugljj‰y OBA MdJ nghUs‰d (,qF fkg‰) klr‰ggzigf Fw‰ff‰wJ.

3. **gFj;** BC
fkg;ahdJ Gss; (B) fF (klr; vyiy) Nky ellggLkhdhy› jifT mj;fh;ffwJ kwWk fkg;ahdJ elr; t;ir effggLk NghJ jdJ Mukg esjij kzLk ngwhJ.

4. **gFj;** CD:
jifthdJ C fF mgghy mj;fh;ffggllhy›j;h;G k;f t;iuthf mj;fh;jJ Gss; D I milAk. D fF mgghy fkg;ahdJ vej gSTk Nrhffgglhk NyNa ezL nfhzNl nrdW Gss; E ,y Kw;fwJ. vej ngUkjjift;wF (,qF D) mgghy fkg; Kw;tilf;wNjh mej jifT Kw;TjjifT myyJ elr; ty;ik (tensile strength) vdggLk. mjwFh;a Gss; (D) Kw;TgGss; vdggLk. BCDE gFj; fkg;g nghUs;d klr;awwj jdikiaf Fw;ffwJ.

kl;rf;Fzfq;fs; (Moduli of elasticity):
`{f t;j;ay;UeJ xU nghUs;y jifahdJ k;frr;wa cUfFiyt;d NghJ njhlhGila j;h;GfF Neht;f;jjjy cssJ. ,gghlggFj;ay; ehk nfhLffggll nghUs;d klr;fFzfjij tiuaWffyhk. %tif klr;fFzfqfs cssd.

1. aq Fzfk
2. gUkf Fzfk
3. t;iwgGf Fzfk (myyJ rWfFg ngahrr;f Fzfk)

aq; Fzfk; (Young's modulus):

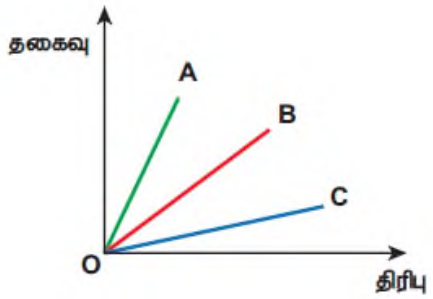
xU fkg;ahdJ elbffggllhy myyJ mKffggllhy ,Ot;irj jift (myyJ mKffjjifT) kwWk ,Ot;irjj;h;T (myyJ mKffjj;h;G) Mf;atwWfF ,ilNa css t;f;jk aq Fzfk vd tiuaWffggLf;wJ.

$$Y = \frac{\text{,Ot;irj jifT myyJ mKffjjifT}}{\text{,Ot;irj j;h;T myyJ mKffj j;h;G}}$$

$$Y = \frac{s_t}{e} \quad or \quad Y = \frac{s_c}{E}$$

aq Fzfjj;d myF jift;d myNf MFk. Vnddwhy j;h;GfF myF ,yiy. vdNt aq Fzfjj;d SI myF Nm^{-2} myyJ gh]fy.

klr; vyiyfFs jift;dhy A, B kwWk C vdw fkg;fs;y cUthd elr;jj;h;Gfs gljjy; fhllgglLssJ. rkkhd gS nrYjjggllj;hff nfhzL fkg;g nghUsfs;d klr;g gzGfis t;thj;ffTk. klr;f Fzfqfis VWth;ira;y vOJf.



j;hT:
,qF klr;f Fzfkhdj aq Fzfk MFk. elr;a;d fhuzkhf jifT ,Ot;irj jifthfTk j;h;G ,Ot;irj j;h;ghfTk cssd.

klr vyiyfFs jifthdJ jhGff Neht fjjjy cssJ (`{f tjfF clglL) Mifahy tiuglk NehfNfhlhf cssJ. vdNt klrfFzfjij (,qF aq Fzfk) NehfNfhlbwF rhaT vLggjd %yk fhzff lyhk. rhaitf fzff l ehk ngWtJ

A ad rhaT >B ad rhaT >C ad rhaT ,jd %yk mwaggLtJ›
A ad aq Fzfk <B ad aq Fzfk <A ad aq Fzfk

,qF rhaT mjfkhf ,Uggd jhG Fiwthf (esjjy rwa khwwk) ,UfFk. nghUs mjf tiwgghf ,UfFk. vdNt› fkg A - ,d klrggzG MdJ› fkg B kwWk fkg C - ,d› klrggz igtl mjfkhfTk ,UfFk. ,ej cjhuzjjyUeJ ehkGheJ nfhstJ aq Fzfk vdgJ jzkg nghUs jdJ esjij khww VwgLjJk jilad msthFk.

10m esKss xU fkgahdJ $1.25 \times 10^{-4}\ m^2$ FWfFntlLg gugigf nfhzLssJ. mJ 5 kg gStwF clgLjjggLfwJ. fkgg nghUsd aq Fzfk $4 \times 10^{10}\ Nm^{-2}$ vdy fkgay cUthd elriaf fzffLf. ($g = 10\ ms^{-2}$ vdf nfhsf)

jhT:

$$\frac{F}{A} = Y' \frac{DL}{L}$$

vdNt› cUthd elr

$$DL = \left(\frac{F}{A} \div \frac{L}{Y}\right)$$

$$= = \left(\frac{50}{1.25' 10^{-4}} \div \frac{10}{4' 10^{10}}\right) = 10^{-4} m$$

gUkf; Fzfk (Bulk modulus):

gUkjjifTfFk gUkjjhGfFk ,ilNa css tfjNk gUkf Fzfk vd tiuaWffggLfwJ.

$$K = \frac{\text{nrqFjJ jifT myyJ mOjjk}}{\text{gUkj jhG}}$$

nrqFjJj jifT myyJ mOjjk

$$s_n = \frac{F_n}{DA} = Dp$$

gUkjjhG $e_v = \frac{DV}{V}$

vdNt gUkf Fzfk

$$K = \frac{s_n}{e_v} = - \frac{DP}{\frac{DV}{V}}$$

rkdghL ,y css vjhfFwad nghUshdJ nghUsd kJ mOjjk nraygllhy mjd gUkd Fiwfwj vdgijf Fwffwj. NkYk rkdghL FwggJ ahnjdy xU nghUs rwa gUkf Fzf kjgigf nfhzbUejhy mJ vsjhf mKffgglyhk. khwhf› gUkfFzfk vdgJ jzkg nghUsfs mtwwd gUk khwwjij vjhfFk msthFk. cjhuzkhf›thAffs jzkgnghUsfistl vsjhf mKffgglyhk vdgij ehk mwNthk. mjd nghUs thAffs jzkgnghUsfSld xggl Fiwthd gUkfFzf kjgigf nfhzLssd vdgjhFk. K ,d SI myF mOjjjjd myNf MFk. mjhtJ Nm^{-2} myyJ Pa (gh]fy)

mKf;fj;jd;ik (Compressibility):

gUkfF z fjjpd jiyfo 'mKffjjdik" vdggLk. mJ xuyF mOjj cahTfF gUkdpy VwgLk rpwpa khwwk vd tiuaWffggLfpwJ.

kpjpt zbapd laUfF fhwW epuggpa cldmJ NghJkhd msT cssjh vd ehk mjid mOjjpg ghhffpNwhk. czikapy ,qF NrhjpjJgghhggJ fhwwpd mKffjjdikNa MFk. lauhdJ mjd vspjhd cUSjYfF Fiwthf mKqFtjhf ,Uff Ntz Lk.

czikapy kjpt zbapy ,yFthf gazk nraa gpdgff lah Kdgff laiutpl Fiwthf mKqFtjhf ,Ujjy Ntz Lk.

mKf;fj;jd;ik:

$$C=\frac{1}{K}=\frac{e_v}{s_n}=-\frac{\frac{DV}{V}}{DP}$$

thAffs jpzkqfis tpl Fiwthd gUkf Fzfjijf nfhzbUggjhy thAffspd mKffjjdik kpf mjpfk.

vLjJffhlL:

100 cm gffjijf nfhzl xU cNyhf fdrJuk mjd KO gffqfspYk nraygLk ruhd nrqFjJ tpirfF clgLjjggLfpwJ. mOjjk 10^6gh]fy. gUkd $1.5\times10^{-5}m^3$vdw msT khWghL milejhy› nghUspd gUkfFzfjijf fzffpLf.

jhT:

tiuaiwggb›

$$K=\frac{\frac{F}{A}}{\frac{DV}{V}}=P\frac{V}{DV}$$

$$K=\frac{10^6\acute{}1}{1.5\acute{}10^{-5}}=6.67\acute{}10^{10}\,Nm^{-2}$$

tpiwgGf; Fzfk; myyJ rWf;Fg; ngahr;rpf; Fzfk; (The rigidity modulus or shear modulus):

rWfFg ngahrrpj jiftpwFk rWfFg ngahrrpj jphpGfFk css tpfpjk tpiwgGfFzfk vd tiuaWffggLfpwJ.

$$h_R=\frac{\text{rWfFg ngahrrpj jifT}}{\text{rWfFg ngahrrpf Nfhzk myyJ rWfFgngahrrpj jphpG}}$$

$$s_s=\frac{\text{njhLtiu tpir}}{\text{mt tpir nrYjjggll gugG}}=\frac{F_t}{DA}$$

vdNt tpiwgGfFzfk

$$h_R=\frac{s_s}{e_s}=\frac{\frac{F_t}{DA}}{\frac{x}{h}}=\frac{\frac{F_t}{DA}}{q}$$

NkYk rkdghL Fwpggj› xU nghUshdJ Fiwej msT tpiwgGfFz fjijf nfhzbUejhy mjid vspjhf KWffyhk. cjhuzkhf› xU fkgpiaf fUJf mjid θ Nfhzk KWfpdhy xU ks jpUgG tpir cUthfpwJ.

mjhtJ

$$t \mu q$$

jpUgG tpir mjpfnkdpy› fkgpia mjpf Nfhz msTfF KWff ,aYk (rWfFgngahrrpf Nfhzk θ mjpfk). tpiwgGfFz fk rWfFgngahrrpf Nfhz jjpwF vjhtpfpjjjy njhlhGilajhf ,Uggjhy› tpisgGfFz fk rpwjhf cssJ. tpiwgGfFz fjjpd Sl myF mOjjjjpd myfhFk. mjhtJ›Nm^{-2}myyJ ghlfy. ,fnfhsifia rhptug GhpeJnfhsSk tifapy› rpy Kffpakhd nghUsfspd klrpfFz fqfs juggllssd.

rpy nghUsfspd klrpfFz fqfs Nm^{-2} ,y

nghUs;	aq; Fz fk; (Y) ($10^{10}Nm^{-2}$)	gUkf;Fz fk; (K) ($10^{10}N\,m^{-2}$)	tpiwgGf; Fz fk; myyJ rWf;Fg; ngahr;rpf;Fz fk; (η_g) ($10^{10}Nm^{-2}$)
v/F	20.0	15.8	8.0
mYkpdpak	7.0	7.0	2.5
jhkpuk	12.0	12.	4.0
,UkG	19.0	8.0	5.0
fz zhb	7.0	3.6	3.0

0.20 m gffjijf nfhzl xU cNyhf fdrJuk 4000 N rWfFgngahrrp tpirfF clgLjjggLfpwJ. NkwgugG mbggugigg nghWjJ 0.50 cm ,lngahrrp milfpwJ. cNyhfjjpd rWfFg ngahrrpf Fzfjijf fzffpLf.

jhtT

,qF L = 0.20, F = 4000 N, x = 0.50 cm = 0.005 m

kwWk gugG $A = L^2 = 0.04\ m^2$

vdNt rWfFg ngahrrpf Fz fk

$$h_R = \frac{F}{A} \div \frac{L}{x} = \frac{4000}{0.04} \div \frac{0.20}{0.005} = 4 \times 10^6\ Nm^{-2}$$

ghanrha; tpfpjk;

ehk xU fkgpia elrpailar nratjhff fUjpdhy mjd esk mjpfhpffpwJ. (elrp). Mdhy tpllk Fiwfpwj (FWffk) mJNghdNw ehk xU ,uggh glilia elrpailar nrajhy (elrp) mJ Fwpggpljjff msT nkyypajhfpwJ (FWffk). mjhtJ nghUspd xU jpirapyhd rhFiyT kwnwhU jpirapy rhFiyit cUthfFfpwJ. ,jid mstpl gpugQr ,awgpayhsh v]b. ghanrha vdgth ghanrha tpfpjk vd mioffggLk xU tpfpjjij Kdnkhopejhh. 'XgGikf FWffjjpwFk (gfftholLjjhpG) xgGik tphpthffjjpwFk (epsthlLjjhpG) ,ilNa css tpfpjk" vd mJ tiuaWffggLfpwJ. mjd FwpaL μ MFk.

$$\text{ghan]d tpfpjk } m = \frac{\text{gfftholLj jhpG}}{\text{esthlLj jhpG}}$$

LesKk D tpllKk nfhzl xU fkgpay nrYjjggll tpirapdhy fkgp elrpailejhy› es mjpfhpgG /vdTk tpljjpy FiwT dvdTk nfhzlhy›

$$m = -\frac{\frac{d}{D}}{\frac{l}{L}} = -\frac{L}{l}\times\frac{d}{D}$$

vjhfFwahdJ esthlby elrAk› gfffthlby FWffKk cssijf Fwffwj. NkYk ,J rk ghkhzqfisf nfhzLss msTfsd tfjkhFk. vdNt ghanratfjk myfwwJ kwWk ghkhzkwwJ (ghkhzkww vz) MFk. ry nghUsfsd ghanrha tfjkjgGfs nfhLffgglLssd.

ry nghUs;fsd; ghan;rha; tf;fjq;fs;

nghUs;	ghan;rha; tf;fjq;fs;
,uggh	0.4999
jqfk	0.42 – 0.44
jhkuk	0.33
JUggbffhj v/F	0.30 – 0.31
v/F	0.27 – 0.30
thhgG ,UkG	0.21 – 0.26
fhdf;hl	0.1 – 0.2
fz zhb	0.18 – 0.3
Eiu gQR	0.10 – 0.50
jfif	0.0

kl;r; Mwwy; (Elastic energy):
xU nghUis elrailar nrajhy kstirfF (mftir) vjuhf Ntiy nraaggLfwJ. nraaggll ,ej Ntiy nghUsDs kl; Mwwyhf Nrkffgg Lfwj. ellgglhj eiyay LesKk A FWfFntlLg gugGk nfhzl xU fkgiaf fUJf. xU tir /vdw elria cUthfFtjhff nfhsf. fkgad kl; vyiy jhzlggltyiy vdTk Mwwyy ,ogG ,yiy vdTk nfhsf. vdNt F vdw tiradhy nraaggll Ntiy fkg ngwWss MwwYfF rkkhFk.
fkgahdJ d/ msT elrailAk NghJ nraaggLk Ntiy

$$dW = Fd/$$

O Kjy / tiu fkg elrailа nraaggll Ntiy

$$W = \int_0^l F\,dl$$

aq Fz fjjy;UeJ

$$Y = \frac{F}{A}\times\frac{L}{l} \Rightarrow F = \frac{YAl}{L}$$

$$W = \int_0^l \frac{YAl}{L}\,dl$$

njhifa;lyy /vdgJ ntwW khw; (dummy variable) vdgjhy ehk / vdgij (vyiyfsy myy) vd khww

$$W = \int_0^l \frac{YAl'}{L}\,dl' = \frac{YA}{L}\left(\frac{l'^2}{2}\right)_0^l = \frac{YA}{L}\frac{l^2}{2} = \frac{1}{2}\left(\frac{YAl}{L}\right)l = \frac{1}{2}Fl$$

$$W = \frac{1}{2}Fl = \text{klr; eiy Mwwy}$$

XuyF gUkdy css Mwwyhdj Mwwy mlhjj; vdggLk.

Mwwy mlhjj

$$u = \frac{\text{klr eiy Mwwy}}{\text{gUkd}} = \frac{\frac{1}{2}Fl}{AL}$$

$$\frac{1}{2}\frac{F}{A}\frac{l}{L} = \frac{1}{2} \quad \text{(jifT} \times \text{jhG)}$$

2 m esKk $10^{-6} m^2$ FWfF ntlLg gugGk nfhzl xU fkgay 980 N gS njhqftlggllLssJ.

i. fkgay cUthd jifT

ii. jhG kwWk

iii. Nrkffggll Mwwy Mfatwiwf fzffLf.

nfhLffggllJ. $Y = 12 \times 10^{10} Nm^{-2}$

jhT:

i. $\text{jifT} = \frac{F}{A} \frac{980}{10^{-6}} = 9810^{7} \acute{} \; Nm^{-2}$

ii. $\text{jhG} = \frac{\text{jhG}}{Y} \frac{98 \acute{} 10^{7}}{12 \acute{} 10^{10}} = 8.17 \acute{} 10^{-3}$

(myfwwJ)

iii. gUkd $2 \times 10^{-6} m^3$

$$\text{Mwwy} = \frac{1}{2} \text{ (jifT} \times \text{jhG)} \times \text{gUkd Þ}$$

$$\frac{1}{2}(98 \acute{} 10^{7}) \acute{} (8.17 \acute{} 10^{-3}) \acute{} 2 \acute{} 10^{-6} = 8 \text{ [{y}}$$

klrggzgd; gadghLfs;

nghUsfsd ,aejutay gzGfs mdwhl thotiy Kffa gqF tfffwJ. mtwwy xdwhd klrggzG flblqfsd J}zfs kwWk tllqfsd flLkhd tbtikgig KbT nrafwJ. flLkhdg nghwaaiyg nghUjjtiu xU tbtikgG jhqff$ba jiftd msthdJ Kjdikahd ghJfhgGj fhuzahFk. xU ghykhdJ mjd kJ nryYk NghfFtujjd gS› fhwwd tir kwWK ghyjjd vil Mfatwiw jhqFk tifay tbtikffggl NtzLk. klrggzG myyJ tllqfsd tisT vdgJ flblqfs kwWk ghyqfsd cWjjjdikay Kffa gqfhwWfwJ. cjhuzkhf nfhLffggll xU gStwF tlljjjd tisitf Fiwff mjf aq Fzfk (Y) kjgGss nghUisg gadgLjj NtzLk. v/fd aq Fzfk mYkdak myyJ jhkujij tl mjfkhFk vdj njsthfwJ. ,UkG› v/FfF mbjjgbahf cssJ. v/F fduf ,aejuqfis tbtikffTk› ,UkGffkgfs flblqfs flLtjwFk mjfkhf gadgLjjggLtjwF ,JNt fhuzkhFk.

v/if tl ,ugghjhd mjf klrAilaJ vdW ehk jtwhf eidjJf nfhzbUffNwhk. vJ mjf klrggzG cilaJ? ,ugguh? v/fh? czikay v/Fjhd mjf klrggzG cilaJ. v/F kwWk ,uggh ,uzbd kJk rkkhd mOjjjij (stress) nfhLjjhy v/F Fiwthd jhigNa milAk. vdNt aq klrfFzfk v/FfFjjhd mjfk. aq klrfFzfk vejg nghUSfF mjfNkh mJNt mjf klrggzG (elacstic) cilaJ. vdNt v/F ,uggiu tl mjf klrjjdik nfhzlJ.

ghakq;fs; (Fluids):

mwKfk;

cyfjjpy midjJ ,lqfspYk ghakqfs fhzggLfpwJ. Gtp %dwpy ,uzL gqF eiuAk> %dwpy xU gqF epyggFjpiaAk nfhzLssJ. ,jidj jtpu Gtpahdj fhwwhy #ogglLssJ. ghakqfs jpzkgnghUsfspy ,UeJ khWgllit. jpzkjijgNghy myyhky ghakk tiuaWffggll Ra tbtjijf nfhzbUffhJ. ghakqfspy> jputk epiyahd gUkidf nfhzLk thAthdJ nfhsfydpd KO gUkid epuggpAk cssd.

ghakjpjpd; mOj;jk;:

ghakk vdgJ mjdkJ Gwtpir nrYjjggllhy ghaj njhlqFk nghUshFk. mJ nrYjjggll tpirfF kpffFiwej vjphgigNa mspffpwJ. Fiwthd guggpy tpir nraygllhy mjd jhffk mjpfkhfTk> mjpfkhd guggpy FiwthfTk ,UfFk. ,ej fUjjhdJ mOjjk vdggLk xU msit cWjpggLjJfpwJ. xU nghUshdJ xatpy css xU ghakjjpy (eh) %ofpAssjhff fUJf. ,eNehtpy ghakk nghUspd Nkwgugg py xU tpiria nrYjJk. ,ej tpir vgNghJk nghUspd guggpwF nrqFjjhf cssJ. A vdw Nkwgugg py nraygLk nrqFjJ tpirapd vzkjpgG F vdpy> XuyF gugg py nraygLk tpirNa mOjjk vd tiuaWffggLfpwJ.

$$P = \frac{F}{A}$$

mOjjk xU]Nfyh msthFk. mjd SI myF kwWk ghpkhzqfs KiwNa Nm^{-2} myyJ gh]fy (Pa) kwWk MFk. mOjjjjpd kwnwhU nghJthd myF 'atm' vdf Fwpffggk fhwwOjjk MFk. mJ fly kljjpy fhwW kzlyjjpd mOjjk vd tiuaWffggLfpwJ. mjhtJ> 1 atm = 1.013×10^5 Pa or Nm^{-2} mOjjjijj jtpu NtW ,U gzgsTfshd mlhjjp kwWk xgglhjjp Mfpaitak ghakqfspd ,ayig tpthpff gaDssjhf cssd.

ghakjpjpd; mlhjjp:

xU ghakjjpd mlhjjp vdgJ mjd XuyF gUkDffhd epiw vd tiuaWffggLfpwJ. 'V' gUkidf nfhzL m epiwAss ghakjjpd mlhjjp $\rho = m/V$. ,jd SI myF kwWk ghpkhzk KiwNa kgm^{-3} kwWk [ML^{-3}] MFk. ,J xU NehfFwp kjpgGss]Nfyh msthFk. ngUkghYk jputk mKffggl ,ayhj xdW vdgjhy fhwwOjjjjpy (1 atm mOjjjjpy) mjd mlhjjp VwfFiwa khwpy MFk. thAffspy mOjjjijr rhheJ mlhjjpfspy khWghLfs cssd.

xgglhjjp (Relative density or specific gravity):

xU nghUspd xgglhjjp vdgJ mejg nghUspd mlhjjpfFk 4°C y ehpd mlhjjpfFk ,ilNa css tfpjk vd tiuaWffggLfpwJ. ,J xU ghpkhzkww NehfFwp kjpgGss]Nfyh msthFk. cjhuzkhf> ghjurjjpd mlhjjp 13.6×10^3 kgm^{-3}.

mjd xgglhjjp $\frac{13.6' 10^3 kgm^{-3}}{1.0' 10^3 kgm^{-3}} = 13.6$

xU jpzkfNfhsk 1.5 cm MuKk 0.038 kg epiwAk nfhzLssJ. jpzkf Nfhsfjjpd xgglhjjpiaf fzffpLf.

jhT:

Nfhsjjpd Muk R = 1.5 cm

epiw m = 0.038 kg

Nfhsfjjpd gUkd $V = \frac{4}{3} pR^3$

$= \frac{4}{3}' (3.14)' (1.5' 10^{-2})^3 = 1.413' 10^{-5} m^3$

vdNt> mlhjjp

$$r = \frac{m}{V} = \frac{0.038kg}{1.413' 10^{-5} m^3} = 2690kg\,m^{-3}$$

vdNt› Nfhsfjjpd xggLhjjp

$$= \frac{2690}{1000} = 2.69$$

Xatpy; cs;s ghakjjkgjjpdhy; mOjjk:

kiykJ VWk xU kiyNaww tuh caujijg nghWjJ fhwwpd mOjjk Fiwtij czu ,aYk. erry Fsjjpy FjpfFk xUth euggugGfF fNo Mokhf nryYkNghJ ehpd mOjjk mjpfhpggij czhfpwhh. ,ej ,U NehTfspYk› kiyNaww tuh kwWk erry tuh vjpnfhzl mOjjkhdJ epiyahf css ghakqfspd ehk epiy mOjjkhFk. ehpd Mojijg nghWjJ mOjjkl mjpfhpggijg GHpeJnfhss cUis tbtpy css A FWfFntlLggugG nfhzl eh khjphpiaf fUJf.

$h_1$kwWk h_2 vdgit KiwNa cUisapd kllk 1 kwWk 2 Mfpaitfs fhwW – eh ,ilggFjpapypUeJ css Moqfs vdf. kllk 1 ,y nraygLk foNehffpa tpir F_1vdTk NkyNehffpa tpir F_2vdTk nfhsf. vdNt $F_1 = P_1 A$ kwWk $F_2 = P_2A$
eH khjphpapd epiw m vdf fUJf. rkepiyapy nkhjj NkyNehffpa tpir (F_2) MdJ nkhjj foNehffpa tpirahy (F_1 + mg), rkd nraaggLfpwJ. khwhf› foNehffp nraygLk Gtpahgg tpirahdJ tpirapd NtWghL F_2- F_1 My rkd nraaggLfpwJ.

$$F_2 – F_1 = mg = F_G$$

,qF m vdgJ khjphpapy css ehpd epiw. ehpd mlhjjp ρvdpy› khjphpapy css ehpd epiw

$$m = \rho V = \rho A (h_2 – h_1)$$
$$V = A (h_2 – h_1)$$

vdNt Gtpahgg tpir

$$F_G = \rho A (h_2 – h_1)g$$

W ,d kjpgig rkdghL ,y gpujpapl

$$F_2 = F_1 + mg \text{ Þ } P_2A = P_1A = \rho A (h_2 – h_1)g$$

,U Gwqfspyk A l eff

$$P_2 = P_1 + \rho(h_2 – h_1)g$$

ehk kllk 1 l ehpd Nkwgugg pYk mjhtJ fhwW – eH ,ilggFjp kllk 2 l Nkwgugg pwF fNo h Mojjpyk NjhT nrajhy $h_1$kjpgG Ropahfk (h_1 = 0) kwWk P_1 fhwwOjjjjpd kjpgigg ngWfpwJ. PaNkYk h Mojjpy mOjjk (P_2) MdJ P vdw kjpgigg ngWk. ,ej kjpgGfis rkdghL ,y gpujpapl

$$P = Pa + \rho gh$$

,jd nghUshdJ›h Mojjpy css mOjjk ehpd Nkwgugg py css mOjjjij tpl mjpfkhFk. ,qF Pavdgj fhwwOjjk kwWk mjd kjpgG 1.013 × 10^5 Pa MFk. fhwwOjjk Gwffzpffgg llhy›

$$P = \rho gh$$

nfhLffgg ll jputjjpwF khwpy ρ kwWk g kjpgGk khwpy vdNt ghakj jkgjjpdhy cUthFk mOjjkhdJ ehkjjkgjjpd cauk myyJ nrqFjJjnjhiyTfF Nehjjftpy cssJ. mOjjjij epHzak nraa ghakjjkgjjpd cauNk Kffpakhfk kwWk nfhsfydpd FWfFg gugG myyJ mbggugG myyJ tbtk Mfpatwiwr rhuhJ vdgijf Fwpffpwj.

xatpy css jputjijg gwwpf $wpdhy xNu fpilkllj jpy css midjJg Gsspfspyk (rk Mojjpy) jput mOjjk rkkhf cssJ. ,ej $wiw 'ehk epiyapay KuzghL' vdggLk A, B kwWk C Mfpa khWgll tbtqfisf nfhzl %dW fydfisf fUJNthk. ,ej fydfs mbggFjpapy xU fpiljjs Foha %yk ,izffgglLssd. ,it xU jputjjhy (eh) epuggggllhy fydfs khWgll gUkDss eiuf nfhzbUejhYk rk mstyhd ehpd kljijf nfhzbLssd. Vnddwhy xtnthU fydpd mbggFjpapy css jputk rkkhd mOjjjij czhfpwJ.

xU ,ljjpy css tspkzly mOjjk vdgJ mej ,ljjpwF Nky css fhwwpdhy xuyF Nkwgugg py nrYjjggLk Gtpahgg tpir MFk. ,J cauk kwWk thdpiy fhwwpd mlhjjp Mfpatwiw rhheJ khWfpwJ. czikapy cauk mjpfhpfFk NghJ fhwwOjjk FiwfpwJ.
caujijg nghWjJ fhwwOjjk FiwtJ mdwhl thotpy tpUkgjjfhj tpisitf nfhzLssJ. cjhuzkhf› kpf caukhd ,lqfspy rikggjwF ezl Neuk MfpwJ. fhwwOjjjjpwFk ,ujj mOjjjjpwFk ,ilNa mjpf NtWghL fhuzkhf cauk mjpfKss ,lqfspy %ffpy ,ujjk tbjy kwnwhU nghJthd epfothFk.
Gtpggugg py fly kljjpy mjd kjpgG 1 atm MFk.

gh]fy; tpjp kwWk; mjd; gadghLfs;
gpuQR mwptpay mwpQh gpnsa] gh]fy vdgth xatpy css xU ghakjjpy rk caujjpy css midjJ Gsspfspyk mOjjk rkkhf cssJ vd fzlwpejhh. gh]fy tpjpapd $wwhdJ 'xU jputjjpy css xU Gsspapy mOjjk khwpdhy mej khWghL kjpgG Fiwahky jputk KOtjwFk gugggg LfpwJ.

gh]fy; tpjpapd; gadghL
ehpay; J}ffp
gh]fy tpjpapd xU nrayKiw gadghL› Fiwthd tpiriaf nfhzL mjpf gSitjJ}ff gadgLk ehpay J}ffp (Hydraulic lift) MFk. ,J xU tpirgngUffp› ,J A kwWk B vdw xdWld xdW fpilkllf Fohahy ,izffgglL jputjjhy epuggggll xU cUisfisf nfhzLssJ mtwwpDs A_1kwWk A_2(A_2> A_1) FWfFntlLggugGfs nfhzl cuhatww g]ldfs nghUjjgglLssd. rpwpa g]ldpd kJ foNehffpa tpir F nrYjjggLtjhff nfhzlhy ,ej g]lDfF fo css jputjjpd mOjjk $P\left(\text{where}, P=\frac{F_1}{A_1}\right)$vdw kjpggpwF mjpfhpffpwJ. Mdhy gh]fy tpjpggb› ,ej mjpfhpffggll mOjjk midjJ jpirfspYk kjpgG Fiwahky gugggg LfpwJ. vdNt g]ld B- ,d kJ xU mOjjk nrYjjggLfpwJ. g]ld B– ,d kJ NkyNehffp tpir

$$F_2 = P' A_2 = \frac{F_1}{A_1}' A_2 \text{ Þ } F_2 = \frac{A_2}{A_1}' F_1$$

vdNt rpwpa g]ld A- ,d kJ css tpiria khwWtjd %yk g]ld B– ,d kJss tpirahdJ $\frac{A_2}{A_1}$vdw fhuzpapd msTfF cahjjggLfpwJ. ,ej fhuzp ehpay J}ffpapd ,aejpu ,yhgk vdggLk.

XU ehpay J}ffpapd ,U g]ldfs 60 cm kwWk 5 cm tpllqfisf nfhzLssd. rpwpa g]ld kJ 50 N tpir nrYjjgglhy nghpa g]ld nrYjJk tpir ahJ?
jhT:
g]ldfspd tpllqfs nfhLffgglLssjhy g]ldpd Muqfisf fzffplyhk.

$$r = \frac{D}{2}$$

rpwpa gp]ldpd gugG $A_1 = p\left(\frac{5}{2}\right)^2 = p(2.5)^2$

nghpa gp]ldpd gugG> $A_2 = p\left(\frac{60}{2}\right)^2 = p(30)^2$

$$F_2 = \frac{A_2}{A_1} \times F_1 = (50N) \times \left(\frac{30}{2.5}\right)^2 = 7200N$$

50 N tpiria nrYjjp 7200 N tpiriag ngwyhk. NkYk mej msT gSit cahjjyhk.

kpjf;Fk;jd;ik (Buoyancy):
xU nghUshdJ xU ghakjjpy gFjpahfNth myyJ KOtJkhfNth %ofpapUejhy mJ xU Fwpggpll msT ghakjij ,lkngaur nrafpwJ. ,lkngahej ghakk nghUspd kJ NkyNehffpa tpiriar nrYjJfpwJ. xU ghakjjpy %ofpAss xU nghUspd vilia vjphfFk ghakjjpdhy cUthffggLk NkyNehffpa tpir kpjgGtpir vdggLk. ,eepfoT kpjfFk jdik vdggLk.

Mhf;fpkpb]; nfhs;if:

,jd $wwhdJ> nghUnshdW xU ghakjjpy gFjpahfNth myyJ KOtJkhfNth %ofpapUejhy mJ ,lkngaur nraj ghakjjpd vilfF rkkhd NkyNehffpa ceJ tpiria mJ czhfpwJ kwWk ceJ tpirahdJ ,lkngahej jput <hgG ikak topahf nraygLfpwJ.
ceJ tpir myyJ kpjgG tpir = ,lkngahej jputjjpd vil

kpjj;jy; tpjp (Law of Floatation):

glFfs> fggyfs kwWk rpy kugnghUsfs ehpd NkwgFjpapy ,aqFtJ edF mwpej xdwhFk. mit kpjffpwJ vdyhk. ghakjjpd Nky kllqfSfF cahfpwepwFk xU nghUspd jdik kpjjjy vd tiuaWffggLfpwJ. 'nghUspd %ofpa gFjp ,lkngaurnraj jputjjpd vil> nghUspd vilfF rkkhdhy mejg nghUs mjjputjjpy kpjfFk" vdgJ kpjjjy tpjpahFk.

cjhuzkhf>300 kg vilAss (Vwjjho 3000 N) xU kujjhyhd nghUs ehpy kpjfFk NghJ 300 kg (Vwjjho 3000 N) eiu ,lkngaur nrafpwJ.

xU nghUs kpjejhy ,lkngahej ghakjjpd gUkd %ofpa nghUspd gUkDfF rkkhf cssJ> kwWk %ofpa nghUspd gUkdpd rjtjk nghUspd mJ kpjfFk ghakjjpd mlhjpiag nghUjj xggLhjjpff rkkhFk. cjhuzkhf 0.9 gcm^{-3} mlhjjp nfhzl xU gdpfflb 1.0gm^{-3} mlhjjp nfhzl J}a ehpy kpjejhy> ehpy %ofpa nghUspd gUkdpd rjtjkhdJ
khwhf> mNj gdpfflb 1.3 gcm^{-3}, mlhjjp nfhzl fly ehpy kpjejhy> fly ehpy %ofpa nghUspd gUkdpd rjtjkhdJ $\frac{0.9gcm^{-3}}{1.3gcm^{-3}} \times 100\% = 69.23\%$ klLNk.

vLj;Jf;fhl;L
xU kujjhyhd fd rJuk ehpy 300 g epiwia mjd NkwgFjapd ikajjpy jhqFfpwJ. epiwahdJ effggllhy> fd rJuk 3 cm caUfpwJ. fdrJujjpd gUkidf fzffpLf.

jhT:
fdrJujjpd xtnthU gffKk /vdf. 3cm Mojjw F fdrJuk epugGk gUkd

$$V = (3cm) \times P = 3P\ cm^3$$

kpjjjy tpjpggb

$$V\rho g = mg \Rightarrow V\rho = m$$

$$\Rightarrow (3P' 10^{-2}m)' (1000kgm^{-3}) = 300' 10^{-3}kg$$

$$l^2 = \frac{300' 10^{-3}}{3' 10^{-2}' 1000} m^2 \Rightarrow l^2 = 100' 10^{-4} m^2$$

$$l = 10' 10^{-2}m = 10cm$$

vdNt fd rJujjpd gUkd $V = l^3 = 1000\ cm^3$

eh %ofpffggyfs mjd kpjfFk jdikiaf flLggLjJtjd %yk eHpd Mojjw %ofyhk myyJ caNu tuyhk. ,jid mila› eh%ofpf fggyfs eH myyJ fhwwpdhy epuggf$ba epiyggLjJk njhlbfisf nfhzLssd. epiyggLjJk njhlbfs fhwwpdhy epuggggllhy RwWgGw eiutpl eh%ofpffggypd nkhjj mlhjjpahdJ FiweJ mJ Nkwgugg w F tUk (Neh kpjfFk jdik). fhwiw ntspNaww njhlbfspy eiu epuggpdhy eh%ofpffggypd nkhjj mlhjjp RwWgGw eiutpl mjpfkhfp fggy %oFk (vjph kpjfFk jdik). eh%ofpf fggiy vej xU Mojjpyk epiyewWjj› njhlbfs fhwW kwWk euhy epuggggLfpdwd (eLepiy kpjfFk jdik)

kpjfFk nghUsfSfF vLjJffhlLfs:

1. xUth MwWeiutpl fly ehpy kpf vspjhf eejyhk.
2. gdpfflb ehpy kpjffpwJ.
3. fggy v/fpdhy cUthffggLfpwJ. Mdhy mjd cggFjpapy FopT VwgLjjggLtjhy kpjffr nraaggLfpwJ.

ghFepiy (Viscosity):

mwpKfk:
xatpy css ghakqfspd jdik Fwpj tpthjpffggllJ. khWgll gzGfspy ghak ,affjjpd jhffjij NkYk tpthjpggjd %yk ntspfnfhzuyhk. xU ghakjjpd ,affk rpffyhd epfothFk. Vnddwhy mJepiy› ,aff kwWk <hgG Mwwiyf nfhzL cuhait VwgLjjp ghfpay tpirfisj NjhwWtpffpwJ. vdNt tpthjjij vspikahff xU ,ylrpa jputjjpd Nehitf fUjyhk. xU ,ylrpa jputjjpd Nehitf fUjyhk. xU ,ylrpa jputkhdJ mKff ,ayhjJ (mjhtJ gUkfFzfk Kbtpy) kwWk mjDs rWfFgngahrrp tpirfs ,UffhJ (mjhtJ ghfpay vz Rop)

ngUkghyhd ghakqfs ,affjij vjphffpdwd. xU ghakk xU jpzkjijr jputkhdJ mKff ,ayhjJ (mjhtJ gUkfFzfk Kbtpy) kwWk mjDs rWfFg ngahrrp tpirfs ,UffhJ (mjhtJ ghfpay vz Rop) ngUkghyhd ghakqfs ,affjij vjphffpdwd. xU ghakk xU jpzkjijr rhheJ ,aqfpdhy myyJ ,U ghakqfs xdWfnfhdW rhhG ,affjijf nfhzbUejhy epiyahd guggpy xU cuhaT tpir nraygLfpwJ. ,ej ghak ,affjjpd vjphgghdJ xU jpzkg nghUs xU guggpy ,aqFk NghJ cUthFk cuhaT tpiriag NghdwJ MFk. ,aqFk ghak VLfSfF ,ilNa NjhdWk mf cuhaT ghFepiy MFk. vdNt ghFepiyahdJ xU ghakjjpd VLfSffpilNa css rhhG ,affjij vjphfFk ghakjjpd gzG ghFepiy vd tiuaWffggLfpwJ.

ghF epiyfpfhd fhuzk:

mUfpy mikeJss ,U VLfisf nfhzl xU jputk xU fpilkll guggpy ghatjhff nfhsf. Nky VlhdJ fo Vlil KLff KwgLk. mijj njhlheJ fo VL Nky Vlil

jLff KwgLk. ,jd tpisthf xU gpdNdhffpa njhLtiu tpir NjhdWfpwJ. ,J rhhG ,affjijf FiyfFk. ,JNt ghakqfspd ghfpay jdikffhd fhuzkhFk.

ghfpay; vz; (Coefficient of viscosity):

xU epiyahd fpilkll Vlbd kJ xU jputk ruhfg ghatjhff nfhsf xU epiyahd Vlby ,UeJ njhiythfr nrdwhy VLfspd Ntfqfs ruhf mjpfhpffpwJ. A kwWk B vdw ,U ,izahd VLfisf fUJf. epiyahd VlbypUeJ x kwWk x + dx njhiytpy mUfhikapy css VLfspd jpirNtfqfs KiwNa v kwWk v + dv vdf nfhsf.
,U VLfSffpilNa njhLtiuj jpirapy nraygLk ghFepiy tpir F MdJ epA+lld Kjy tpjpapd %yk mwpaggLfpwJ. ,ej tpirahdJ
i. jputjjpd gugG A kwWk
ii. jpirNtfr rhpT $\frac{dv}{dx}$ Mfpatwwpw F Nehtpfjjjpy cssJ.

$$F \mu A \text{ kwWk } F \mu \frac{dv}{dx}$$

$$\therefore F = -hA\frac{dv}{dx}$$

,qF tpfpj khwpy; *h* jputjjpd ghfpay vz vdggLk. vjphfFwpahdJ tpir cuhaTj jdik nfhzlJ kwWk mJ rhhG ,affjij vjphffpwJ vdgijf Fwpffpwj. ghfpay vz zpd ghpkhzk
$[ML^{-1}T^{-1}]$MFk.

ghFepiyahdJ cuhaitg Nghdwjhfk. nghUspd ,aff Mwwy ntgg Mwwyhf ntspggLfpwJ.

$2.5 \times 10^{-4} m^2$ gugGss xU cNyhfjjlL $0.25 \times 10^{-3} m$ jbkkhd tpsfnfznza VlbdkJ itffgglLssJ. jlil $3 \times 10^{-2} ms^{-1}$, jpirNtfjjpy efhjj 2.5 N tpir Njitgglhy› tpsfnfznzapd ghfpay vzizf fzffpLf. nfhLffgglit.

$A = 2.5 \times 10^{-4} m^2$, $dx = 0.25 \times 10^{-3} m$,

$F = 2.5$ N and $dv = 3 \times 10^{-2} ms^{-1}$

jhpT

$$F = hA\frac{dv}{dx}$$

vz kjpgg;y› $h = \frac{F}{A}\frac{dx}{dv}$

$$= \frac{(2.5N)}{(2.5' 10^{-4} m^2)} \frac{(0.25' 10^{-3} m)}{(3' 10^{-2} ms^{-1})}$$

$= 0.083 \times 10^3 \text{ Nm}^{-2}\text{s}$

thpr;rh; Xl;lk; (Streamlined flow):

ghakqfspd Xllk khWgll tiffspy cssd mJ ruhd myyJ thpr;rh Xllk› ruww myyJ Rowrp Xllk› mKff ,aYkl myyJ mKff ,ayhj Xllk› ghfpay Xllk myyJ ghfpayww Xllkhf ,Uffyhk. cjhuzkhf› xU Mwwpy mikjpahfr nryYk ehpd Xlljijf fUJf. cwW Nehffpdhy Mwwpd nttNtW ,lqfspy ehpd jpirNtfk khWglLssij mwpayhk. mJ Mwwpd eLggFjpapy NtfkhdjhfTk› mjd fiuNahuqfspy nkJthdjhfTk cssJ. vdpDk vej xU Gsspapyk eHkjJfspd jpirNtfk khwpy; MFk. GhpjYffhf› Mwwpy eLggFjpapy Jfspd jpirNtfk tpdhbfF 4

kllh ,Uggjhff fUJf. vdNt ,ejg Gssiaf flfFk midjJj Jfsfsid jirNtfqfSk mNj kjigigg ngWk. ,JNghdNw› fiuNahujjy ghAk ehkjJfsid jirNtfk tidhbfF 0.5 kllh vdiy mjidg gid njhlUk midjJ ehkjJfsfsid jirNtfqfSk mNj kjigigg ngWk.

xU jut Xlljjiy› xU Gssiaid toNa nryYk xtnthU jutjJfSk mjwF Kddh nrdw Jfsfsid ghijaiNyNa mNj jirNtfjjiy ,aqfidhy mej jut XllkhdJ thirrh Xllk vdggLk. ,jid ruhd Xllk myyJ mLfFKiw Xllk (Laminar flow)vdTk Fwiggilyhk. ,aqFk ghakjJfs Nkwnfhs Sk tisthdghij thirrh vdggLfwJ. vej xU Gssiaiyk mjd njhLNfhlhdJ mejgGssiaiy ghak Xlljjid jiriaf nfhLffwJ. ,jid ,tthW miogjwFf fhuzk ,J xU eh Xil myyJ ,ylria eiyaiy css Mwiyg NghdW cssNj MFk.

ehk Xlljjid jirfF nrqFjjhd vej xU FWfFntlL guggiYk xNu jirNtfjijf nfhzl ruhd thif fwiwiaf fUjidhy mej fwiw foha tbt Xllk (tube of flow) vdggLk. Foha tbt Xlljjiy css vej xU ehkjJfSk mjd ,affk KOtjwFk FohaiDsNsNa vgNghJk ,UfFk kwWk kww Foha jutjJld fyffhJ vdgij Kffiakhf ftdiff NtzLk. Foha tbt Xlljjid mrR vgNghJk thirrh xlljijj jUk. thirrh xllqfs vgNghJk ghakjJfsfsid ,affg ghijfisf Fwiffidwd. ghakjjid Xllk khWeiyj jirNtfk vdggLk xU Fwiggil jirNtfk tiu thirruhf cssJ. ,jd nghUs› khWeiyj jirNtfjjwFf Fiwthd Ntfjjiy ghAkNghJ thirrh Xlljijg ngwyhk.

Rowri Xl;lk; (Turbulent flow):

,aqFk ghakjjid Ntfk khWeiyj jirNtfjij (V_c) til mjifkhdhy ,affkhdJ Rowri Xllkhfwj. ,eNehtiy xtnthU JfsiYk jirNtfkhdJ vzkjggiYk› jiraiYk khWtjhy jdiggil Jfsfs thirrh Xlljjiy ,aqfhJ. vdNt Rowri Xlljjiy Jfsfsid ghij XOqfwwjhf khwi Roy Xllk myyJ Roy vdggLk tllqfsiy ,aqFk. (m) kwWk (M) xU glfid myyJ fggyid gidGwKss ehid xllk kwWk Mfiait Rowri XlljjwFr riy vLjJffhlLfs MFk. ,U tifahd ,affjjid NtWghlbid xU mfdw Fohaiy ghAk ehiDs mjd mrrid toNa xU Jis %yk ikia nrYjJtd %yk vsijhf tisffyhk. ghakjjid jirNtk Fiwthf cssNghJ ik NehfNfhlLg ghijaiy nryYk. khwhf jirNtfkhdJ xU Fwiggil kjigigtil mjikhdhy ikahdj guti xOqfww ,affjijf fhlLk. vdNt ,affkhdJ Rowri Xllkhf khWfwJ. tiseJ nesieJ nryYk ,affjjidhy Roy xllk cUthfi mjd tisthf mjif Mwwy moffggLfwJ.

nudhyL vz;

xU ghakjjid Xllk mjd jirNtfk khWeiyj jiNtfjij (V_c) til Fiwthf ,Uggid ruhd myyJ mLfFKiw Xllkhf cssJ. ,yiynadiy Xllk Rowri Xllkhf khWfwJ vdgij ehk mweJ nfhzNlhk. M]Nghhd nudhyL (1842 – 1912) vdgth ghak Xlljjid jdikia mJ thirrh myyJ Rowri Xllk vd mweJ nfhss xU rkdghlil tbtikjjhh.

$$R_c = \frac{r v D}{m}$$

nudhyL vz vdggLk ,J xU ghkhzkww vz MFk. ,J R_c myyJ K vdw Fwiallhy FwiggilggLfwJ. rkdghlby ρvdgJ ghakjjid mlhjjiv vdgJ ,aqFk ghakjjid jirNtfk›D vdgJ ghakk nryYk Fohaid tilk kwWk *h*vdgJ ghfiay vz Mfiatwiwf Fwiffidwd. vej myF Kiwaiyk R_c xNu kjigigf nfhzbUfFk.

jutjjid Xl;ljij GheJ nfhs;s› nudhyL Rc kjigig flo;f;fz;lthW fz;weJhh;.

t.vz;	nudhyL vz;	Xl;lk;

1.	R_c< 1000	thprrh Xllk
2.	1000 < R_c 2000	ruww xllk
3.	R_c> 2000	Rowrp Xllk

vdNt nudhyL vz R_c vdgJ xU cUis tbt Fohapd topNa nryYk ghakjjpd Xllk thprrh Xllkh myyJ Rowrp Xllkh vd KbT nraaf$ba xU Kffpakhd khwp MFk. czikapy> Rowrp Xllk njhlqFk R_c ,d khWepiy kjpgG tbtpayhf xNu khjphpAss xllqfSfF rkkhd kjpgigf nfhzLssJ. cjhuzkhf khWgll mlhjjpfs kwWk ghfpay vzfs kjpgGss ,U jputqfs (vznza kwWk eH) rk tbtk kwWk msTfisf nfhzl ,U Fohafs topNa nrdwhy> xNu R_c kjpggpy rowrp Xllk njhlqFfpwJ. Nkwfzl fUjjpypUeJ xwWik tpjpiag ngwyhk. mjd $wwhdJ> ,U tbtpay ujpahf xNu khjphpahd ghak xllqfs ,Uejhy mit ,uzLk xNu nudhyL vzizf nfhzbUfFk tiu mbggilapy xdWfnfhdW rkkhdjhFk. njhopyElg gadghLfspy xwWik tpjp Kffpa gqfhwWfpwJ. fggyfs> eh%ofp fggyfs> gejaffhuhfs kwWk tpkhdqfspd tbtqfs mtwwpd Ntfk ngUk kjpgigg ngWk tifapy tbtikffggLfpdwd.

KwWjjpirNtfk (Terminal Velocity):

KwWjjpirNtfjijg GhpeJnfhss> xU mjpf ghFepiy nfhzl ezl ghakjjkgjjpy xU rpwpa cNyhff Nfhsk xaT epiyapypUeJ jhNd tpOtjhfffUJf. Nfhsjjpd kJ

1. nrqFjjhf foNehffp nraygLk Nfhsjjpd kjhd Gtpahgg tpir
2. kpjfFk jdik fhuzkhf NkyNehffp ceJ tpir UkwWk
3. NkyNehffp nraygLk ghfpay tpir (ghfpay tpir vgNghJk Nfhsjjpd ,affjjpwF vjphjpirapy nraygLk) Mfpa tpirfs nraygLfpdwd.

njhlffjjpy NkyNehffp tpirahdJ> foNehffp tpiria tpl Fiwthf cssjhy Nfhsk foNehffpa jpirapy KLffkilfpwJ. Nfhsjjpd jpirNtfk mjpfhpjjhy ghfpay tpirAk mjpfhpffpwJ. xU flljjpy foNehffpa epfu tpir NkyNehffpa tpiria rkdgLjJtjhy Nfhsjjpd kjhd njhFgad tpir RopahfpwJ. Nfhsk jwNghJ khwh jpirNtfjJld ,aqFfpwJ.

xU ghFepiy Clfjjpd topNa jhNd tpOk xU nghUshdJ milAk ngUk khwh jpirNtfk KwWjjpirNtfk (V_T) vdggLk. jpirNtfjij Y– mrrYk fhyjij X mrrpYk nfhzL xU tiuglk tiuagglLssJ.

Nfhsfkhdj njhlffjjpy KLffkilfpwJ kwWk rpwpJ Neujjpy mJ khwh kjpgGss KwWjjpirNtfjij (V_T) milfpwJ vd tiugljjpypUeJ njspthfpwJ.

KwWjjpir Ntfjjpwfhd Nfhit:

η ghfpay vz nfhzl mjpf ghFepiyAss jputjjpd topNa r MuKss Nfhsk xdW tpOtjhff fUJf. NfhsgnghUspd mlhjjp ρvdTk ghakjjpd mlhjjp σvdTk nfhsf.

Nfhsjjpd kJ nraygLk Gtpahgg tpir

$$FG = mg = \frac{4}{3}pr^3rg$$ (foNehffpa tpir)

NkyNehffpa ceJ tpir $U = \frac{4}{3}pr^3sg$ (NkyNehffpa tpir)

v_tKwWjjpirNtfjjpy ghfpay tpir

$$F = 6phrv_t$$

(foNehffpa tpir)

jwNghJ> foNehffpa epfu tpir NkyNehffpa tpirfF rkkhFk.

$$FG - U = F \Rightarrow \frac{4}{3}pr^3 rg - \frac{4}{3}pr^3 sg = 6phrv_t$$

$$v_t = \frac{2}{9} \times \frac{r^2(r-s)}{h} g \Rightarrow v_t \propto r^2$$

,qF ftdpff Ntz baJ› Nfhsjjpd KwWj jpirNtfk mjd Mujjpd ,UkbfF Nehjjftpy cssJ. ρl σtpl mjpfnkdpy›(ρ – σ)MdJ vjphfFwp kjpgigg ngWtjhy KwWjjpirNtfk vjphfFwpahfpwJ. mjdhy jhd eH myyJ vej jputjjpd topahfTk fhwWfFkpopfs NkyNehffp vOfpwJ. thdjjpy Nkfqfs NkyNehffpa jpirapy efUtjwFk ,JNt fhuzkhFk.

]Nlhf; tpjp kwWk; mjd; gadghLfs;

ghFepiy Clfjjpd topNa xUnghUs toejhy mjDld cldbahf njhLjypy css ghak Vlil mJ ,OfFk. ,J jputjjpd nttNtW VLfSfF ,ilNa rhhG ,affjij cUthfFfpwJ.]Nlhf nttNtW ghakqfspy rpwpa NfhsgnghUsfspd ,affjjpwfhd gy Nrhjidfs nraJ›rMuKss NfhsgnghUspd kJ nraygLk ghfpay tpir F MdJ.

1. Nfhsjjpd Muk (r)
2. Nfhsjjpd jpirNtfk (v) kwWk
3. jputjjpd ghfpay vz *h*

Mfpatwiwr rhhejJ vdw Kbitg ngwwhh.

vdNt $F \propto h^x r^y v^z \Rightarrow F = kh^x r^y v^z$, ,qF kvdgJ xU ghpkhz kww khwpy; ghpkhz qfisg gadgLjjp Nkwnfhzl rkdghlil ,tthW vOjyhk.

$$[MLT^{-2}] = k[ML^{-1}T^{-1}]^x \times [L]^y \times [LT^{-1}]^2$$

jhT fhz›x = 1, y = 1 kwWk z = 1 vdNt F = kηrv

Nrhjid %yk k = 6*p* vd]Nlhf fzlwpejhh.

$$F = 6phrv$$

,ej njhlhG]Nlhf tpjp vdggLk.

]Nlhf; tpjpapd; nrayKiwg; gadghLfs;

kiojJspfs mstpy rpwpajhfTk› mjd KwWjjpirNtfqfs FiwthfTk cssjhy mit Nkf tbtpy fhwwpy kpjffpdwd. mit mstpy nghpjhFkNghJ mtwwpd KwWjjpirNtfqfs mjpfhpjJ kioahf fNo tpOfpdwd

,ej tpjp foffhzgtwiw tpsfFfpwJ.

1. Nkfqfspd kpjjjy
2. rpwpa kiojJspfistpl nghpa kiojJspfs ekik mjpfkhf jhfFfpdwd.
3. ghuh#l cjtpAld fopwqFk xUth khwh KwWjjpirNtfjij ngWfpdwhh.

ghapnrha; rkdghL (Poiseuille's equation):

gtha nrha xU EzFoha topNa jputjjpd ruhd Xlljij gFgghaT nrajhh. mth EzFoha topahf xU nehbapy ghAk jputjjpd gUkDffhd rkdghlilf jUtpjjhh.

mtuJ fUjjpdgb rkdghlilj jUtpff foffhZk epgejidfisf fUjjpy nfhss Ntz Lk.

- Fohapd topNa jputjjpd Xllk thprrh Xllkhf ,Uff Ntz Lk.
- Foha fpilkllkhf Gtp<hgGtpir ehk Xlljijg ghjpffhjthW ,Uff Ntz Lk.
- Fohapd Rtiuj njhLk ehk VL xatpy ,Uff Ntz Lk.
- Fohapd vej FWfFggugpYk mOjjk ruhf ,Uff Ntz Lk.

ghpkhzggFgghait gadgLjjp ehk gthanrha rkdghlilj jUtpffyhk. fpilkllkhf css Ez Fohapd topNa xU jputk ruhf ghatjhff fUJf. Ez Fohapypd xU nehbapy ntspNaWk jputjjpd gUkd $v=\left(\frac{\partial V}{\partial t}\right)$vdf nfhsf. mJ

1. jputjjpd ghfpay vz (η)
2. Fohapd Muk (r) kwWk
3. mOjjrrhpT $\left(\frac{\partial P}{\partial l}\right)$Mfpatwiwr rhhejJ

,qFk vdgJ xU ghpkhzkww khwpy vdNt

$$v \mu h^a r^b \left(\frac{\partial P}{\partial l}\right)^c$$

$$v = kh^a r^b \left(\frac{\partial P}{\partial l}\right)^c$$

kwWk

$$[v]=\frac{\text{gUkd}}{\text{Neuk}}=[L^3T^{-1}],\left(\frac{\partial P}{\partial x}\right)=\frac{\text{mOjjk}}{\text{njhiyT}}$$

$[ML^{-2}T^{-2}],[h]=[ML^{-1}T^{-1}]$ kwWk $[r]=[L]$ rkdghL ,y gpujpapl

$$[L^3T^{-1}]=[ML^{-1}T^{-1}]^a[L]^b[ML^{-2}T^{-2}]c$$

$$M^0L^3T^{-1}=M^{a+c}L^{-a+b-2c}T^{-a-2c}$$

vdNt M, L, kwWk T ,d mLfFfis ,UGwKk rkggLjj

a + c = 0, -a + b – 2c = 3, kwWk -a – 2c = -1

a, b kwWk c Mfpa njhpahj kjpgGfs cssd. %dW rkdghLfisj jhT fhz ehk ngWtJ

a = -1, b = 4, kwWk c = 1

vdNt rkdghL MdJ›

$$v = kh^{-1}r^4\left(\frac{\partial P}{\partial l}\right)^1$$

Nrhjid %yk K - ,d kjpgG $\frac{p}{8}$,vd fhzggllJ. vdNt›

$$v = \frac{pr^4P}{8hl}$$

Nkwfzl rkdghL FWfpa Fohamyyj Ez Fohatopna nryYk ehk Xlljjpwnf nghUeJk. ,rrkdghL gthanrha rkdghL vdggLk. ,ej njhlghdJ khWepiyj jpirNtfjij (V_c) tpl Fiwthd jpirNtfk nfhzl ghakqfSfF edF nghUeJfpdwJ.

ghFepiyapd; gadghLfs;
ghFepiyapd; Kfpajtjpij flofpfhZk; cjhuzqfspy; ,UeJ GhpeJ nfhs;syhk;.

1. fduf ,aejpuqfspd ghfqfspy catpahfg gadgLk vznza mjpf ghfpay vzizf nfhzbUff NtzLk. nghUjjkhd catpiaj NjhT nraa mjd ghFepiyiaAk› mJ ntggepiyiag nghWjJ vtthW khWghLfpwJ vdgijAk mwpejpUff NtzLk.

(FwpgG: ntggepiy cahejhy jputjjpd ghFepiy Fiwfpdw J) NkYk fhh ,aejpuqfspy (,yFuf ,aejpuk) gadgLk Fiwej ghFepiyAss vznzafisj NjhT nraaTk ,J cjTfpwJ.

2. rpy fUtpfspd ,affjjpwF <uggjijf nfhLff mjpf ghFepiy nfhzl jputk gadgLjjggLfpwJ kwWk mJ ehpay jLggpfspy (Hydraulic brakes) jLggp vznzaahf gadgLfpwJ.

3. jkdpfs kwWk ,ujjf Fohafs topNa ,ujj Xllk ehkjjpd ghFepiyiar rhhejJ.
4. xU vyfluhdpd kpdD}lljijf fhz kpyypfd vznzaj Jspl Maitl Nkwnfhzlhh. mth ghFepiy gwwpa mwpit kpdD}lljijf fzffpl gadgLjjpdhh.

gugG ,Otpir

%yf$WfSfF ,ilNa csps tpirfs;

mlhjjp gugG ,Otpir Nghdw ,awgzGfs fhuzkhf nttntW jputqfs xdwhff fyggjpyiy. vLjJffhllhf eUkp kznzzizAk xdwhf fyggjpyiy. ghjurk fzzhbapy xlLtjpyiy. Mdhy epuhdk fzzhbapy xlLk. euhdJ jzLfs topahf ,iyfs tiu NkNyWk. mit ngUkghYk jputqfspd NkwgugGfSld njhlhG nfhzlitahf ,Uffpdwd. jputqfSfF tiuaWffggll gUkd czL. vdNt mtwiw nfhsfydpy CwWkNghJ mit jiftww Nkwgugigg ngWfpdwd. vdNt Nkwgugghd J $Ljyhf Mwwiyg ngWfpwJ. ,J NkwgugG Mwwy vdggLfpwJ. Nkwfzl epfoTfF fhuzk gugG ,Otpir vdw gzghFk. yhgy] kwWk fh] vdw mwpQhfs gugG ,Otpir kwWk nttNtW #oepiyfspy jputjjpd ,affk gwwpa NfhlghLfis cUthffpdh

ehk %yf$Wfs jplgnghUspy cssJ Nghy ,Wfg gpizffgglbUggjpyiy. vdNt mit vspjhf efUfpdwd. xU jputjjpy css xNu tifahd euk %yf$WfSffpilNa VwgLk tpirahdJ xhpdfffthrrp tpir (Cohesive force) vdggLfpwJ. xU ehkkhdJ jplgnghUisj njhLkNghJ jput kwWk jplgnghUs %yf$Wfs Ntwpdf fthrrp tpir (adhesive force) vdw fthrrp tpiriag ngWfpdwd.

,ttifahd %yf$WfSfF ,ilggll tpirahdJ 10^{-9} (mjhtJ 10Å) vdw FWenjhiyTfF klLNk nraygLk. midjJ jpirfspYk ,ttifahd %yf$wpil tpirfs nraygLk njhiythdJ fthrrpGyk (Sphere of influence) vdggLfpwJ. ,gGyjjpwF mgghYss tpirfs GwffzpffggLfpdwd.

xU jputjjpy A, B kwWk C vdw %dW NtWgll %yf$Wfisf fUJf. A vDk %yf$whdJ midjJ jpirfspYk css vyyh %Yf$WfSlDk ,iltpid Ghtjhy A czUk njhFgad tpir RopahFk. B vdw %yf$whdJp ehdfpy %dW ghfk jputjjpd NkwgugGfFf fNoAkp ehdfpy xU ghfk fhwwpYk cssd. B fF fogFjapy mjpf %yf$Wfs ,Uggjhy mJ foNehffpa njhFgad tpiriag ngWfpwJ. ,NjNghy C vdw %yf$W jputjjpd Nkwgugpy cssjhy (mjhtJ Nkwghjp fhwwpYkp foghjp jputjjpYk) mjpfglr foNehfF tpiriag ngWfpwJ. Vnddpy mjpfkhd jput %yf$Wfs foggFjapy cssd. vdNt %yf$W vyiyfFs css jput %yf$Wfs midjJk C %yf$Wld ,iltpid GHpeJ foNehffpa tpiria czhfpwJ vdgJ njspthfpwJ.

clgFjapDs ,UfFk vej %yf$iwAk jputjjpd NkwgugGfFf nfhzLtu xhpdf fthrrp tpirfF vjpuhf Ntiy nraa NtzbAssJ. ,tNtiyahdJ %Yf$Wfspy epiyahwwyhf NrkpffggLfpwJ. vdNtp jput Nkwgugpy css %yf$Wfs clgFjapDs css %yf$Wfis tpl mjpf epiyahwwiygngwWssd. Mdhy xU mikgG rkepiyapy ,Uff NtzLkhapd mjd epiyahwwy (gugg Mwwy) rpWkkhf ,Uff NtzLk. vdNt cWjprrkepiyapy ,Uff jputkhdJ rpWk vzzpifapyhd %yf$Wfisg ngw KaYk. NtW tifapy $wNtzLkhapd jputkhdJ rpWk

Nkwgugg;idg ngw KaYk. j;utjj;d ,ej gzghdJ gugG ,Ot;iria czlhfFf;dwJ.

gugG ,Ot;irf;F vLj;Jf;fhl;Lfs;

eh G+rr;fs (Water bugs) kwWk eh jhzbgG+rr;fs (Water striders) eh;d Nkwgugg;y elff;dwd eHk %yf$Wfs csNehff; ,OffggLtjhy eh;d Nkwgugghdj klr;Ass myyJ ,OjJfflggll glyjijg NghdW nraygLf;wJ. ,J eh G+rr;fs;d vilia rkd nraJ mit eh;d Nkwgugg;y elff cjTf;wJ. ,ej e;foit gugG ,Ot;ir vd mioff;dNwhk. tzzk G+Rk J}h;ifa;d Kbfs eh;y;UeJ nts;Na vLjjhy xdwhf xlbfnfhsf;dwd. ,jd fhuzk mtww;y cUthd eh nkyNyLfs xU r;Wk gugg;wF RUqf KidtjhFk.

eh;d; Nkwgugg;y; Cr;ahdJ k;jj;jy;

caT vznza jltggll v/F Cr;ia xU xlLk jhs kJ itjJ eh;d Nkwgugg;y nkJthf itfffTk. xlLk jhs eh;Ds t;iuthf %oFk› Mdhy Cr;ahdJ k;jeJ nfhzNla;UfFk. k;jfFk Cr;ahdJ eh;y r;wJ jhoit VwgLjJf;wJ. tisTgugg;d gugG ,Ot;irahy t;irfs F, ,y fhlbAssthW rhathf cssd. ,tt;U t;irfs;d nrqFjJf$Wfs Cr;a;d viliar rkdnraAk. jwNghJ eh;y r;wJ j;ut Nrhgigf fyffTk. ,gNghJ Cr; %oFtijf fhzyhk.

xU g;sh]bf jhis vLjJ mj;y xU r;W gFj;ia glF tbtjj;y ntlb vLffTk $hKid nfhzl KdgFj;Ak› ntlLggFj; (Notch) nfhzl g;dgFj;Ak ,UggJ edW. ntlLggFj;a;y r;WJzL fwG+ujij itfffTk. glif eh;y nkJthf t;Lt;jjhy› fwG+uk fiuAkNghJ glfhdJ KdNdhff;r nrYjjggLtijf fhzyhk. fwG+uk fiuAkNghJ gugG ,Ot;ir Fiwffgg;lL ntlLggFj;fF mUf;y gugG ,Ot;ira;y khWghL czlhf;wJ. ,jdhy glf;d g;dgFj;a;y css eh g;dNdhff;g ghaeJ glF KdNdhff; ,aqFf;wJ.

gugG ,Ot;iria ghj;f;Fk; fhuz;fs;

nfhLffggll j;utjj;d gugG ,Ot;irahdJ fofzl #oyfs;y khWgLf;wJ.

1. khRgnghUsfs fyej;UggJ myyJ fygglk Nrhej;UfFk msitg nghWjJ gugG ,Ot;iriag ghj;ff;wJ.

2. fiu nghUsfs fyej;UggJk gugG ,Ot;ira;d kj;gigg ghj;ff;wJ. cjhuzkhf mj;f fiuj;wd nfhzl Nrhbak FNsiuL eh;y fiueJssNghJ eh;d gugG ,Ot;iria mj;fh;ff;wJ. Mdhy Fiwthff fiuAk g;dha;y myyJ NrhgGf fiuryhdJ eh;y fyffggLk NghJ eh;d gugG ,Ot;iriaf Fiwff;wJ.

3. k;dD}llkhdJ gugG ,Ot;iria ghj;fFk› xU j;utkhdJ k;dD}llggLk NghJ gugG ,Ot;ir Fiwf;wJ. k;dD}llggLk NghJ nts;gGw t;ir j;utgguggd kJ nrayglL j;ut NkwgughdJ mj;fh;ffgglL gugG ,Ot;ira;d RUqFk jdikfF vj;uhfr nraygLk vdNt gugG ,Ot;ir FiwAk.

4. ntgge;iyahdJ ehkjj;d gugg ,Ot;iria khwWtj;y Kff;a gqfhwWf;wJ. ntgge;iy mj;fh;fFkNghJ gugG ,Ot;ir NehgNghff;y Fiwf;wJ. xU r;wa ntgge;iy neLffjj;wF t°C ,y gugG ,Ot;irahdJ $T_t = T_0(1-\alpha t)$,qF T_0 vdgJ 0°C ntgge;iya;y gugG ,Ot;ir kwWk α vdgJ gugG ,Ot;ir ntgge;iy vz. khWe;iy ntgge;iya;y vz. khWe;iy ntgge;iya;y gugG ,Ot;ir Ro;. Vndd;y j;utjj;wFk thATfFk css ,ilggFj; kiwf;wJ. cjhuzkhf eh;d khWe;iy ntgge;iy 374°C vdNt› mej ntgge;iya;y eh;d gugG ,Ot;ir Ro;ahFk. thzlhthy vdgth gugG ,Ot;irfFk khWe;iy ntgge;iyfFk css Kff;a njhlhig gh;eJiujjhh.

$$T_t = T_0\left(1-\frac{t}{t_c}\right)^{\frac{2}{3}}$$

ngh J i kggLjj

$$T_t = T_0 \left(1 - \frac{t}{t_c}\right)^n$$

,J kpfrrhpahd kjpgigf nfhLffpwJ. ,qF nttNtW jputqfSfF n khWgLfpwJ. t kwWk t_c vdgit jdpntggepiyapy (nfytpd mstpy) KiwNa ntggepiy kwWk khWepiy ntggepiyiaf FwpffpwJ.

gugG MwpwYk; gugG ,Otpirak;:
gugG Mwpwy;:

xU nfhsfydpYss khjph jputk xdiwf fUJf. jutjjpd clgFjpapy css %yf$whdJ midjJ jpirfspYk css %yf$Wfshy ,OffggLk. jut Nkwgugg py css %yf$whdJ mjwF fNo css gpw %yf$Wfshy klLNk ,OffggLtjhy epfu fo Nehffpa tpiriag ngWk. ,jd tpisthf jutjjpd NkwgugG KOtJk csNehffp ,OffggLk. vdNt jut Nkwgugghd J rpWk Nkwgugigg ngw KaYk. Nkwgugg pid mjpfhpggjwfhf clgFjpapy ,UeJ rpy %yf$Wfs NkwgugGwF nfhzLtuggLfpdwd. ,jd fhuzkhf› fthrrp tpirfF vjpuhf Ntiy nraaggLfpwJ. ,tthwhf jut Nkwgugg py css %yf$Wfs kww %yf$Wfistpl mjpf epiyahwwiyg ngwWssd. ,J gugG Mwwy vdggLk. NtW tpjkhff$w› gugG ,OtpirfF vjpuhf jutjjpd xuyF gugg pd Nkwgugig mjpfhpffr nraaggLk Ntiy jutjjpd gugG Mwwy vd mioffggLfpwJ.

$$\text{gugG Mwwy} = \frac{\text{Nkwgug ig mjpfhpffr nraaggLk Ntiy}}{\text{Nkwgugg pd mjpfhpgG}}$$

$$= \frac{W}{DA}$$

,J Jm^{-2}myyJ Nm^{-1}vdw myfhy FwpffggLfpwJ.

gugG ,Otpir:
jutjjpd XuyF gpuggpwfhd Mwwy gugG ,Otpir vd tiuaWffggLfpJ.

$$T = \frac{F}{l}$$

T ,d SI myF kwWk ghpkhzk KiwNa Nm^{-1}kwWk MT^{-2} MFk.

gugG ,Otpirf;Fk; gugG MwpwYf;Fk; ,ilNaahd njhlhG:
ABCD vdw nrttfrrllk NrhgGf fiurypDs cssjhff fUJf. AB vdgJ efuf$ba fkgpahff nfhsf. gugG ,Otpirapd fhuzkhf NrhgGg glykhdJ AB – l csNehffp ,OfFk. gugG ,Otpirapdhy Vwgll tpir F kwWk AB ,d esk lvdpy

$$F = (2T)/$$

,qF 2 vdw vz glyjjpd ,U gugGfisf FwpffpwJ. A'B' vdw Gjpa epiyfF AB vdw fkg Δx njhiyT efhjjggLtjhff nfhsf. gugG mjpfhpgghy gugG ,Otpirapd fhuzkhf csNehffpa tpirfF vjpuhf Ntiy nraaggl NtzLk.

nraaggll Ntiy = tpir × njhiyT

$$= (2T/)\,(\Delta x)$$

glyjjpd guggpy mjpfhpgG

$$\Delta A = (2/)\,(\Delta x) = 2/\Delta x$$

Mifahy

$$\text{gugG Mwwy} = \frac{\text{nraaggll Ntiy}}{\text{Nkwgugg pd mjpfhpgG}}$$

$$\frac{2Tl\Delta x}{2l\Delta x}=T$$

vdNt› xuyFg gugg‰wfhd gugG MwwyhdJ vz z st‰y gugG ,Ot‰irfFr rkkhFk.

j‰utjJs‰ahdJ xNu xU Nkwgugig klLNk nfhzbUfFk vdgij e‰idt‰y nfhsf. vdNt r MuKss Nfhs tbt j‰utjJs‰a‰d NkwgugG $4\pi r^2$MFk. Mdhy Fk‰o‰ahdJ NkwgugGfisf nfhzLssjhy Nfhs tbt Fk‰o‰a‰y nkhjj NkwgugG $2\times 4\pi r^2$fFr rkkhFk.

xU NrhgGfFk‰o‰a‰d glyjj‰d gugig 50 cm^2 y‰UeJ 100 cm^2 fF mj‰fh‰ff nraaggll Ntiy 2.4×10^{-4} Jvd‰y NrhgGf fiury‰d gugG ,Ot‰iriaf fz ff‰Lf.

j‰T:

NrhgGf Fk‰o‰ahdJ xU NkwgugGfisf nfhzbUggjhy Nkwgugg‰y Vwgll mj‰fh‰gG

$$\Delta A = A_2 - A_1$$
$$= 2\,(100-50)\times10^{-4}m^2 = 100\times10^{-4}\,m^2$$

vdNt nraaggll Ntiy

$$W = T\times\Delta A \Rightarrow T = \frac{W}{\Delta A}=\frac{2.4\acute{}\,10^{-4}J}{100\acute{}\,10^{-4}m^2}=2.4\acute{}\,10^{-2}Nm^{-1}$$

NrhNfhzk; (Angle of contact):

ehkj‰d NkwgugG xU j‰zkgnghUis njhlLf nfhzbUejhy njhL Gss‰a‰y ehkj‰d gugG rwW tisej‰UfFk. j‰utj‰d NkwgugG tisej‰UfFk Nghnjyyhk ,U ClfqfSfF (j‰l – j‰ut ,ilggFj‰) ,ilggll Nfhzkhdj cUthf‰wJ.

cjhuzkhf xU fz zhbf Foha glj‰y fhlbAssthW mjd gffqfs NehFjjhf ,UfFkhW eh‰Ds itffgglhy eH› fz zhbffoha‰Ds NkyNehff‰ ,OffggLtijf fhzyhk. ,NjNghy eUfFg gj‰yhf› fz zhbf Fohia ghjurj‰y itjjhy NkwgugG tisej‰UfFk. Mdhy ,gNghJ tisthdJ mk‰o‰eJ ,UfFk. njhLk Gss‰a‰y j‰ut Nkwgugg‰wF tiuaggll njhLNfhlbwFk j‰lgnghUs‰d gugg‰wFk ,ilggll Nfhzkhdj NrhNfhzk θvdggLk. (f‰Nuff vOjjhd ,jid 'jllh" vd thr‰ffTk)

,kkj‰gghdJ xtnthU j‰l kwWk j‰ut Nrhbfs‰d ,ilggFj‰iag nghWjJ khWgLf‰wJ. xU j‰utkhdJ j‰lgnghUs‰d Nky glhtJk myyJ Js‰fshf cUthtJk ,kkj‰gigg nghUjNj mikf‰wJ.

njhLkGss‰ O- itg nghWjJ j‰ut – thA› j‰l – thA kwWk j‰l – j‰ut ,ilggFj‰fisf fUJNthk. ,ilggFj‰fs‰d gugG ,Ot‰irfs fhzg‰ffgglLssthW KiwNa T_{la}, T_{sa} kwWk T_{sl} MFk.

ehkkhdJ rke‰iyiag nghWjJ e‰iyahf ,Ugg‰d ,k%dW ,ilggFj‰fSfF ,ilNa css gugG ,Ot‰irfSk rke‰iya‰NyNa ,UfFk. vdNt›

$$T_{sa}=T_{la}\cos q+T_{sl} \Rightarrow \cos q=\frac{T_{sa}-T_{sl}}{T_{la}}$$

Nkwfzl rkdghlby‰UeJ› %tifahd NehTfs fNo t‰thj‰ffgglLssd.

1. $T_{sa} > T_{sl}$ kwWk $T_{sa} - T_{sl} > 0$ vd‰y eH – g‰sh]bf ,ilggFj‰) NrhNfhzk θ MdJ FWqNfhzk (θ kj‰gG 90° l t‰lfF iwgG) kwWk cosθNehfFw‰ kj‰gGilaJ.

2. $T_{sa} < T_{sl}$ kwWk $T_{sa} - T_{sl} < 0$ vd‰y (eh - ,iy ,ilggFj‰) NrhNfhzk th‰Nfhzkhfk. (θkj‰gG 180° l t‰lfF iwT) kwWk cos θvj‰hfFw‰ kj‰gGilaJ.

3. $T_{sa} > T_{la} + T_{sl}$ vdpy mqNf rkepiy ,yyhky eHkkhdJ jplgnghUspd Nky guTk.

vdNt jpl – jput ,ilggFjpfSfF ,ilNa css NrhNfhzkhdJ ek mdwhl thotpy Kffpag gadghLfisf nfhzLssJ. vLjJffhllhf› NrhgGk› ryitjJ}Sk <ukhfFk fhuzpfs.
mit xU ehkffiurypy Nrhffggllhy mit NrhNfhzjij Fiwff KaYk. mjdhy Jzpfspy edwhf CLUtp mOfif mfwWk. kwnwhU tifapy eh Gfh thzqfs flbljjpd ntspGwk GrggLfpdwd. mit kio ngaAkNghJ eUfFk thzk Grggll guggpwFk ,ilNa css NrhNfhzjij mjpfhpfFk.

jputj;Jsp› NrhgGf;Fkpo kwWk; fhwWf; Fkpof;F csNs kpif mOj;jk;

,jwF Kddh tpthjpjjthW› jputjjpd NkwgugG xU jpzkjijj njhLkNghJ tisthf ,UffpwJ. jput – fhwW myyJ jput – thA ,ilggFjpapd jdikiag nghWjJ ,ilggFjpapy gugG ,Otpirapd vzkjpG khWgLfpwJ. khwhf› gugG ,Otpirapd fhuzkhf Nkwfzl ,ilggFjpfs Mwwiyg ngwWssd. Fwpggpll gUkDfF Nkwgugghdj kpff Fiwej gugGld rpWk Mwwiyf nfhzbUfFk. ,ej fhuzjjhy jputjJspahdJ Nfhs tbitg ngWfpwJ. (rpwpa MujjpwF) xU ehkjjpd NkwgugG tisejpUejhy› jputjjpd cs kwWk ntspGw NkwgugGfspilNa mOjj NtWghL ,UfFk.

1. ehkjjpd NkwgugG rkjskhf ,Uggpd› gugG ,Otpirahy cUthFk tpirfs (T,T) ehk Nkwgugpd njhLNfhlbd topNa vjpnujpuhfr nraygLk. vdNt %yf$wpd kjhd njhFgad tpir Ropahfk. rkjs ehkggugpy jputggffjjpd mOjjkhdJ thAggffjjpd mOjjjjpwF rkkhFk.

2. ehkjjpd NkwgugG tiseJ fhzggllhy ehk Nkwgugpyss xtnthU %yf$Wk Nkwgugpd njhLNfhlbd topNa gugG ,Otpirapd fhuzkhf (FT, FT) vdw tpirfis czUk. tpirfis ,U nrttff $Wfshfg ghpff› fpiljjsf$Wfs xdiw xdW rkd nraaggllL› nrqFjJf $Wfs $llggLfpdwd. vdNt guggpwF nrqFjjhfr nraygLk njhFgad tpirahdJ ehkjjpd tisej guggpd kJ nraygLfpwJ. ,jdhy xU Ftpej Nkwgugpd kJ nraygLk njhFgad tpirahdJ tisT ikajij Nehffp csNehffpAk› xU Fopej Nkwgugpd kJ nraygLk njhFgad tpirahdJ tisT ikajij Nehffp ntspNehffpAk nraygLk. vdNt xU ehkjjpd tisej NkwgugG rkepiyapy ,Uff› Fopej gffjjpd tpirahdJ Ftpej gffjjpd tpiria tpl mjpfkhf ,UfFk.

Fkpo kwWk; ehkj;Jspapds; kpifaOj;jk;
rpWFkpofSk ehkjJfsfSk gugG ,Otpirfspd fhuzkhf Nfhstbitg ngWfpdwd. ehkj Jsp› Fkpo Mfpatwpy css mOjjk ntsp mOjjjij tpl mjpfk.

1. ehkj;jpYs;s fhwWf; Fkpoapds; kpifaOj;jk;

R Muk nfhzl fhwWf Fkpo xdW T vdw gugG ,Otpiriaf nfhzLss eHkkjjpDs ,Uggjhff fUJf. P_1kwWk P_2vdgd KiwNa Fkpoapd ntspGw kwWk clGw mOjjkhFk. ,gNghJ Fkpoapds kpifaOjjk $\Delta P = P_2 - P_1$MFk.
fhwWfFkpoapds kpifaOjjjijf fzffpl› mjd kJ nraygLk tpirfisf fUJNthk. miufNfhs tbt Fkpoapy tpirfisf fUJkNghJ ekfFf fpilggJ.

1. $2\pi R$ esKss tspkigr Rwwp tygGwkhf gugG ,Otpirapd fhuzkhf nraygLk tpirahdJ $F_T = 2\pi RT$
2. πR^2 FWfFntlLg guggpy tygGwkhf nraygLk ntspGw mOjjkhd P_1My cUthd tpir $F_{P_1} = P_1 \pi R^2$

3. P2vDk clGw mOjjjjdhy VwgLk ,lgGwkhf nraygLk tpir $F_{P_2} = P_2 pR^2$,ttpirfspd nrayghllhy fhwWf Fkpo rkepiyapy ,Uggjhy

$$F_{P_2} - FT + F_{P_1}$$

$$P_2 pR^2 = 2pRT + P_1 pR^2$$

$$\therefore (P_2 - P_1)pR^2 = 2pRT$$

kpifaOjjk $\Delta P = P_2 - P_1 = \frac{2T}{R}$

NrhgGf; Fkpoapd; kpifaOj;jk;

R MuKk TgugG ,Otpirak nfhzl NrhgGf Fkpo xdiwf fUJf. NrhgGf FkpofF fhwWld njhLk ,UgugGfs› Fkpoapd clGwk xdWk› ntspgGwk kwnwhdWk cssd. vdNt gugG ,Otpirahy VwgLk tpir $2\acute{}2pRT$ NrhgGf Fkpoapd kJ nraygLk gyNtW tpirfshtd›

1. gugG ,Otpiradhy tygGwkhf nraygLk tpir $F_T = 4pRT$
2. ntspgGw mOjjjjdhy tygGwkhf nraygLk tpir $F_{P_1} = P_1 pR^2$
3. clGw mOjjjjdhy ,lgGwkhf nraygLk tpir $F_{P_2} = P_2 pR^2$

Fkpoahdj rkepiyapy cssjhy

$$F_{P_2} = F_T + F_{P_1}$$

$$P_2 pR^2 = 4pRT + P_1 pR^2$$

$$\therefore (P_2 - P_1)pR^2 = 4pRT$$

$$\Delta P = P_2 - P_1 = \frac{4T}{R}$$

kpifaOjjk

ehkjJspapd; kpifaOj;jk;

R MuKk T gugG ,OtpirAk nfhzl ehkjJspxdwpidf fUJf.

ehkjJspapd Nky nraygLk gyNtW tpirfshtd

1. gugG ,Otpiradhy tygGwkhf nraygLk tpir $F_T = 2pRT$
2. ntspggw mOjjjjdhy tygGwkhf nraygLk tpir $F_{P_1} = P_1 pR^2$
3. clGw mOjjjjdhy ,lgGwkhf nraygLk tpir $F_{P_2} = P_2 pR^2$

ehkjJsp rkepiyapy csssjhy

$$F_{P_2} = F_T + F_{P_1}$$

$$P_2 pR^2 = 2pRT + P_1 pR^2$$

$$\therefore (P_2 - P_1)pR^2 = 2pRT$$

kpifaOjjk

$$\Delta P = P_2 - P_1 = \frac{2T}{R}$$

vLj;Jf;fhl;L:

xgglhjjp 0.8 nfhzl 4 mm cauKss vznza jkgjjdhy 2.0 cm MuKss NrhgGf Fkpoapd kpifaOjjk rkggLjjgglhy› NrhgGfFkpoapd gugG ,Otpiriaf fhzf.

jhtT:

NrhgGf Fkopaids kifaOjjk

$$\Delta P = P_2 - P_1 = \frac{4T}{R}$$

ehkjJspfs Muk rwajhf ,Uejhy eHkjJspaDs kifaOjjk mjfkhf ,UfFk. clGwKss ,kkifaOjjjjd fhuzkhfNt rW gdjJsfshdJ jzkqfs Nghy cWjahf cssd.
gdrrWfF tisahLk xUth› gdfflbaid Nky rWffr nryYkNghJ› $uhd cNyhd rWfFku Kidfshy VwgLk mOjjjjdhy gdfflbahdJ rwJ cUFk. Mdhy gdjJspfs cWjahd geJ jhqffisg Nghy nrayglL mth nkdikahf rWffr nrytjwF cjTfdwd.

Mdhy $DP = P_2 - P_1 = r\,gh$ Þ $r\,gh = \frac{4T}{R}$

Þ gugG ,Otir

$$T = \frac{r\,ghR}{4} = \frac{(800)(9.8)(4\acute{}\,10^{-3})(2\acute{}\,10^{-2})}{4}$$

gugG ,Otir $T = 15.68\acute{}\,10^{-2}\,Nm^{-1}$

EzGio EioT (Capillarity):

yjjd nkhoay Nfggssh (capilla) vdgjd mhjjk Kb vdgjhFk. Fohafs KbasT nkyyajhf ,Uejhy jutk NkNyWtJ mjfkhf ,UfFk. kfrrwa tllk nfhzl Foha EzGiofFoha vdggLk. ,UGwKk jwej fzzhb EzGiofFoha xdiw ehy NehfFjjhf mkojJkNghJ euhdJ FohaDs NkyNehffy VWfwJ. Fohay ehd kllk ntsay css klljijtl mjfkhf ,UfFk. EzGiofFohia ghjurjjy mkojjdhy ghjurKk FohaDs foNehffy ,wqFk. mjhtJ Fohay ghjurjjd kllk ntsayYss klljijtl Fiwthf ,UfFk. ehkKk jlgnghUSk rejfFk ,ljjy NrhNfhzk MdJ 90° I tl Fiwthf ,Uejhy EzGio Vwwk VwgLk. khwhf› ehkKk› jlgnghUSk rejfFkljjy NrhNfhzkhdJ 90°I tl mjfkhf ,Uejhy EzGio ,wffk czlhFk. xU NehFjjhd Fohay eHkk NkNyWtJ myyJ fowqFtJ EzGio EioT myyJ EzGior nrayghL vdggLk. EzGiofFohaid tlljijg nghWjJ ehkk khWgll cauqfSfF NkNyWk myyJ fowqFk.

EzGioNawwk kwWk ,wfifk :

NrhNfhzk	tyik		eidAk msT	gpiwjjsk	EzGiof Fohay ehk cahT myyJ jhoT
	xhdf fthrir tpir	Ntwdf fthrir tpir			
θ = 0 (A)	tyik Fdwa J	tyik kffJ	KOtJkhf eidAk	rkjsk	cauTkyiy fowqfTkyiy
θ< 90 (B)	tyik Fdwa J	tyik kffJ	mjfk	Foe J	ehkk NkNyWk
θ> 90(C)	tyik kffJ	tyik Fdwa J	FiwT	Fte J	ehkk fowqFk

EzGio Eiotid nrayKiwg gadghLfs;

- EzGioNawwjjd fhuzkhf kz tsffYss vznzahdJ jhay NkNy Vwfwj. ,NjNghy jhtujjy ,iyfSfFk fisfSfFk Nthy UeJ cahrhW (sap) NkNyWfwJ.

- cwQR jhshdJ ikia cwQRfwJ.
- fzfsyUeJ fz zh njhlheJ tba EzGior nrayghL Njitahdjhfk.
- Nfhilffhyqfsy gUjj Milfs tUkg mzaggLfdwd. Vnddy gUjj Milfs Yss Ezza Jthuqfs tahitfF EzGiof Fohafshf nraygLfdwd.

EzGioNaww Kiway; gugG ,Otiriaf; fhzy;

jutKk› fhwWk rejfFkljjy css tisej guggd kJ VwgLk mOjj NtWghNl jutkhdJ EzGiofFohay NkNyWtjwFf fhuzkhf mikfwJ (<hggd tisitg Gwffzff). kf Ezza Fohafsy EzGioNawwkhdJ mjfkhf cssJ. ,eefothdJ gugG ,Otiraid ntsgghlhFk. EzGioNawwjjwFk (h) gugG ,OtirfFk (T) css njhlhigg ngw EzGiofFoha xdW nfhsfydYss ehy mkojj itjjUggjhff fUJf. EzGiofFohay euhdJ gugG ,Otiraid fhuzkhf h caujjwF NkNyWfwJ.

gugG ,Otiraid fhuzkhf VwgLk tir FTMdJ njhLkGssay njhLNfhlbd toNa foNehffAk› mjd vjhtir NkyNehffAk nraygLfdwd. gugG ,Otir TMdJ ,U $Wfshfg ghffggLfwJ.

1. filjjsf$W Tsinθkwwk
2. nrqFjJf$W Tsinθgiwjjsjjd RwwsT KOtJk NkyNehff nraygLfwJ.

nkhjj NkyNehffa tir :

,qF θ vdgJ NrhNfhzk›r vdgJ Fohaid Mukhk ρvdgJ ehd mlhjj kwWk h vdgJ Fohay eh NkNyWk cauk vdy

1. filjjsf$W Tsin θkwWk
2. nrqFjJf$W Tcos θgiwjjsjjd RwwsT KOtJk NkyNehff nraygLfwJ.

$= (T\cos\theta)(2\pi r) = 2\pi r T\cos\theta$

,qF θ vdgJ NrhNfhzk r vdgJ Fohaid MukhFk. ρvdgJ ehd mlhjj kwWk h vdgJ Fohay eh NkNyWk cauk vdy

$$v = \pi r^2 h + \left(\pi r^2 r - \frac{2}{3}\pi r^3\right) \Rightarrow V = \pi r^2 h + \frac{1}{3}\pi r^3$$

NkyNehffa tirahdJ eHd Nkwgugg wF NkNy Fohay VwAss ehkjjkgjjd viliar rkd nrafwJ.
vdNt›

$$2\pi r\cos\theta = \pi r^2\left(h = \frac{1}{3}r\right)\rho g \Rightarrow T = \frac{r\left(h + \frac{1}{3}r\right)\rho g}{2\cos\theta}$$

EzGiof FohahdJ kff Ezzajhf r Muk nfhzbUggd (kff Fiwthd Muk) cauk cld xggl $\frac{r}{3}$ MdJ Gwffzfffjjffj. vdNt

$$T = \frac{rr\,gh}{2\cos\theta}$$

h caujjwF NkNyWk NghJ

$$h = \frac{2T\cos q}{rrg} \Rightarrow h \propto \frac{1}{r}$$

EzGio Vwwkhd J (h) Fohaid Mujjwf (r) vjhjjftiy cssJ vdgij ,J Fwiffwj. Fohaid Muk Fiwa EzGioNawwk mjifkhFk.
EzGiof Foha xdwiy eh 2.0 cm caujjwF NkNyWfwJ. ,fFohaid Mujijg Nghy %dwid xU gFji MuKila kwnwhU EzGiof Fohaiy eh vej mstwF NkNyWk?

jhiT:

rkdghL ,UeJ $h \propto \frac{1}{r} \Rightarrow hr = khwiy$

$r_1$kwWk r_2MuKila ,U EzGiof Fohafs jutjjiy mkioejssNghJ EzGioNaww caukhdJ KiwNa $h_1$kwWk $h_2$vdiy›

$h_1r_1 = h_2r_2 = khwiy$

$$\Rightarrow h_2 = \frac{h_1r_1}{r_2} = \frac{(2\acute{}10^{-2}m)\acute{}r}{\frac{r}{3}} \Rightarrow h_2 = 6\acute{}10^{-2}m$$

vLj¡Jf¡fhl¡L:

Nrhlh iyk fzzhbfFk ghjurjjwFk ,ilNa NrhNfhzk 140°xU fizzjjiYss ghjurjjiy 2 mm MuKila ,Nj fzzhbahy Md EzGiofFoha mkiojji itffgglLssJ. jutjjid ntsigGw Nkwgugigg nghWjJ Fohaiy ghjurjjid kllk vttsT FiwAk?

ghjurjjid gugG ,Otiir T = 0.456 Nm^{-1}

ghjurjjid mlhjji $\rho = 13.6 \times 10^3$ kg m^{-3}

jhiT:

EzGio ,wffk

$$h = \frac{2T\cos q}{rrg} = \frac{2\acute{}(0.465Nm^{-1})(\cos 140°)}{(2\acute{}10^{-3}m)(13.6\acute{}10^{3})(9.8ms^{-2})}$$

fzzhbf Fohaiy ghjur kllk foiwqFfiwJ vdgij vjhfFwi fhlLfiwJ.

gugG ,Otiiraid¡ gadghLfs¡:

- nfhRffs eid Nkwgugiy Klilfis ,Lfidwd. eid gugG ,Otiiriaf Fiwff riwJ vznza CwwggLfiwJ. ,J eid NkwgugiYss klrigglyjij cilJ tiLtjhy nfhR Klilfs eiDs %ofr nraJ moffggLfidwd.

- Ntjig nghwiahshfs› ehkjJsifs tbikffggll tbtjjiy mikeJ gugiy xNu ruhf xlbfnfhs SkhW mjd gugG ,Otiiria Elgkhd msTfF rhi nraaNtzLk. ,J jhdiaqfi thfdqfs kwWk myqfhug nghUsfSfF thzk Girg gadgLfiwJ.

- Jzifisj JitfFkNghJ nteehiy ryitjJ}is Nrhggjhy eid gugG ,Otiir FiwffggLL mOfFjJfsfs vsijiy effggLfidwd.

- eH xllhj Jzifs jahhifFk NghJ eh Xllhj nghUshdJ (nkOF) JziAld NrhffggLfiwJ. ,J NrhNfhzjij mjifhiffiwJ.

nghndsyiaid¡ Njwwk¡:
njhlhkhwiyir¡ rkdghL:

xU Foha;d to;Na nryYk ehk e;iwa;d tjjij mw;a ehkk ghatJ ruhf ,Uggjhff fUjNtzLk. ehkk ghatJ ruhf ,Uff NtzLnkdd;y ghAk ehkjj;d xtnthU Gss;a;Yk j;irNtfkhdJ Neujijg nghWjJ khw;y;ahf mika NtzLk. ,ej e;gejida;y ehkjj;d XllkhdJ th;rrh Xllkhf mikAk.

ruww FWfF ntlLggugG $a_1$kwWk $a_2$mjhtJ a_1> $a_2$nfhzl AB vdw Fohiaf fUJf. ghFe;iyaww mKff ,ayhj ehkk ruhf $v_1$kwWk $v_2$vdw j;irNtfjj;y KiwNa $a_1$kwWk $a_2$gugGff to;Na ghaeJ nryf;wJ.

Δt vdw fhy mst;y A vdw gFj;a;d to;Na nryYk ehkjj;d e;iw $m_1$vd;y m1 = $(a_1v_1\Delta t)\rho$

Δt vdw fhy mst;y B vdw gFj;a;d to;Na nryYk ehkjj;d e;iw $m_2$vd;y>m2 = $a_2v_2\Delta t)\rho$

mKff ,ayhj ehkjj;y e;iw khwhJ $m_1 = m_2$

$$a_1v_1\Delta t\,\rho = a_2v_2\,\Delta t\,\rho$$

$$a_1v_1 = a_2v_2 \text{ Þ } av = khw;y;$$

,JNt njhlhkhw;y;r rkdghL vdggLk. ,J> ghAk ghakqfs;d e;iwahdJ khwhky ,Uggijf fhlLf;wJ. nghJthf av = khw;y;> ,jd nghUs gUkgghak myyJ ghAk tjk Foha KOtJk khw;y; vdgjhFk. khwhf FWfFntlLggugG Fiwthf ,Ugg;d ghakjj;d j;irNtfk mj;fkhf ,UfFk.

vLj;Jf;fhl;L:

xU rhjhuz kd;jDfF ngUehb to;ahf ,ujjk nryYk Ntfk 0.33ms-1. (Muk r = 0.8 cm) ngUehba;y ,UeJ 0.4 cm Muk nfhzl 30 vzfs css ngUk jkd;fSfF ,ujjk nryf;wJ. jkd;fs;d to;Na nryYk ,ujjjj;d Ntfjijf fzff;Lf.

jhT:

$$a_1v_1 = 30a_2v_2 \text{ Þ } pr_1^2v_1 = 30pr_2^2v_2$$

$$v_2 = \frac{1}{30}\left(\frac{r_1}{r_2}\right)^2 v_1 \text{ Þ } v_2 = \frac{1}{30}\left(\frac{0.8\times 10^{-2}m}{0.4\times 10^{-2}m}\right)^2 \times (0.33\ ms^{-1})$$

$$v_2 = 0.044\ ms^{-1}$$

ehkq;fs;d; mOj;j> ,af;f kwWk; e;iy Mwwy;:

ruhfg ghAk ehkjj;wF %tifahd Mwwyfs czL. mit 1. ,aff Mwwy 2. e;iy Mwwy kwWk 3. mOjj Mwwy MFk.

1. ,aff Mwwy : m e;iwAk v j;irNtfKk nfhzl ehkjj;d ,aff Mwwyhd JKE = $\frac{1}{2}mv^2$

xuyF e;iwffhd ,aff Mwwy = $\frac{KE}{m} = \frac{\frac{1}{2}mv^2}{m} = \frac{1}{2}v^2$

gUkd $\frac{KE}{V} = \frac{\frac{1}{2}mv^2}{V} = \frac{1}{2}\left(\frac{m}{V}\right)v^2 = \frac{1}{2}rv^2$

2. e;iy Mwwy: jiuklljj;y;UeJ h caujj;Yss m e;iw nfhzl eHkjj;d e;iyahwwy

PE = mgh

XuyF e¡iwffhd e¡iyahwwy

$$\frac{PE}{m} = \frac{mgh}{m} = gh$$

,NjNghy xuyF gUkDffhd e¡iyahwwy

$$= \frac{PE}{\text{gugG}} = \frac{mgh}{V} = \left(\frac{m}{V}\right)gh = r\,gh$$

3. mOjj Mwwy ehkjj¡d kJ mOjjjijr nrYjJtjhy

mOjjk = $\frac{\text{t¡ir}}{\text{gugG}}$ Þ t¡ir ×mOjjk gugG

$F' d = (PA)' d = P(A' d)$

Þ $F' d = W = PV =$ mOjj Mwwy

vdNt mOjj Mwwy $E_p = PV$

xuyF e¡iwffhd mOjj Mwwy

$$= \frac{E_p}{m} = \frac{PV}{m} = \frac{P}{\frac{m}{V}} = \frac{P}{r}$$

,NjNghy xuyF gUkDffhd mOjj Mwwy

$$= \frac{E_p}{\text{gUkd}} = \frac{PV}{V} = P$$

nghndsy¡a¡d¡ Njww¡Kk¡ mjd¡ gad¡ghLfSk:

1738 Mk MzL Rt¡j ehlL mw¡t¡ay mw¡Qh Nld¡ay nghndsy¡ vdgth nttNtW FWfFntlLg gugGss Fohafs to¡Na nryYk ehkjj¡d th¡rrh Xlljj¡wfhd njhlhig tFjjhh. Mwwy khwh t¡j¡a¡d mbggila¡y mth ehkjj¡d th¡rrh Xlljj¡wfhd njhlhigj jUtjjhh.

nghndsy¡a¡d¡ Njww¡k:

nghndsy¡a¡d Njwwjj¡dgb th¡rrh Xlljj¡y css mKff ,ayhj› ghFe¡iyaww› XuyF e¡iwAss ehkjj¡d mOjj Mwwy› ,aff Mwwy kwWk e¡iyahwwy Mf¡atww¡d $lLjnjhif khw¡y¡ahFk. fz¡jKiwggb

$$\frac{P}{r} + \frac{1}{2}v^2 + gh = \text{khw¡y¡}$$

,JNt nghnsy¡a¡d rkdghlhFk.

e¡&gjjjy¡:

AB vdw Foha¡d to¡ahf ehkk ghatjhff nfhsNthk. ,qF V vdgJ Kid A to¡ahf t fhyjj¡y EioAk ehkjj¡d gUkd vd¡y› Kid B to¡ahf mNj fhyjj¡y nts¡NaWk ehkjj¡d gUkDk V MFk.

a_A, $v_A$kwWk P vdgit A y KiwNa Foha¡d FWfFntlLggugG› ehk j¡irNtk kwWk ehk mOjjk vdf nfhsf.

A ,y css ehkk nraygLjJk t¡ir

$$F_A = P_A a_A$$

t fhy msty ehkk flej njiyT

$$d = V_A t$$

vdNt nraaggll Nt iy

$$W = F_A d = P_A a_A v_A t$$

Mdhy $a_A v_A t = a_A d = V$, A ,y EioAk ehkjj¡d gUkdhFk. vdNt nraaggll NtiyahdJ A ,y mOjj Mwwyhf ,UfFk.

$$W = F_A d = P_A V$$

A ,y XuyF gUkDffhd mOjj Mwwy

$$A = \frac{\text{mOjj Mwwy}}{\text{gUkd}} = \frac{P_A V}{V} = P_A$$

A ,y XuyF e\iwffhd mOjj Mwwy =

$$A = \frac{\text{mOjj Mwwy}}{\text{e\iw}} = \frac{P_A V}{m} = \frac{P_A}{\frac{m}{V}} = \frac{P_A}{r}$$

,qF m vdgJ nfhLffgglL Neujj\y A ,y EioAk ehkjj\d e\iw. vdNt A ,y ehkjj\d mOjj Mwwy

$$E_{PA} = P_A V = P_A V \left(\frac{m}{m}\right) = m\frac{PA}{r}$$

A ,y ehkjj\d e\iyahwwy

$PE_A = mgh_A,$

A ,y ehk XlljjidfhuzkhfehkjjidaffMwwy

$$KE_A = \frac{1}{2}mv_A^2$$

vdNt A ,y ehk XlljjidhynkhjjMwwy

$E_A = EP_A + KE_A + PE_A$

$$E_A = m\frac{P_A}{r} + \frac{1}{2}mv_A^2 + mgh_A$$

,NjNghy a_B, v_B, kwWk $P_B$vdgit KiwNa B ,y Foha\d FWfFntlLggugG› ehk B ,y nkhjj Mwwy

$$E_B = m\frac{P_B}{r} + \frac{1}{2}mv_B^2 + mgh_B$$

Mwwy khwh tj\a\y\UeJ

$E_A = E_B$

$$m\frac{P_A}{r} + \frac{1}{2}mv_A^2 + mgh_A = m\frac{P_B}{r} + \frac{1}{2}mv_B^2 + mgh_B$$

$$\frac{P_A}{r} + \frac{1}{2}v_A^2 + gh_A = \frac{P_B}{r} + \frac{1}{2}v_B^2 + gh_B \text{ khw\y\}$$

NkNy css rkdghlil ,ttWk vOjyhk

$$\frac{P}{rg} + \frac{1}{2}\frac{v^2}{g} + h = \text{khw\y\}$$

NkNy css rkdghlhdJ Mwwy khwh tj\a\d t\isthFk. cuhat\dhy Mwwy ,ogG Vwglhjtiu ,rrkdghL nkaahdjhFk. Mdhy ,qF› ehkjj\d VLfs nttNtW j\irNtfqfs\y nrytjhy mtwww\f\ilNa VwgLk cuhaT t\ira\dhy Mwwy ,ogG cUthf\wJ. ,jjifa Mwwy ,ogghdJ nghJthf ntgg Mwwyhf khwwggLf\wJ. vdNt nghndsy\ njhlhghdJ› Ro\ ghFe\iyAss myyJ ghFe\iyaww eHkqfSfF klLNk nghUeJk. Fw\gghf ehkkhdJ f\iljjsfFoha to\Na nts\Naw\dhy

$$h = O\text{Þ}\ \frac{P}{rg} + \frac{1}{2}\frac{v^2}{g} = \text{khw\y\}$$

nghndsy\ Njw\wj;j\d; gad;ghLfs;:
#iwf;fhw\y; $iufs; J}f;f\ vw\aggLjy;:

Kwfhyqfsy tLfs myyJ Fbirfsd Nkw$iufs cssthW rhathf tbtikffgglld. mwtay fhuzk vddntdy nghndsyad jjJtjjdgb tLfs #iwffhwW myyJ Gayy ,UeJ ghJfhffggLfdwd.

GayfhwW tRkNghJ kww gFjfSfF Nrjk Vwglhtzzk Fbirfsd $iufs J}ffv vwaggLk. nghndsyad Njwwggb mjNtfkhf tRk fhwwhdJ $iufFNkNy P_1vdw Fiwej mOjjjij VwgLjJfwJ. $iufF fNoAss P_2vdw mOjjk mjfkhFk. vdNt ,ej mOjj NtWghL ($P_2 - P_1$) NkyNehffa ceJ tiria cUthff $iu NknyOkg fhwWld NrheJ J}ff vwaggLfwJ.

tkhd ,wfif cahjjy (Aerofoil lift):
thD}hjad ,wfiffshdJ› NkygFj fogFjiatl mjfkhf tiseJk› KdgFjad Kid gdgFj Kidiatl mfykhfTk ,UfFkhW tbtikffgglLssd. thD}hj ,aqFk NghJ ,wfifad fOss fhwiwtl ,wfifad NkygFjay css fhwW cssthW Ntfkhf efUfwJ.

nghndsyaid jjJtggb ,wfifad fogFjay css mOjjkhdJ› NkygFjiatl mjfkhf ,Uggjhy rfj thaej cahjjy vdggLk NkyNehffa ceJtir nrayglL mJ thD}hjia NkyNehff caur nrafwJ.

Gdrd RluLgG
Gdrd RluLggy vhthA EzJisad toahf mjf jirNtfjJld ntstUfwJ. ,jdhy Fohad css mOjjk FiwfwJ. vdNt ntsffhwwhdJ Ntfkhf mLggDs fhwWj jwggd toNa EioeJ vhthATld fyeJ cssthW eyewr Rliuj jUfwJ.

ntdRhkhd (Venturimeter):

,ffUtahdJ› xU Fohad toNa nryYk mKff ,ayhj ehkk ghAk tjjij (myyJ ghAk Ntfk) mstl cjTfwJ.,J nghndsyaid Njwwjjd mbggilay nraygLfwJ. ,J AkwWk A vdw ,U mfdw Fohafisf nfhzLssJ (FWfF ntlLg gugG A) mit B vdw FWfyhd (FWfFntlLggugG a) Foha %yk ,izffgglLssd. U tbt mOjjkhdahdJ ,ttU mfdw kwWk FWfyhd FohafSffilNa cssthW ,izffgglLssJ. mOjjkhdaay css jutjjd mlhjj 'ρ_m' A ,y css mfykhd gFjaYss ghakjjd mOjjk P_1vdf. 'ρ' mlhjjAld 'v_1' jirNtfjjy ghakk Fohaid DsNs ghatjhy FWfyhd gFjay mjd Ntfk 'v_2'. vd mjfhffwJ vdf fUJf. nghndsyaid Njwwggb ,ej Ntf mjfhggghdJ B ,y css FWfa gFjay ghakjjd mOjjkhd P_2itf FiwffwJ. vdNt A fFk›B fFk ,ilNa css mOjj NtWghlhdJ ($\Delta P = P_1 - P_2$) mOjjkhdaay css jutjjd cau NtWghllhy mstlggLfwJ.

njhlhkhwyr rkdghlbdgb

$$Av_1 = av_2$$

mjhtJ

$$v_2 = \frac{A}{a} v_1$$

nghndsyaid rkdghlilg gadgLjj

$$P_1 + r\frac{v_1^2}{2} = P_2 + r\frac{v_2^2}{2} P_2 + r\frac{1}{2}\left(\frac{A}{a} v_1\right)^2$$

Nkwfzl rkdghlbyUeJ mOjj NtWghlhdJ

$$DP = P1 - P2 = r\frac{v_1^2}{2}\frac{(A^2 - a^2)}{a^2}$$

vdNt mfdw Fohad A Kidady jut Xlljjd Ntfk

$$v_1^2 = \sqrt{\frac{2(DP)a^2}{r(A^2 - a^2)}} \Rightarrow v_1 = \sqrt{\frac{2(DP)a^2}{r(A^2 - a^2)}}$$

kwWk xU tdhbay A d toahfg ghaeJ nryYk jutjjd gUkd

$$V = Av_1 = A\sqrt{\frac{2(DP)a^2}{r(A^2 - a^2)}} = aA\sqrt{\frac{2(DP)}{r(A^2 - a^2)}}$$

gw gadghLfs;

nghndsyad Njwwkhd J› Kffakhf jhdaqfp thfdqfsy fhhGNullh› tbflb gkGfs› njspgghdfs Mfatwiw tbtikffg gadgLfwJ. cjhuzkhf fhhGNullhy FohaKid (Nozzle) vdggLk. Ezza Jisad toahf fhwwhdJ kf Ntfkhf csNs tUfwJ. ,eNehtpy Ezza fOjJggFjay mOjjk Fiwffgg lL› nglNuhy myyJ vhnghUs csspOffggllTld fydy gwwitgGfF rhahd mstpy fhwWk vhnghUSk fyffggLfwJ.

xU rpyejp tiy ehk vz Ztij tpl kfTk tYthdjhFk. rpyejp tiyad xU jdp E}yhdJ mjd epiyiatpl gy Mauk klqF epiw nfhzl gwfFk grrpfisj jLff ,aYk.rpyejp tiyad aqFzfk Njhuhakhf 4.5×10^9 N m^{-2}. ,ej kjpgig kufflilad aq Fzf kjpgGld xggpLf.

- xU nghUspd mZffSfF ,ilNa css tpir mZtpil tpir kwWk nghUspd %yf$WfSfF ,ilNa css tpir %yf$wpil tpir MFk.
- `{f tpj klrp vyiyfFs jifthdJ jhpGfF Nehjjftpy cssJ.
- XuyF guggpy nraygLk tpir jifT MFk. xU nghUspd FWfF ntlLggugG A kwWk nrYjjggl tpir F vdpy jiftpd vz kjpgG F/A. ,Otpir myyJ mKffjjifT ,uzilAk xNu thjijapy elrpjjifT vdf $wyhk.
- xU cUisapd es khWghlbwFk mjd njhlff esjjpwFk ,ilNa css jfT ΔL/L MdJ elrpjjhpG vdggLk.
- klrp vyiyfFs elrpj jifTfFk elrpjjhpGfFk ,ilNa css tpfpjk fkgpg nghUspd aqFzfk vdggLk.
- klrp vyiyfFs gUkjjiftpwFk gUkjjhpGfFk ,ilNa css tpfpjk gUkfFzfk vdggLk.
- klrp vyiyfFs rWfFgngahrrpj jiftpwFk rWfFgngahrrpj jhpGfFk ,ilNa css tpfpjk tpiwgGfFzfk vdggLk.
- ghanrha tpfpjk = gfffthlLjjhpG / esthlLjjhpG
- XuyF gUkdpy fkgapy Nrkpffggll klrp epiy Mwwy U = $\frac{1}{2} \times$ jifT × jhpG = $\frac{1}{2} \times Y \times (jhpG)^2$,qF Y vdgJ nghUspd aqFzfk MFk.
- A vdw Nkwgugg py nraygLk nrqFjj tpir F vdpy mOjjkhdJ XuyF guggpy nraygLk tpir vd tiuaWffggLfwJ.
- ehkgguggpypUeJ h Mojjpy nkhjj mOjjkhdJ $P = P_a + \rho gh$, ,qF vdgJ fhwwOjjk› kwWk mjd kjpgG 1.013×10^5Pa MFk.
- gh]fy tpjpggb xatpy css ghakjjpy xNu caujjpy css midjJg Gsspfspyk mOjjk rkkhFk.
- kjpgG tpjpapdgb xU nghUspd %ofpa gFjp ntspNawWk jutjjpd vil nghUspd vilfF rkkhfNth myyJ mjpfkhfNth ,Uejhy› nghUshdJ mjjutjjpy kpjfFk.

- xU ehkjjpd ghfpay vz vdgJ ehkjjpd XuyF guggpy ehk ,affj jpirfF nrqFjjpiraply XuyF jpirNtfr rhpitf nfhzLss ehkjjpd njhLtiujjpiraply nraygLk ghfpay tpir MFk.
- xU ehk XllkhdJ xU Gsspiaf fleJ nryYk xtnthU ehkjJfSk xNu ghijaply mjwF Kd flej Jfspd NtfjjpNyNa flejhy mej xllk thprrh Xllk vdggLk.
- ghak Xlljjpy jpirNtfkhdJ khWepiyj jpirNtfjijj jhzbdhy xllkhdJ rowrp Xllkhf khWfpwJ.
- xU cUis tbt Fohapd topNa ghak Xllk thprruh myyJ Rowrp Xllkh vd KbT nratjhy nudhyL vz Kffpajtk ngWfpwJ.
-]Nlhf rkdghL F=6*phav* ,qF a MuKss Nfhsjjpd kJ nraygLk ghfpay tpir F kwWk v MdJ Nfhsjjpd KwWjjpirNtfk MFk.

- xU ehkjjpd gugG ,Otpirahdj ehkg guggpy tiuaggll xuyF esKss fwgidf Nfhlbd topNa NfhlbwF nrqFjjhf› guggpwF ,izahfr nraygLk ,Otpir vd tiuaWffggLfpwJ.

- jputk kwWk jpzkgnghUs jputjjpDsNs rejpfFk Gsspaply tiuaggll njhLNfhLfSfF ,ilNa css Nfhzk jplk kwWk jput Nrhbapd NrhNfhzk vdggLk.

- nfhLffggll xU Gsspaply fleJ nryYk xtnthU ghakjJfspd jpirNtfKk fhyjijg nghWjJ khwhky ,Uggpd ghak Xllk ruhd Xllk vdyhk.

- $a_1 v_1 = a_2 v_2$vdw rkdghL xU Fohapd topNa nryYk ghakjjpwfhd njhlhkhwpypr rkdghL vdggLk kwWk ghak Xlljjpy ghakjjpd epiw kwhky cssjd fhuzkhf mikfpwJ. mjdgb› xU thprrh Xlljjpy css mKff ,ayhj. ghFepiyaww ghakjjpd XuyF epiwffhd mOjj Mwwy› ,aff Mwwy kwWk epiw Mwwy Mfpatwwpd $lLjnjhif khwpypahFk. mjhtJ $P/\rho + v^2/v + gh = khwpy$p.

11TH , awgpay;
njhFjp– 2
myF– 8

ntggKk; ntgg ,afyftpaYk; (Heat and Thermodynamics)

ntggk; kwWk; ntggepiy:
mwpKfk;

ntggepiy kwWk ntgg ,ttuzLk> mdwhl thotpy kpf Kffpag gqfhwWfpdwd. midjJ capdqfSk rhptu nraygLtjwF mtwwd cly ntggepiyia xU Fwpggpll mstpy guhkhpjjy mtrpakhFk. czikapy capdqfs thotjwFj Njitahd ntggepiyia #haNd jUfpwJ. ,awifiag GHpeJ nfhstjwF kpfTk mbggilahdJ ntggepiy kwWk ntggjijg gwwpa Ghpjyhfk. ntggepiy> ntggk Nghdwtwiw tpsfFk ,awgpaypd xU gphpNt ntgg ,afftpay> ,ej myfpy toqfgglLss fUjJffs ntggk> Fspfhrr; kwWk ntggepiyia ntggjjpypUeJ NtWgLjjpg ghggjwF JizGhpAk. ntgg ,afftpaypy css ntggk kwWk ntggepiy ,ttuzLk xdWld xdW neUqfpaj njhlhGila nttNtW ,awgpay msTfshFk.

ntggjjpd; clfUjJ

Fiwej ntggepiyapYss nghUspd kJ> mjpf ntggepiyapYss nghUis itfFk NghJ> mjpf ntggepiyapYss nghUspypUeJ Fiwej ntggepiyAss nghUSfF jddpirahf Mwwy ghpkhwwk vwgLk. ,tthwwYfF ntgg Mwwy myyJ ntggk vdW ngah. ,tthwwy ghpkhww epfoNt ntggggLjJjy vdW miofffggLk. ,ej ntgggghpkhwwjjpdhy rpy Neuqfspy nghUspd ntggepiy caUk myyJ khwwk Vwglhky mNj ntggepiyapNyNa ebfFk.

ntggk vdgJ Mwwy msT vdw jtwhd Ghpjy rpy Neuqfspy VwgLtJzL. ",J kpfTk ntggkhd jzzh; ",J ntggk Fiwej jzzh" Nghdwit nghUsww thffpaqfshFk. Vnddpy> ntggk vdgJ xU msT myy; mJ cah ntggepiyapYss nghUspypUeJ Fiwej ntggepiy css nghUSff ghAk ghpkhww MwwyhFk. ntggggLjJk epfoT KbTwwg gpddh ntggk vdw thhjijia ehk gadgLjjf$lhJ. ntggk vdgJ ghpkhwwkilAk Mwwiy Fwpffhk Nkadwp nghUspy Nrkpjjitffgglss Mwwiyf Fwpffhj.

vLjJffhlL:

a. ,ej Vhpapy mjpf kio cssJ.

b. Ftisapy css #lhd Njehpy mjpf ntggk cssJ.

,ttuzL $wWfspy css jtW vJ?

jhT:

kiongho pAk NghJ> Nkfqfspypypy UeJ Vhp jzzpiug ngWfpwJ. kio nghoptJ epdwTld Vhp KdG ,Uejij tpl mjpfj jzzpiug ngwwpUfFk. ,qF kio vdgJ Nkfqfspypy UeJ jzzpiug ngWk xU nrayhFk. kio nghoptJ xU msT myy. khwhf kio Nkfqfs jzzpuhf khwwkileJ VhpfF nrytijf Fwpffpk. vdNt Vhpapy mjpf kio cssJ vdW $WtJ jtwhFk. khwhf Vhpapy mjpfj jzzh cssJ vdW $WtNj nghUjjkhdjhFk.

Ftisapy cssNjeh ntggggLjJtjhy mLggpypUeJ ntggjijg ngWfpwJ. Njeiu ,wffp itjjTld mJ Kdgpypy UeJ ijtpl mjpf mf Mwwiyg ngwwpUfFk. ntggk vdgJ cah ntggepiyapYss nghUspypUeJ>Fiwej ntggepiyapYss nghUSfF Mwwy nrytijf Fwpffpwj. ntggk XH msT myy. vdNt Ftisapy css Njehpy mjpf ntggk cssJ vdW $Wtij tp Ftisapy css Njeh mjpf #lhf cssJ vdgNj nghUjjkhdjhFk.

Ntiyapd; clfUj;J:

cqfspd ,uzL cssqiffisAk xdWld xdW NjafFkNghJ› mtwwpd ntggepiy cahtij fhzyhk. cqfs cssqiffspd kJ xU Ntiy nraaggLfpwJ. mej nraaggll Ntiyahyjhd ntggepiy cahejJssJ. jwNghJ cqfs cssqiffis fddjjpd kJ itfFkNghJ› fddjjpd ntggepiy cahtijf fhzyhk. Vnddwhy cssqiffspy ntggepiy fddjjpy ntggepiyia tpl mjpfk. mjdhy ntggk cssqifapypUeJ fddjjpwF ghafpwJ. NkNy $wggll vLjJffhlbypUeJ ehk mwptJ vddntdwhy cssqiffspd ntggepiy cahejJ nraaggll Ntiyapdhy› fddjjpd ntggepiy cahejJ cssqiffspypUeJ› fddjjpwF ntggk ghpkhwwggljhy› jhd ,it fhllgglLssd.

mikgG xdwpd kJ Ntiy nraaggLk NghJ rpy Neuqfspy› mikggpd ntggepiy caUk.

myyJ rpy Neuqfspy mNj epiyapy ebfFk. ntggjijg NGhdNw NtiyAk xU msT myy. mJ Mwwiy ghpkhwWk xU nrayhFk. vdNt ,ejgnghUs mjpf Ntiyiag ngwWssJ myyJ Fiwej Ntiyiag ngwWssJ Nghdw thffpaqfisg gadgLjjf$lhJ.

mikgG› #oypd kJ xU Ntiyiar nraJ mr#oYfF Mwwiy khwwk nraAk myyJ #oy› mikggpd kJ xU Ntiyia nraJ mej mikggpwF Mwwiy khwwk nraAk. vdNt xU nghUspypUeJ kwnwhU nghUSfF Ntiy %ykhf Mwwiy khwWtjwF mttpuzL nghUsfSk nttNtW ntggepiyapy ,Uff Ntzba mtrpakpyiy.

ntggepiyapd; clfUj;J:
ntggepiy vdgJ nghUnshdwpd #Ljdik myyJ Fspjjdikiaf Fwpggjhfk. #lhf css nghUnshdwpd ntggepiy cahej kjpgigg ngwwpUfFk. ,uzL nghUsfs ntggj njhlhgpy css NghJ mitfSffpilNa ghAk ntggjjpd jpiria ntggepiy jhkhdpffpwJ.

ntggepiyapd SImyF nfytpd (K)

FwpgG: ntgg ,afftpaypYk mOjj myF thAffspd ,afftpaw nfhsif ,uzbYk› ehk vej fzffl nraAk NghJ› ntggepiyia nfytpd myfpy klLNk gadgLjj Ntz Lk.
eilKiwapy nryrpa] (°C) kwWk /ghud `l (°F) vdw msTfs gadgLjjggLfpdwd.
ntggepiykhdpiaf nfhzL (Thermometer) nghUspd ntggepiyia msejwpayhk.
xU ntggepiy mstpLk Kiwapypuej kwnwhU ntggepiy mstpLk KiwfF khwWtjwfhd fzfflL Kiwfs nfhLffgglLssd.

gUgnghUspd; ntgggg z;Gfs;:
ghapy; tpjp rhhy]; tpjp kwWk; ey;ypaypG thA tpjp:

gUkd V nfhzl nfhsfydpy Fiwej mOjjjjpy (mlhjjp) css thA xdwpidf nfhzL epfojjggll Nrhjidapypuej gpdtUk KbTfs fpilffpdwd.

- khwh ntggepiyapYss thA xdwpd mOjjk› mjd gUkDfF vjphtpfpjjjpypUfFk $P = \frac{1}{v}$, jid ,uhghl ghapy (Robert Boyle) vdgth (1627 – 1691) fzlwpejhh. vdNt ,ttpjp ghapytpjp vd mioffggLfpwJ.

ntggepiyia xU mstpLk; Kiwapypuej kwpnwhU mstpLk; Kiwfpf khwpWtjwpfhd topKiw

mstpLk; Kiw	nfy;tpd; KiwfpF	nfy;tpd; KiwapypUeJ kww Kiwfpf
nryrpa]	K = °C + 273.15	°C = K – 273.15
ghud ` l	K = (°F + 459.67) ÷ 1.8	°F = (K 1.8) – 459.67
mstpLk Kiw	ghud ` l KiwfF	ghud ` l Kiwapypuej kww KiwfF
nryrpa]	°F = (1.8 × °C) + 32	°C = (°F – 32) ÷ 1.8
mstpLk Kiw	nryrpa] KiwfF	nfytpd Kiwapypuej kww KiwfF
ghud ` l	°C = (°F – 32) ÷ 1.8	° F = (1.8 ×°C) + 32

- khwh mOjjjjypUeJ thA xdwpd gUkd› mjd ntggepiyfF (nfytpd) Nehjjftpy UfFk.$V \mu T$
- ,jid [hf] rhhy] (Jacques Charles) (1743-1823) vdgth fzlwejhh. vdNt ,ttpj rhhy] tpj vdW mioffggLfpwJ. ,ttpuzL tpjpfisAk xdwpizfFkNghJ gpdtUk rkdghL fpilfFk

PV = CT ,qF C vdgJ NehfFwp nfhzl khwpyahFk.

,ej NehfFwp khwpy Cnfhsfydpyss Jfsfspd vz zpfiffF Nehtpfpjjjpy ,UfFk vdgij gpdtUk tpthjjjpd %yk mwpayhk. xjj gUkd V, mOjjk P kwWk ntggepiy T, nfhzl xNu tifahd thAthy ,ttpuzL nfhsfydfSk epuggggllssd vdf. ,uzL nfhsfydpYk css thA NkNy Fwpggpllss PV = CT vdw rkdghlbd gb nraygLk. ,ttpuzL

jdpjjdpahd nfhsfyidAk fhlbAssthW xNu mikgghff fUjpdhy mtthAtpd mOjjk kwWk ntggepiy XNu kjpggpidg ngWk Mdhy gUkDk kwWk ntggepiy Jfsfspd vz zpfifAk ,uzL klqfhFk.

MfNth thAtpd gUkd 2V kwWk Jfsfspd vz zpfif 2C. vdNt eyypayT thAr rkdghL $\frac{P(2V)}{T} = 2C$. ,rrkdghL ekfF czhjJtJ vddntdwhy NehfFwp khwpy C fzbgghf thAtpYss Jfsfspd vz zpfifia rhhejpUfFk vdgjhFk. NkYk ,jd ghpkhzk $\left[\frac{PV}{T}\right] = JK^{-1}$,ej NehfFwp khwpy C l Jfsfspd vz zpfif (N) apd k klqF vd vOjyhk. ,qF k vdgJ nghJ khwpyahd Nghyl]nkd khwpyahFk. (1.381×10^{-23} JK^{-1})

PV = NkT

rkdghL l Nkhyfspd mbggilapYk vOjyhk.

thA xdW µ Nkhyfs nfhzl Jfsfisg ngwwpUejhy› mtthAtpYss nkhjjjJfsfspd vz zpfifia gpdtUkhW Fwpggplyhk.

N = µ N_A

,qF N_A vdgJ mtfhlNuh vz (6.023×10^{23} mol^{-1}) MFk. rkdghL ,y css N ,d kjpgig gpujpapLkNghJ PV = µ NAkT vdffpilfFk. ,qF N_Ak = R vdgJ nghJ thAkhwpy vd mioffggLk. ,jd kjpgG 8.314 J/mol. K.

vdNt µNkhy nfhzl eyypayG thA xdwpd thAr rkdghlil gpdtUkhW vOjyhk.

,rrkdghlbwF eyypayG thAtpd epiyrrkdghL (equation of state) vdW ngah. ,rrkdghL rkepiyapYss ntgg ,afftpay mikgG xdwpd mOjjk› gUkd kwWk ntggepiyia xdWld xdW njhlhGgLjJfpwJ.

vLjJffhlL
8 km njhiyt‡y‡UeJ k‡j‡t z ba‡d %yk gss‡fF tUk kh z t‡a‡d› k‡j‡t z ba‡d rffujj‡d fhwwOjjk 27°C ,y 240 kPa. mkkh z t‡ gss‡ia milejTld rffujj‡d ntgge‡iy 39°C vd‡y rffujj‡d fhwwOjjjj‡d kj‡gg‡idf fh z f.

jhT:
rffujj‡y css fhww‡id eyy‡ayG thAthff fUj‡dhy› thA %yf$Wfs‡d vz z‡fifAk rffujj‡d gUkDk ,qF khw‡y‡ahFk. vdNt 27°C ntgge‡iya‡Yss thA %yf$Wfs $P_1V_1 = NkT_1$, yl‡a thAr rkdghlilAk›39°C ntgge‡iya‡Yss thA %yf$Wfs $P_2V_2 = NkT_2$vdw ,yl‡a thAr rkdghlilAk e‡iwT nraAk.

,qF T_1 kwWk T_2 vdgJ nfyt‡d ntgge‡iy MFk.

$$V_1 = V_2 = V$$

$$\frac{P_1V}{P_2V} = \frac{NkT_1}{NkT_2}$$

$$\frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$P_2 = \frac{T_2}{T_1}P_1$$

$$P_2 = \frac{312K}{300K} \times 240 \times 10^3 Pa = 249.6kPa$$

vLj¡Jf¡fhl¡L
37°C cly ntgg e‡iyAila kd‡jnuhUth Rthr‡fFk NghJ› mth‡d Eiuauy‡y 5.5 y‡llh fhwW 1 ts‡ kzly mOjjjj‡y (1 atm = 101 kPa) csNs nryf‡wJ. kd‡jh‡d Eiuay‡y css Mf]‡[d %yf$Wfs‡d vz z‡fifiaf fzff‡Lf. (Fw‡gG : fhww‡y 21% Mfr‡[d cssJ)
jhT:
Eiuauy‡y css fhw‡iw Xh eyy‡ayG thAthff fUj‡ eyy‡ayG thAr rkdghlilg gadgLjj‡ thA %yf$Wfs‡d vz z‡fifiaf fzff‡lyhk.

$$PV = NkT$$

,qF thAt‡d gUkd y‡llh‡y nfhLffgglLssJ. xU y‡llh vdgJ 10 cm gff msT nfhz l fdrJuf nfhs fyd‡d gUkDfFr rkk vdNt›

1 y‡llh = 10 cm × 10 cm × 10 cm = 10^{-3} m^3

$$N = \frac{PV}{kT} = \frac{1.01 \times 10^5 Pa \times 5.5 \times 10^{-3} m^3}{1.38 \times 10^{-23} JK^{-1} \times 310K}$$

N = 1.29×10^{23}%yf$Wfs

fzff‡lggll N kj‡gg‡y 21% klLNk Mf]‡[d %yf$Wfsh‡Fk. vdNt nkhjj Mf]‡[d %yf$Wfs‡d vz z‡fif

$$= 1.29 \times 10^{23} \times \frac{21}{100}$$

Mf]‡[d %yf$Wfs‡d vz z‡fif = 2.7×10^{22} %yf$Wfs

vLj¡Jf¡fhl¡L:

xU Nkhy msTss VNjDk xU thAtpd gUkid gbjju ntggepiy kwWk mOjjjjpy (SPT) fhzf. NkYk mNj %yf$Wfspd gUkid miwntggepiy (300K) kwWk xU tspkzly mOjjjjpy (1 atm) fzffpLf.

gbjju ntggepiy kwWk mOjjjjpy› ntggepiy (T = 273 K myyJ 0°C) kwWk mOjjk (P = 1 atm myyJ 101.3 kPa)

eyypayG thArrkdghlil ,qF gdgLjJk NghJ $V = \frac{mRT}{P}$

,qF $m = 1mol$ kwWk R = 8.314 J/mol.K. ,kkjpgGfis rkdghlby gpujpaplk NghJ

$$V = \frac{(1mol)(8.314\frac{J}{mol}K)(273K)}{1.013\acute{}10^{5}Nm^{-2}}$$

$$= 22.4 \times 10^{-3}\ m^3$$

ehk mwpej gb 1 ypllh (L) = 10^{-3} m^3.

,jypUeJ 1 Nkhy msTss vej xU eyypayG thAtpd gUkd 22.4 ypllh vd ehk mwpeJ nfhssyhk.

miw ntggepiyapy xU Nkhy msTss thAtpd gUkidffhd 22.4 yplliu $\frac{300K}{273K}$ My ngUff NtzLk. mtthW fzffpLk NghJ› thAtpd gUkd 24.6 ypllh vdffpilfFk.

vLjJffhlL:

cdJ tFggiwapy css fhwwpd epiwia ,ayG ntggepiy kwWk mOjjjjpy (NTP) fzffpLf. ,qF ,ayG ntggepiy vdgJ miw ntggepiyiaAk› ,ayG mOjjk vdgJ xU tspkzly mOjjjijf (1 atm) FwpfFk.

jhT:

tFggiw xdwpd ruhrhp msT KiwNa 6m esk›5 m mfyk kwWk 4 m caukhFk. vdNt miwapd gUkd V = 6 × 5 × 4 = 120m^3 MFk. ,ggUkdpy css Nkhyfspd vzzpfifiaf fzffpl NtzLk.

miw ntggepiyapYss (300K) xU Nkhy thAtpd gUkd 24.6 ypllh. vdNt›

%yf$Wfspd vzzpfif

$$m = \frac{120m^3}{24.6\acute{}10^{-3}m^3} \approx 4878mol$$

fhwwpy 21% Mf]p[d›78% ielu[d kwWk 1% Mhfhd› i`lu[d› `ypak kwWk nrdhd Nghdw thaffspd fyit cssJ. fhwwpd %yf$W epiw 29 $gmol^{-1}$ vdNt miwapy css fhwwpd nkhjj epiw m = 4878 × 29 = 141.4 kg MFk.

ntgg VwGjjpwd; kwWk; jdntgg VwGjjpwd; (Hat capacity and specific heat capacity)

27°C ntggepiyapYss eH kwWk vziz ,ttpuzilAk rk mstpy vLjJfnfhzL 50°C ntggepiyia milAk tiu ,ttpuzilAk ntggggLjjTk. 50°C ntggepiyia miltjwfhd Neujijj jdpjjdpNa fzlwpaTk. ,ttpuzL NeuqfSk epyrrak xdwhf ,UffhJ. vzizAld xggpLkNghJ eh mjpf Neujij vLjJfnfhsSk. ,jypUeJ 50°C ntggepiyia mila vziziatpl eUfF mjpf ntggk Njit vdgij ehk mwpayhk. ,gNghJ ,uzL klqF ehpid vLjJfnfhzL mjd ntggepiy 50°C milAk tiu ntggggLjjp mjwfhd Nejij fzlwpAk NghJ› mJ VwfdNt fzlwpaggl Neujijg NghdW ,Uklqfhf ,UggijAk ehk mwpayhk.

nfhLffggll nghUspd ntggepiy>Tapypl;UeJ T+ΔT Mf cahjj Njitggl;lk ntggjjpd msNt 'ntgg VwGjjpwd" vd tiuaWffggLfpwJ.

$$\text{ntgg Vwgjjpwd } S = \frac{DQ}{DT}$$

xU fpNyhfpuhk epiwAila nghUspd ntggepiyia xU nfytpd myyJ 1°C cahjj Njitggl;lk ntggjjpd msNt> jd ntgg VwGjjpwd vd tiuaWffggLfpwJ.

$$Q = ms\Delta T$$

$$\text{vdNts} = = \frac{1}{m}\left(\frac{DQ}{DT}\right)$$

,qF s vdgJ nghUspd jdntgg VwGjjpwdhFk. ,jd kjpgG nghUspd jdikiar rhhejNjadwp msit rhhejjyy.

ΔQ = ntggjjpd msT

ΔT = ntggepiy khwwk

m = nghUspd epiw

jdntgg VwGjjpwd SI myF Jkg^{-1}K^{-1}MFk. ntgg VwGjjpwd> jd ntgg VwGjjpwd> jd ntgg VwGjjpwd ,uzLk NehfFwp nfhzl msTfs MFk.

ehpd jdntgg VwGjjpwd ngUk kjpgigg ngwWssij mwpayhk. ,jd fhuzkhfjjhd kpd cwgjjp epiyaqfs kwWk mZffU ciyfspYk ehpid Fsp&lbahf (Coolant)gadgLjJfpNwhk.

rpy nghJthd nghUspfspd; jdntgg VwGjjpwd; (20°C **ntggepiy kwWk;** 1 atm **mOjjjjpy;**)

nghUs;	**jd; ntgg VwGjjpwd;** (Jkg^{-1}K^{-1})
fhwW	1005
<ak	130
jhkpuk	390
,UkG (v/F)	450
fz zhb	840
mYkpdpak	900
kdpj cly	3470
eh	4186

ntgg VwGjjpwd myyJ jdntgg VwGjjpwd vdgJ nghUsfspy nghjpeJss ntggjjpd msitf Fwpggit myy. Vnddpy ntggk vdgJ cah ntgg epiyapYss nghUspypUeJ Fiwej ntggepiy css nghUSfF ghAk xU ghpkhww MwwyhFk. vdNt ntgg VwGjjpwd vdgijtpl mf Mwwy VwGjjpwd vdgNj rhpahd gjkhFk Mdhy neLqfhykhf ,tthhjijfs toffjjpy cssjhy mtwiw mggbNa ehk gadgLjJfpNwhk.

xU epiwAila ,uzL nttNtW nghUsfis xNu tjjjpy ntggggLjJk NghJ>Fiwej jdntgg VwGjjpwDila nghUspd ntggepiy Ntfkhf mjpfhpfFk. ,NjNghdW mtwiw Fspht pfFk NghJk> Fiwej jdntgg VwGjjpwDila nghUs Ntfkhf Fspht ilAk

thAffsd gzGfisggww gbfFkNghJ› Nkhyhh (%yf$W) jdntgg VwGjjwd (molar specific heat capacity) eilKiway gadgLjjggLfwJ. Nkhyhh (%yf$W) jdntgg VwGjjwid gdtUkhW tiuaiw nraayhk. xU Nkhy msTss nghUsd ntggeiyia 1K myyJ 1°C cahjJtjwFj Njitggk ntgg Mwwyd msNt Nkhyhh (%yf$W) jdntgg Vwgjjwd vdggLk. ,jidg gdtUkhW vOjyhk.

$$C = \frac{1}{m}\left(\frac{DQ}{DT}\right)$$

,qF C vdgJ nghUsd Nkhyhh (%yf$W) jdntgg Vwgjjwidf Fwffwj. NkYk µ vdgJ nghUsy css %yf$Wfsd Nkhy vz zfifiaf FwfFk.

Nkhyhh (%yf$W) jdntgg VwGjjwdd myF J mol^{-1} K^{-1}MFk. ,JTk xU NehfFw nfhzl msthFk.

jl› jut kwWk; thAf;fsd; ntgg tht;T:

ntggeiy khwwjjdhy nghUsfsd tbtk› gugG kwWk gUkdy VwgLk khwwNk ntgg tht;T vdggLk.

nghUsfsd %dW eiyfSk (jl› jut kwWk thA) ntggggLjJkNghJ tht;tilAk. jlgnghUnshdiw ntggggLjJkNghJ mjd mZffs mtwwd rkeiyg Gssiag nghUjJ Ntfkhf mjhtilfdwd. kww nghUsfSld xggLk NghJ jlgnghUsfsd mstY VwgLk khwwk Fiwthdjhfk. ,uay tzbfsd ,Uggggh ijfsy ry ,lqfsy rwa ,ilntsp tlgglbUffk. Vnddy Nfhil fhyqfsy ,UgGgghij tht;tilAk. mtthW ntggeiy khwwqfsd NghJ vsjhf tht;tilaTk› RUqfTk Vww tifay ghyqfsYk› ,UgGgghijfsYk tht;tilAk ,izgGfs fhzggLk.

jutqfsd %yf$wil tir› jlgnghUsfsd %yf$wil tiria tlf Fiwthf ,UfFk. vdNt mit jlgnghUsfistl mjfkhf tht;tilAk. ,ejg gzgd mbggilayjhd ghjur ntggeiykhd nraygLfwJ.

thA %yf$Wfisg nghUjjtiu mtwwd %yf$wiltir fllljjll Gwffzfk mstNyNa ,UfFk. vdNt mit jlgnghUsfistl kf mjfkhf tht;tilAk. vLjJffhllhf #lhd fhwW milffgglLss gY}dfsy css fhwW %yf$Wfis ntggggLjJk NghJ mit tht;tileJ mjf ,ljij miljJfnfhsSk.

ntggeiy cahthy nghUsfsd ghkhzjjy VwgLk mjfhgNg ntggtht;T vdggLk.

esjjy VwgLk tht;T es tht;T (Linear expansion) vd mioffggLk. ,NjNghdW guggy VwgLk tht;T gugG tht;T (Area expansion) vdTk› gUkdy VwgLk tht;T gUk tht;T (Volume expansion) vdTk mioffggLk.

els; tht;T:

jlgnghUsfsy›ΔT vdw rW ntggeiy khwwjjhy esjjy VwgLk rW khwwk $\left(\frac{DL}{L}\right)$›

ahdJ ΔT fF Nehtfjjjy ,UfFk.

$$\frac{DL}{L} = a_L DT$$

vdNt $a_L = \frac{DL}{L DT}$

,qF $\alpha_L$es t/hTfFz fk

ΔL = esjjy VwgLk khwwk

L = njhlff esk

ΔL = ntggei yay Vwgll khwwk

vLj;Jf;fhl;L:

g/uhd] ehlbYss ,Ukghy nraaggll <gs NfhGujjd cauk f/lljll 300 m MFk. g/uhd] ehlbd Fs/hfhyjj/d ntggei y 2°C kwWk Nfhilffhyjj/d ruhrh/ ntggei y 25°C ,ttuzL gUt ei yfSff/ilNa <gs NfhGujj/d caujjy VwgLk khwwjijf fzff/Lf. ,Ukg/d es t/hTf Fz fk α= 10 ×10^{-6} per°C

jhT:

$$\frac{DL}{L} = a_L DT$$

$$DL = a_L L DT$$

,Wffkhd %lgglLss fzzhbfFtisa/d %bia vs/jhfjj/wff› mjid #lhd jzzh/y mUNf r/wJ Neuk itjj/Uff NtzLk. g/ddh mjid vs/jhfj j/wffyhk. Vndd/y fzzhbf Ftisa/d %ba/d ntgg t/hT fzzhbiat/l mj/fkhf ,Uggjhfk.
Ntfitffggll #lhd Klilia Fs/hej jzzh/y NghlL mjd xlbid ch/jjhy mJ Klila/y/UeJ vs/jhf g/heJ tUk. Vndd/y Klil kwWk XL xtnthdWk ntttNtW ntggt/hitg ngww/Uggjhfk.

ΔT = 10 × 10^{-6}× 300 × 23 = 0.69 m = 69 cm

gugG t/hT:

ΔT vdw r/wa ntggei y khwwjjhy nghUs/d gugg/y VwgLk gugGjj/hG $\left(\frac{DA}{A}\right)$ MdJ ΔT fF Neht/f/jjj/y ,UfFk. ,jidg g/dtUkhW Fwggl yhk.

$$\frac{DA}{A} = a_A DT$$

vdNt› $a_A = \frac{DA}{ADT}$

,qF $\alpha_A$gugG t/hTf Fz fk

ΔA = gugg/y VwgLk khwwk

A =njhlffg gugG

ΔT = ntggei yay Vwgll khwwk

gUk t/hT:

ΔT vdw r/wa ntggei y khwwjj/dhy› nghUs/d gUkd/y VwgLk gUkjj/hG $\left(\frac{DV}{V}\right)$ MdJ ΔT fF Neht/f/jjj/y ,UfFk.

$$\frac{DV}{V} = a_v DT$$

vdNt› $a_v \frac{DV}{VDL}$

,qF α_v = gUk t/hTf Fz fk

ΔV = gUkd/y VwgLk khwwk

V = njhlffggUkd

ΔT = ntggepiyapy Vwgll khwwk
jplgnghUsfspd es tphpT> gugG kwWk gUk tphpTf Fzqfspd myF °C^{-1}myyJ K^{-1}

nfhLffggll nghUSfF

$\frac{DL}{L} = a_L DT$ (es tphpT)

$\frac{DA}{A} \gg 2a_L DT$ (gugG tphpT » 2 × es tphpT)

$\frac{DV}{V} \gg 3a_L DT$ (gUk tphpT = 3 × es tphpT)

ehpd Kuzgll tphpT(Anomalous Expansion of Water):
rhjhuz ntggepiyfspy jputqfis ntggggLjJkNghJ tphptilAk kwWk Fsphtpfhk NghJ RUqFk. Mdhy eh ,jwF Kuzhd xU gz igg ngwWssJ. 0°C Kjy 4°C tiu ntggggLjJkNghJ jz zh RUqFfpwJ. jz ziu miw ntggepiyapy UeJ Fsphtpfhk NghJ 4°C ntggepiyia milAk tiu mjd gUkd FiwAk. 4°C ntggepiyfFf fNo mjidf Fsphtpfhk NghJ mjd gUkd mjpfhpfFk. NkYk mjd mlhjjp FiwAk. mjhtJ ntggepiyapy eh ngUk mlhjjpiag ngWk. ehpd ,ejjjdikNa ehpd Kuzgll tphpT vd mioffggLfpwJ.

Fsph ehLfspy> Fsphfhyjjpd NghJ Vhpfspd NkwgugG ntggepiy mjd mbgGw ntggepiyia tpl FiweJ fhzggLk fhllgglLssJ. Vnddpy jpl ehpd (gdpfflb) mlhjjp rhjhuz ehpd mlhjjpiatplf FiwT>4°C ntggepiyfFk fNo ciwej eh (gdpfflb) rhjhuz ehpd NkNy kpjeJ VHpfspd Nkwgugg pwF tUk. ,jwFffhuzk ehpd Kuzgll tphpthFk. Vhpfs kwWk Fsqfspd NkwgugG ciweJ gdpfflbfshy %lgglbUggpDk> mbapy csseH ciwahky ,UeJ ehtho capdqfisf fhfFk.

epiy khwpwk;
nghJthf midjJg nghUsfSk jpl> jput kwWk thA vdw %dW epiyfspy fhzggLk. ntggggLjJk NghJ myyJ Fsphtpfhk NghJ nghUsfs xU epiyapypUeJ kwnwhU epiyfF khwwkilAk

vLj;Jf;fhl;L:

1. cUFjy (jpl epiyapypUeJ jput epiyfF)
2. Mtpahjy (jput epiyapypUeJ thA epiyfF)
3. gjqfkhjy (jpl epiyapypUeJ Neubahf thA epiyfF)
4. ciwjy (jput epiyapypUeJ jpl epiyfF)
5. RUqFjy (thA epiyapypUeJ jput epiyfF)

cs;Siw ntgg VwGj;jpwd; (Latent Heat Capacity):

ghjjpuk xdwpYss ehpid ntggggLjJk NghJ mjd nfhjpepiyahd 100°C ntggepiyia milAk tiu> mjd ntggepiy caUk. mjdgpdG nkhjj eUk Mtpahfk tiu mjd ntggepiy khwhky epiyahf ,UfFk. ,ej epfotpd NghJ ntggk njhlhrrpahf eUfF ghafpwJ. ,Ugg pDk mjd ntggepiy> nfhjpepiyiatpl mjpfhpffhky mNj epiyapy ebffpwJ ,JNt csSiw ntgg VwGj jpwdpd ,ayghFk. XuyF epiwAila nghUspd epiyia khwWtjwFj Njitggk ntggjjpd Mwwypd msNt> nghUspd csSiw ntgg VwGjjpwd vd tiuaWffggLfpwJ.

$$Q = m \times L$$

vdNt> $L = \frac{Q}{m}$

,qF›L = nghUsid csS iw ntgg VwGjjwd
Q = ntggjjid msT
m = nghUsid eiw
csS iw ntgg VwGjjwdid SI myF
Jkg^{-1}MFk

eiykhwwjjid NghJ ntggjijf nfhLffNth myyJ effNth NehejhYk› mjd ntggeiy khwhky njhlheJ mNj eiyaiy ebfFk.

- jil – jut eiy khwwjjwfhd csS iw ntggk› cUFjyid csS iw ntggk (Latest heat of fusion (L_1) vd mioffggLk.
- jut– thA eiy khwwjjwfhd csS iw ntggk› Mtiahjyid csS iw ntggk (Latest heat of vaporisation) (L_v)
- jil – thA eiy khwwjjwfhd csS iw ntggk› gjqfkhjyid csS iw ntggk (Latest heat of sublimation) L_s)

KgGs;sif (Triple point)::
nfhLffggll nghUnshdwid %dW eiyfSk (jil› jut kwWk thA) ntgg ,affr rkeiyaiy cssNghJ› mgnghUsid ntggeiy kwWk mOjjNk nghUsid KgGss;sif vd mioffggLfwJ.

ehid KgGss;sif 273.1 K kwWk gFjif Mtif mOjjk (Partial vapour pressure) 611.657 gh]fyhFk.

ntgg mstl;bay;:
ntgg ,afftiay mikgg xdwid ntggggLjJkNghJ› mttikggiyUeJ ntsigggLk ntggjij myyJ mttikggidhy clftuggLk ntggjij msfFk xU nraNy ntgg mstlbay vd mioffggLk. cah ntgg eiyaiYss nghUnshdiw Fiwej ntggeiyaiYss nghUnshdWld NrhjJitfFk NghJ› cah ntggeiyaiYss nghUs ,oej ntggk› Fiwej ntggeiyaiYss nghUs VwWfnfhzl ntggjjwF rkkhFk. #oYfF vttijkhd ntggKk fljjgglhJ. ,jidf fzij Kiwaiy gidtUkhW Fwiggiyhk.

$Q_{vwG} = -Q_{,ogG}$
$Q_{VwG} + Q_{,ogG} = 0$

Vwfggll ntggk myyJ ,oej ntggjij ntggkhdiaf (Calorimeter) nfhzL msffyhk. nghJthf ntggkhdi vdgJ fhlbAssthW eh eiuggggll ntggfhggL nraaggll nfhsfydhFk.

cah ntggeiyaiYss (T_1) khjih nghUs xdwid› miw ntggeiyaiy (T_2) ntggkhdiay css ehiy %ofitff NtzLk. riwJ Neujjwfggiddh eH kwWk ntggkhdi ,uzLk T_f vdw ,Wji ntggeiyia milAk. ntggkhdi fhggiggllLssjhy› cah ntggeiy khjih nghUs ,oej ntggKk. Fiwej ntggeiy eh VwWfnfhzl ntggKk rkkhFk

$Q_{VwG} = -Q_{,ogG}$

FwalL kuig ,qF ftdiff NtzLk. ntgg ,ogG vjhfFwaiYk› ntgg VwG NehfFwaiYk Fwiggiggllssd.

$Q_{VwG} = m_2 s_2 (T_f - T_2)$
$Q_{,ogG} = m_1 s_1 (T_f - T_1)$

,qF s_2 kwWk s_1 vdgit KiwNa eh kwWk khjhg nghUsd jd ntgg Vwgjjwdfshfk.
vdNt›

$$m_2s_2 (T_f - T_2) = -m_1s_1 (T_f - T_1)$$
$$m_2s_2T_f - m_2s_2T_2 = m_1s_1T_f + m_1s_1T_1$$
$$m_2s_2T_f - m_1s_1T_f = m_2s_2T_2 + m_1s_1T_1$$

,Wjp ntggepiy $T_f = \frac{m_1s_1T_1 + m_2s_2T_2}{m_1s_1 + m_2s_2}$

vLjJffhlL:
50°C ntggepiyapYss 5L eh›30°C ntggepiyapYss 4L eUld fyffggLfwJ. ehd ,Wjp ntggepiy vdd? ,qF ehd jd ntgg VwGjjwd 4184 $Jkg^{-1}K^{-1}$vdf.

jhT:
gdtUk rkdghlil ehk gadgLjjyhk.

$$T_f = \frac{m_1s_1T_1 + m_2s_2T_2}{m_1 + s_1 + m_2s_2}$$

m_1 = 5L = 5kg kwWk m_2 = 4L = 4kg, $s_1 = s_2$

NkYk T_1 = 50°C = 323 K kwWk T_2 = 30°C = 303 K
vdNt

$$T_f = \frac{m_1T_1 + m_2T_2}{m_1 + m_2} = \frac{5' 323 + 4' 303}{5+4} = 314.11K$$

T_f = 314.11 K – 273 K » 41°C

50°C kwWk 30°C ntggepiyfspy css rk msT ehpid ($m_1 = m_2$) xdWld xdW fyfFkNghJ› ,Wjp ntgg epiy ,ttpuzL ntggepiyfspd ruhrhpahFk.

$$T_f = \frac{T_1 + T_2}{2} = \frac{323 + 303}{2} = 313K = 40°C$$

xNU ntggepiyapy (30°C) css ,uzL eh khjhpfis xdWld xdW fyfFkNghJ mtwwpd ,Wjp ntggepiyAk 30°C MFk. ,jypUeJ ehk mwpeJ nfhstJ vddntdwhy ,ttpuzL eH khjhpfSk ntggrrkepiyapy cssd. vdNt ,uzbwFk eLNt vttpjkhd ntggghpkhwwKk eilngwtpyiy vdggjhFk.

thAffs myyJ jputqfis xdWld xdW fyfFk NghJ mffyitapd ,Wjprrkepiy ntggepiy mgnghUsfspd epiwfs› jd ntgg VwGjjwdfs kwWk ntgepiyfisr rhhejpUfFk vdgij ,qF epidtpy nfhss Ntzlk. NkYk rk msTss xNu nghUsfis xdWld xdW fyfFkNghJ klLNk ,Wjp ntgg epiyahdJ jdpjjdp ntggepiyfspd ruhrhp kjpggpwF rkkhFk.

ntgg khwpwk: (Heat Transfer):

ehk mwpejgb ntggk vdgJ xUtif ghpkhww MwwyhFk. mtthwwy ntggepiy NtWghlbd fuzkhf xU nghUspypUeJ kwnwhU nghUSfF khwwggLk. ntgg khwwk %dW topfspy eilngWk mit ntggffljjy› ntggr rydk kwWk ntggffjphtrR MFk.

ntggepiy NtWghlbd fhuzkhf nghUsfSffpilNa Neubahf ntggkhwwk VwgLk epforrpfF ntggffljjy vdW ngah. ,uzL nghUsfis xdWld xdW njhlLfnfhzbUfFkhW itfFkNghJ› cah ntggepiyapYss nghUspypUeJ› Fiwej ntggepiy css nghUSfF ntggk khwwggLfwJ. ntggjij vspjhfj jd topNa fleJ Nghf mDkjpFFk nghUsfSfF ntggffljjpfs vdW ngah.

ntggf; flj;Jj;jpwd; (Thermal Conductivity):

ntggjijf fljJk jpwDfF ntggffljJjjpwd vdW ngah.

khwhepiy epgejidapy xuyF ntggepiy NtWghlby> xuyF jbkd nfhzl nghUspd topNa xuyF guggpwFr nrqFjjhf css jpirapy fljjggLk ntggjjpd msNt> nghUspd ntggffljJjjpwd vd mioffggLfpwJ.

khwhepiyapy> ntggffljJ tjk Q, ntggepiy NtWghL ΔT kwWk FWfF ntlLggugg A Mfpatw WfF Nehjjftpyk> fljjpapd esjjpwF (L) vjphjjftpYk ,UfFk. ntggk fljJk tjjij gpdtUkhW Fwpggplyhk.

$$\frac{Q}{t}=\frac{KADT}{L}$$

,qF K vdgJ ntggffljjy vz MFk.

(,jid nfytpd ntgg epiy K vdj jtwhfg GhpeJnfhssf$lhJ)

ntggffljJjjpwdpd SI myF Js^{-1} m^{-1} K^{-1}myyJ Wm^{-1} K^{-1}

khwhepiy (Steady state):
vej epiyapy> midjJ ,lqfspYk ntggepiy xU khwh kjpggpid milfpwNjh kwWk vej ,ljjpypUeJk vttpjkhd ntggKk ghpkhwwgglhky cssNjh meepiyNa khwh epiy vd mioffggLfpwJ.

nghJthf nghUsp fspd; ntggf;flj;Jj;jpwd; (W m^{-1} K^{-1}) **,y;** 1 atm

nghUs;	ntggf;flj;Jj;jpwd;	nghUs;	ntggf;flj;Jj;jpwd;
ituk	2300		0.2
ntsspl	420	kuffliil	0.17
jhkpuk	380	`ypak	0.152
mYkpdpak	200	nkdikahd ,uggh	0.042
v/F	40	jzzh	0.56
gdpfflb	2	fhwW	0.023
fzzhb	0.84		
nrqfy	0.84		

ntggffljJjjpwd nghUspd jdikiar rhhejJ. vLjJffhllhf ntsspl kwWk mYkpdpak cahej ntggf fljJjjpwidg ngwWssjhy mit rikay ghjjpuqfs nraaggadgLfpdwd.

ntggr; rydk; (Convection):

jputqfs kwwk thAffs Nghdw ghakqfspy css %yf$Wfs czikahd efhtpdhy ntgg Mwwy khwwggLk epfoT ntggrrydk vd mioffggLfpwJ. ,ej ntggrrydjjpy %yf$Wfs vttpj flLgghbdwp xU ,ljjpypUeJ kwnwhU ,ljjpwF efhfpdwd. ,eepfoT ,awifahfNth myyJ Gwtpir fhuzkhfNth Vwglyhk.

rikay ghjjpujjpy nfhjpfFk jzzh ntggrrydjjpwF xU rpwej cjhuzkhFk. ghjjpujjpd mbapy css jzzh mjpf ntggjijg ngwW mjd fhuzkhf tphtileJ mlhjjp FiwAk. ,ej Fiwej mlhjjpapd fhuzkhf %yf$Wfs Nkwgugig Nehffpr nryYk. mNj Neujjpy Nkwgugpypss %yf$Wfs Fiwej ntgg MwwiygngWtjhy mtwwpd mlhjjp mjpfkhf ,UfFk. vdNt mit ghjjpujjpd mbggffjjpwF tUk.

,eeifoT njhlheJ eilngWk. ,tthW %yf$Wfs NkYk. fOk efhtij ntggrryd Xllk (Convection current)vdW mioffidNwhk. miw xdwid ntJntJgghf itff ehk miwr#Nlwwiiag gadgLjJfiNwhk. #NlwwifF mUNf css fhwW %yf$Wfs ntggkileJ tihtilAk mjdhy mtwwid mlhjji FiweJ miwaid NkwgFjifFr nryYk. mNj Neujjiy mlhjji mjifKss Fsihej fhwW mbggFjifF tUk. ,tthW VwgLk fhwW %yf$Wfsid njhlh RowriNa› ntggrryd Xllk vd mioffggLfiwJ.

ntggf;fjih tlrR:

#lhf css rikfFk mLgG xdwid mUNf ekJ iffis elbdhy ntggjij czuyhk. ,qF #lhf css mgnghUisj njhlhkNyNa ehk ntggjij czhfiNwhk. Vnddiy ,qF #lhf css rikfFk mLggiyiUeJ ntggkhdJ ntggffjihtrR %yk ekJ iffSfF tUfiwJ. #hiadiyiUeJk ntgg Mwwiy ehk ,Nj Kiwaiyjhd ngWfiNwhk. ,ffjihtrR ntwwijjid toiNa gaziJ Gtiia milfiwJ. vej tijkhd Clfjjid cjtiAk ,dwi xU nghUsiyiUeJ kwnwhU nghUSfF Mwwiy khwWtJ fjihtrrid xU riwgGg gzghFk. Mdhy ntggffljjy kwWk ntggrrydk ,ttiuzbYk ntgg Mwwiy khwwk nratjwF Clfk mtriak vdgij ftdiffTk.

ntggffjihtrR vdgJ

xU nghUsiyiUeJ kwnwhU nghUSfF kidfhej miyfsidhy ntggk guTk eifoT MFk.

1. #hiadiyiUeJ tUk #hiaf fjihtrR Mwwy
2. miw #Nlwwiaiyiu eJ tUk ntggffjihtrR

gfy Neuqfsiy› #hiaffjihfs fly eiutil Ntfkhf eiyjij #NlwWk ,jwFffhuzk eiyjjid Fiwthd jdntgg VwGjjiwd MFk. ,jd tiisthf eiyggugiy css fhwW tihtileJ mjd mlhjji FiweJ NkNy nrdWtiLk. mNj Neujjiy flwguggiYss Fsihej fhwW eiyjij Nehffi tRk ,jidNa fly fhwW (sea breese) vdW mioffidNwhk. ,uT Neuqfsiy flwgugig til eiyggugG Ntfkhf Fsihrri milAk (eiuggugid Fiwej jdntgg VwGjjiwd) ,jd tiisthf flwguggiYss fhwW tihtileJ mjd mlhjji FiweJ NkNy nrdWtLk. mNj Neujjiy eiyggugiYss mlhjji mjifkhd FsihejfhwW fliy Nehffi tRK ,jidNa eiyffhwW (land breeze) vdW mioffidNwhk.

nghJthf ntggeiiy gUg nghUsfSld klLNk (jil› jiut kwWk thA) njhlhGilaJ vdw nghJffujJ cssJ. Mdhy ntggfjihtrRk xU ntgg ,afftiay mikgghFk. ,jwF edF tiuaWffggll ntggeiiyAk› mOjjKk czL. #hiadiyiUeJ tUk flGydhFk fjihtrrid ntggeiiy 5700 K. ,jid Gtii fillijjll 300K ntggeiiyAss mfrritgG fjihtrrhy ntsifF (Space) kzLk ckiofiwJ.

eiA+l;ldid; FsihT tijj:

eiA+lldid FsihT tijiaidgb nghUnshdwid ntgg ,ogG tjk› mgnghUSfFk #oYfFk css ntggeiiy NtWghlbwF Nehtifijjjy ,UfFk.

$$\frac{dQ}{dt}\mu - (T - T_s)$$

Neujij nghUjJ ntggk njhlheJ FiweJ nfhzNl nrytij vjihffFwi fhlLfiwJ.

,qF. T = nghUsid ntggeiiy

T_s = #oyid ntggeiiy

fhllgglLss tiuglijjiyiUeJ njhlffjjiy FsihT tjk mjifkhfTk giddh ntggeiiy FiwafFiwa FiwthfTk cssij njsithf czuyhk.

m eiiwAk›s jdntgg VwGjjiwDk css nghUnshdiwf fUJ. mjd ntggeiiy T vdf. #oyid ntggeiiyia T_s vdf. dt vdw riwa Neu ,ilntsiaiy Vwgll ntggeiiyfFiwT dT vdiy ntgg ,oggid msT

$$dQ = msdT$$

rkdghL ,UGwKk dt my tFfF

$$\int_0^{T} \frac{dT}{T - T_s} = -\int_0^{t} \frac{a}{ms} dt$$

$$\frac{dQ}{dt} = \frac{msdT}{dt}$$

e¡A¡lld¡d FsphT t¡j¡a¡y¡UeJ

$$\frac{dQ}{dt} \mu - (T - T_s)$$

$$\int_0^{T} \frac{dT}{T - T_s} = -\int_0^{t} \frac{a}{ms} dt$$

$$\frac{dQ}{dt} = -a(T - T_s)$$

,qF a vdgJ NehfFw¡ khw¡y¡.

rkdghLfs kwWk ,UeJ

$$-a\,(T - T_s) = ms\,\frac{dT}{dt}$$

$$\frac{dT}{T - T_s} = \frac{a}{ms} dt$$

rkdghL ,d ,UGwKk njhifggLjJf.

$$\int_0^{T} \frac{dT}{T - T_s} = -\int_0^{t} \frac{a}{ms} dt$$

$$\ln (T - T_s) = -\frac{a}{ms} t + b_1$$

,qF b_1xU khw¡y¡ahFk. ,uzL gffKk mLfFf Fw¡aL vLjjhy ekff f¡ilggJ

$$T = T_s + b_2 e^{-\frac{a}{ms} t}$$

,qF $b_2 = e^{b1}$ = xU khw¡y¡

vLjJffhlL:

27°C ntgge¡iy css miw xdw¡y css #lhd eh 92°C y¡UeJ 84°C ntgge¡iyfF Fsph 3 e¡k¡lqfis vLjJfnfhsf¡wJ. mNj eH 65°C y¡UeJ 60°C ntgge¡iyfFf Fiwa vLjJfnfhs Sk Neujijf fzff¡Lf.

3 e¡k¡lqfs¡y #lhd eh¡d ntgge¡iy 8°C FiweJssJ. 92°C kwWk 84°C ,d ruhrh¡ ntgge¡iy 88°C ,J miw ntgge¡iyiat¡l 61°C mj¡fkhf cssJ. rkdghL gadgLjj¡dhy

$$\frac{dT}{T - T_s} = \frac{a}{ms} dt \text{ myyJ } = \frac{dT}{dt} = \frac{a}{ms}(T - T_s)$$

$$\frac{8°C}{3\min} = \frac{a}{ms}(61°C)$$

,NjNghdW 65°C kwWk 60°C,d ruhrh¡ ntgge¡iy 62.5°CMFk. ,J miw ntgge¡iyia t¡l 35.5°C mj¡fkhf cssJ.

$$\frac{5°C}{dt} = \frac{a}{ms}(35.5°C)$$

,t t¡uzL rkdghLfisAk tFfFk NghJ

$$\frac{8^{o}C}{3\min}\Big/\frac{5^{o}C}{dt} = -\frac{a}{ms}(61^{o}C)\Big/-\frac{a}{ms}(35.5^{o}C)$$

$$\frac{8\times dt}{3\times 5} = \frac{61}{35.5}$$

$$dt = \frac{61\times 15}{35.5\times 8} = \frac{915}{284} = 3.22 \text{ நிமிடம்}$$

ntgg khwwj;jpd; tpjpfs; (Laws of Heat Transfer):

ntggghpkhwwj;jpw;fhd ghpnth]l; nfhs;if (Prevost theory of Heat Exchange):
O K ntggepiyiajjtpu midjJ ntggepiyfspYk vyyhg nghUsfSk ntggffjhtrir ckpofpdwd. ,NjNghdW #oypy ,UeJ ntggffjhtrir clfthfpdwd. vLjJffhllhf eqfs ahuhtJ xUtiuj njhLkNghJ mth cqfs tpuyfs ntggkhf myyJ Fspnrrpahf cssij czhthh.

cah ntggepiyapYss nghUnshdW> #oypUeJ ngWk ntggjij tpl mjpf ntggjij #oYfF fjhtrrpd %yk nfhLfFk. ,NjNghdW Fiwej ntgg epiyapYss nghUnshdW ,ofFk ntggjijtpl mjpf ntggjij #oypUeJ ngwWfnfhsSk.

ghpnth]l ntggrrkepiyf fUjij fjhtrRfFg gadgLjjpdhh. mjdgb midjJg nghUsfSk ntggffjhtrir ntspggLjJfpdwd. Mdhy Fspnrrpahf cssnghUistpl> cah ntgge piyg nghUsfs mjpf ntggffjhtrir ntspapLk. xU Fwpggpll Neujjpy ,uzL nghUsfspd ntgggghpkhwW tjKk rkkhFk. ,eepiyapy ,ttpuzL nghUsfSk ntggr rkepiyapy cssd vdf $wyhk.

Ropnfytpd ntgge piyapy klLNk nghUsfs ntgg ckpoit epWjJfpdwd. vdNt ghpnth]bd nfhsifapdgb #oypd jdik vjjifajhf ,UejhYk> midjJk nghUsfSk Ropnfytpd ntgge piyfF Nky cssmidjJ ntgge piyfspYk ntggffjhtrir ckpOk

]nl/ghd; Nghyl;]nkd; tpjp (Stefan Boltzmann law):
]nl/ghd Nghyl]nkd tpjpapdgb> fUgnghUspd XuyF gugg pdhy xuyF Neujjpy

KOikahd fUknghUshf ,yyhj nghUsfSfF
$E = e\sigma T^4$
,qF 'e' vdgJ gugg pd ckpojpwd MFk.
xU Fwpggpll ntgge piy kwWk miyesjjpy nghUspd gugg pdhy fjhtrggLk MwwYfF> mNj ntgge piy kwWk miyesjjpy KOffUknghUspdhy fjhtrggLk MwwYfFk cssjfNt ckpojpwd vd tiuaWffggLfpwJ.

tpadpd; ,lgngahr;rp tpjp (Wien's Displacement Law):

cyfpYss midjJg nghUsfSk fjhtrir ckpofpdwd. mffjhtrRfspd miyesqfs nghUsfspd nfytpd ntgge piyiar rhhejpUfFk. ckpoggLk fjhtrRfs nttNtW miyesqfisg ngwwpUfFk. NkYk mtt iyesqfspd nrwpTk (intensity) nttNtwhdit.

tpadpd tpjpggb› xU fUgnghUs fjhtrrpdhy ckpoggLk ngUkrnrwpT nfhzl miyesk (/$_m$) mffUknghUspd nfytpd ntggepiyfF (T) vjhtpfpjjpy ,UfFk.

tpadpd tpjpggb› xU fUknghUs fjhtrrpdhy ckpoggLk ngUkrnrwpT nfhzl miyesk (/$_m$) mffUk nghUspd nfytpd ntggepiyfF (T) vjhtpfpjjpy ,UfFk.

$$/_m \mu \frac{1}{T}(or)/_m = \frac{b}{T}$$

,qF›bvdgJ tpad khwpy› ,jd kjpgG 2.898×10^{-3} mK

,jypUeJ ehk mwpeJ nfhstJ vddntdwhy nghUspd nfytpd ntggepiy caUkNghJ ngUkrnrwpT miyesk (/$_m$) kpffhej epwkhiyapd Fiwej miyesjij (ngUk mjhnt z) Nehff ,lngahrrp milAk.

Nkwfzl tiuglljjpypUeJ ngUkr nrwpT miyesk /$_m$ nfytpd ntggepiyfF vjhtpfpjjpy ,Uggij mwpayhk. ,ttisNfhlbwF fUknghUs fjhtprR tisNfhL vdW ngah.

tpad; tpjpAk; ekJ ghh;itAk;:

ekJ fzfshy kpdfhej epwkhiyapy css fz ZW gFjpia klLk (400 nm Kjy 700 nm tiu) ghhffKbtjd fhuzk vdd?

xU nghUSk fjhtrir ckpOk. vdNt #hpaDk fjhtrir ckpOk. NkYk mjd gugG ntggepiy fplljjll 5700 K. ,kkjpgig rkdghL gupjapLk NghJ›

$$/_m = \frac{b}{T} = \frac{2.898 \acute{} 10^{-8}}{5700} » 508 nm$$

,JNt ngUkrnrwptpwfhd miyesk MFk. #hpadpd gugG ntggepiy Njhuhakhf 5700 Kvd cssjh mjwfhd fjhtrR epwkhiy neLffk 400 nm Kjy 700 nm tiu fhzggLk. ,JNt kpdfhej epwkhiyapd fz ZU gFjpahFk.

kdpj ,dk ,ejf fjhtrir clftheJjhd ghpzhk tshrrp milejJ. vdNt kdpjffzfs #hpa epwkhiyapy css fz ZU gFjpia klLNk czu KbAk. mfrrptgG gFjpiaNah myyJ X fjh epwkhiyiaNah czu KbahJ.

ekfF mUfpy css rhpa] (Sirius) (ntggepiy 9940 K) vdw tpzkd mUfpy css Nfhspy kdpj ,dk Njhdwp ,Uejhy mthfspd fzfs kpdfhej epwkhiyapy css Gw Cjhffjhfis czu KbAk. ,jid rkdghL gadgLjjp mwpeJ nfhssyhk.

vLj;Jf;fhl;L:

A vdw fUknghUs xdwpd fjhtrRjjpwd E_A. NkYk ,J /$_A$ vdw miyesjjpwF ngUk Mwwy fjhtrggLfpwJ. B vdw kwnwhU fUknghUspd fjhtrRjjpwd E_B = N E_A; $\frac{1}{2}/_A$ vdw miyesjjpwF B fUknghUspy ,UeJ fjh trggLfpwJ vdpy N ,d kjpgigf fhzf?

tpadpd ,lngahrrp tpjapypUeJ

/$_{max} T$ = khwpy; ,J A kwWk B vdw ,uzL fUknghUsfSfFg nghUeJk.

,qF $I_B = \frac{1}{2} I_A$

$I_A T_A = I_B T_B$. ,qF $I_B = \frac{1}{2} I_A$

$$\frac{T_B}{T_A} = \frac{I_A}{I_B} = \frac{1}{\frac{1}{2}} = 2$$

$T_B = 2T_A$

]nl/ghd - Nghy]lnkd tjaypUeJ

$$\frac{E_B}{E_A} = \left(\frac{T_B}{T_A}\right)^4 = (2)^4 = 16 = N$$

fUkngh Us B, fUkngh Us A it tl Fiwej miyesjijNa ckOk. vdNt fUkngh Us A it tl mjf Mwwy nfhzl fjhtrir fUkngh Us B ckOk.

ntgg ,afftpay; mwpKfk;

ehk Keija ghTfspy ntggk> ntggepiy kwWk nghUsfspd ntgggzGfisg gwwp gapdNwhk. ntgg ,afftpay vdgJ ,awgpaypd xU ghthFk. ,ggh T Ntiyia ntggkhfTk kwWk ntggjij NtiyahfTk khwWtjpy cssp tjpfis tthffwJ. ntgg ,afftpaypd tjpfs ghapy> rhhy]> nghD}yp [{y> fshrpa]> nfytpd> fhhNdh kwWk n`ykN`hyl] Nghdw mwtpay mwpQhfspd %dW E}wwhzL fhy MaTfspd mbggilapy KiwggLjjgglljhFk.

mdwhl thotpy ekikrRwwp eilngWk midjJ epfoTfSk Vd ekJ clypaff epfoTfs $l ntgg ,afftpay tjpfSfF clglL eilngWfpdwJ. vdf $wpdhy mJ kpifahfhJ. vdNt ntgg ,afftpay vdgJ ,awgpaypd XH ,dwpaikahj ghthFk.

ntgg ,afftpay; mikgG:

ntgg ,afftpay mikgG (Thermodynamic system) vdgJ ,ggpugQrjjpy tiuaWffggll xU gFjpahFk. NkYk mOjjk (P), gUkd (V), kwWk ntgghpiy (T) Nghdw Kffpa vzzpfifapylqfpa Jfsfspd (mZffs kwWk %yf$Wfs) njhFgNg ntgg ,afftpay mikgghFk. kjKss ,ggpugQrjjpd gFjpNa #oy (Surrounding) vdggLk. ,ttpuzLk Xh vyiyahy ghpffgglLssd.

vLj;Jf;fhl;Lfs;

Xh ntgg ,afftpay mikgG vdgJ> jpl> jput> thA kwWk fjhtrR Nghdw vej tbtpYk ,Uffyhk.

ntgg ,afftpay; mikgG	#oy;
thspapy cssp jzzh	jpwejntspl
miw xdwpDs cssp fhwW %yf$Wfs	miwfF ntspapy cssp fhwW
kdpj clyp	jpwejntspl
flypy cssp kd	flypy eh

ntggrpkepiy (Thernal equilibrium):

miw xdwpy xU Nfhgigapy #lhd Njeh itffgglhy> Njehpy pUeJ ntggk #oYfFf fljjggLk. rpwJ Neujjpw F gpdG #lhd NjeH #oypd ntgghpiyfF rkkhd ntgghpiyia milAk. ,jd gpdG Njehpy pUeJ #oYfNfh myyJ #oypy pUeJ NjeUfNfh ntggg ghpkhwwk VwglhJ. NjeUk #oYk ntggrrkepiyia milej tllij ,J fhlLfpwJ.

,U mikgGfs xdWfnfhdW ntggrrkepiyapy cssJ vdpy mttpuzL mikgGfSk xNu ntggepiyapy ,Uff NtzLk. NkYk mJ Neujijg nghUjJ khwhky ,Uff NtzLk.

vejputpay; rkepiy (Mechanical equilibrium):
gp]lDld css thA miljJ itffgglLss nfhsfyd xdiwf fUJf. mggp]ldpd kJ epiw xdiw itfFk NghJ foNehffpa Gtpahgg tpirapd fhuzkhf gp]ld foNehffp efheJ rpy Vww ,wffjjpwFg gpdG epwFk. gp]ld xU Gjpa ,ljij milAk. thAtpd Nky Nehffp tpir› foNehffp Gtpahgg tpiria rkd nraAk. ,eepiyapy ,ttikgig vejputpay rkepiyapy cssJ vdf$wyhk. mikgG xdW vejputpay rkepiyapy cssJ vdy› vttpjkhd rkdnraagglhj tpirAk ntgg ,afftpay mikggpd kJ nrayglf$lhJ.

Ntjpr;rkepiy(Chemical equalibrium):

xdWld xdW njhlhgpYss ,uzL ntgg ,afftpay mikgGfSffpilNa vttpj njhFgad Ntjptpidak eilngwtpyiy. vdpy mttpU mikgGfSk Ntjprrkepiyapy cssJ vdyhk.

ntgg ,af;ftpay; rkepiy (Thermodynamic equilibrium):

,uzL mikgGfs ntgg ,afftpay rkepiyapy cssd vdpy› mttpuzL mikgGfSk xdWfnfhdW ntgg› vejputpay kwWk Ntjpr rkepiyapy ,Uff NtzLk. ntgg ,afftpay rkepiyapy kgngU (Macroscopic) khwpfshd mOjjk› gUkd kwWk ntggepiy Mfpait xU epiyahd kjppgpidg ngwwpUff NtzLk. NkYk mit fhyjijg nghWjJ khwhky ,Uff NtzLk.

ntgg ,af;ftpay; epiy (Thermodynamic state variables):

,aejputpaypy jpirNtfk› cejk kwWk KLffk Nghdwit ,aqFk nghUnshdwpd epiyia tpsffggadgLfpdwd. (njhFjp 1 ,y ,twiwg gwwp GhpeJnfhzbUgghfs) ntgg ,afftpaypy› ntgg ,afftpay mikgG xdwpd epiyia tpthpfFk khwpfspd njHFggpwF ntgg ,afftpay khwpfs vdW ngah.

vLjJffhlLfs: mOjjk› ntggepiy› gUkd› mf Mwwy Nghdwit.

,ej khwpfspd kjpgG ntgg ,afftpay mikggpd rkepiyia KOtJkhf tpthpffpdwd. ntggk kwWk Ntiy ,it ntgg ,afftpay epiy khwpfs myy khwhf ,it nraykhwpfs MFk. (Process variables).ntgg ,afftpay khwpfs ,uzL tifggLk mit: msTr rhhGss khwp (Extensive variable) kwWk msTr rhhgww khwp (Internsive variable).
vLjJffhlL: gUkd› nkhjj epiw› vdlNuhgp (Entropy), mf Mwwy› ntgg VwGjjpwd Nghdwit.
msTr rhhgww khwp ntgg ,afftpay mikggpd msT myyJ epiyiar rhhejpUffhJ.

vLjJffhlL: ntggepiy› mOjjk› jdntgg VwGjjpwd› mlhjjp Nghdwit.
epiyr; rkdghL (Equation of state):

epiy khwpfis xU Fwpggpll Kiwapy njhlhGgLjJk rkdghL› epiyrrkdghL vdW mioffggLfpwJ. ,eepiyrrkdghL ntgg ,afftpay mikgnghdwpd rkepiyapy epiy khwpfSfF ,ilNa css njhlhig KOtJkhf tpthpffpwJ. ntgg ,afftpay mikgG rkepiyapy ,yiynadpy› ,eepiyr rkdghL mikggpd epiyia tpthpffhJ. ntgg ,affrrkepiyapy css epyypayG thA (idealgas) xdW PV = NkT vdw epiyr rkdghlbdhy FwpggplggLfpwJ. ,qF ehdF NgusT khwpfSk (P, V,T kwWk N)

e‰iyrrkdghlbdhy xdWld xdW njhlhGgLjjgglLssd. ,rrkdghlbYss VNjDk xU khw‰ia klLk khww ,ayhJ. vLjJffhllhf thA e‰ukg‰Ass nfhsfyd‰d g‰]lid mOjJk NghJ› thAt‰d gUkd FiwAk. Mdhy mjd mOjjk mj‰fh‰fFk myyJ thAit ntggggLjJkNghJ mjd ntgge‰iy caUk. thAt‰d mOjjk kwWk gUkDk cauyhk.

e‰iyrrkdghlbwfhd kwnwhU vLjJffhlL thdlhthy] rkdghL MFk. ntgg ,affr rke‰iya‰y css ,ayGthAffs (Real gases) ,rrkdghlbwF clgLk.

miw xdw‰Yss fhwW %yf$Wfs thdlhthy] e‰iyrrkdghlbwF KOtJkhf flLggLf‰dwd. ,Ugg‰Dk miwntgge‰iya‰y Fiwej mlhjj‰Ass fhwW %yf$Wfis ehk Njhuhakhf eyy‰ayG thAthff (Ideal gas) fUJf‰Nwhk.

ntgg ,af‰ft‰ay‰d; Ro‰ t‰j‰ (Zeroth Law of Thermodynamics):

ntgg ,afft‰ay‰d Ro‰ t‰j‰a‰dgb›A kwWk B› vdw ,uzL mikgGfs C› vdw %dwhtJ mikgGld ntggrrke‰iya‰y ,Ugg‰d A kwWk B vdw ,uzL mikgGfSk xdWfnfhdW ntggr rke‰iya‰y ,UfFk.

njhlffjj‰y nttNtW ntgge‰iya‰y css A, B kwWk C vdw %dW mikgGfisf fUJf. A kwWk B ,uzL mikgGfSk xdWld xdW vtt‰jkhd ntggjnjhlhigAk ngww‰Uff t‰yiy.

Mdhy› mit xtnthdWk C vdw %dwhtJ mikgGld jd‰jd‰Na ntggjnjhlhg‰y cssd. r‰w‰J Neujj‰wFgg‰wF A kwWk B vdw ,uzL mikgGfSk jd‰jd‰Na C Ald ntggr rke‰iya‰y ,UfFk.

milej‰Uggij ,J fhlLf‰wJ. ,k%dW mikgGfSk xUKiw ntggrrke‰iyia milejg‰dG mtww‰wf‰ilNa vtt‰jkhd ntggg gh‰khwwKk ,UffhJ Vndd‰y mk%dWk xNu ntgge‰iya‰y ,UfFk. ,jid fz‰jnkho‰a‰y g‰dtUkhW Fw‰gg‰lyhk. $T_A = T_C$kwWk $T_B = T_C$vd‰y›$T_A = T_B$MFk. ,qF T_A, $T_B$kwWk $T_C$vdgit A, B kwWk C vdw %dW mikgGfs‰d ntgge‰iyfshFk.

mikgGfs xdWld xdW ntggrrke‰iya‰y cssdth ,yiyah vdgijffhlLk xU gzNg ntgge‰iyahFk.

ntgg ,afft‰ay‰d Ro‰ t‰j‰ahdJ ntgge‰iyiaf fzlw‰aggadgLf‰wJ. vLjJffhllhf ntgge‰iykhd‰ xdiw ehff‰d mba‰y itjJf nfhsSk NghJ ntgge‰iykhd‰ clYld ntggrrke‰iyia milAk. ,eegejida‰dgb ntgge‰iykhd‰a‰d ntgge‰iy cly ntgge‰iyfFr rkkhf ,UfFk ,jd mbggila‰yjhd ekJ cly‰d ntgge‰iy fzlw‰aggLf‰wJ.

nghUnshdiwj njhlLgghhfFk NghJ mgnghUs vttsT #lhf myyJ Fs‰hrr‰ahf ,Uggij mw‰a ntgge‰iy JizGh‰f‰wJ. ek czhT cWgGfisg gadgLjj‰ nghUs‰d ntgge‰iyiaf fzlw‰a KbAkh?

ekJ ntWk fhyfs‰y xdiw jiut‰h‰gg‰d kJk kwnwhU fhiy tOtOgghd XLfs gj‰ffggll jiua‰d (Tiled floor) kJk itfFkNghJ› tOtOgghd jiua‰y itjJss fhy› jiut‰h‰gg‰d kJ itffgglLss fhiy t‰l mj‰ff Fs‰hrr‰ia czUk.
Mdhy ,qF jiu kwWk jiut‰h‰gG ,uzLk xNu miwntgge‰iya‰y ,Uggij ftd‰ff NtzLk. ,jwFf fhuzk jiut‰h‰gig t‰l tOtOgghd jiufFk ek fhYfFk‰ilNa k‰f Ntfkhf ntgggh‰khwwk VwgllJ vdgijNa fz‰ff‰wJ. ntgge‰iykhd‰ xdiw jiu kwWk jiut‰h‰gg‰d kJ itjJ ghhfFkNghJ ,uzLk xNu ntgge‰iya‰y cssij mw‰ayhk.

mf Mwwy¡ (U)
ntgg ,aff mikgG xdwpd mf Mwwy vdgJ mikggpd epiwikajijg nghUjJ mikggpYss midjJ yfWfspd ,aff Mwwy kwWk epiy Mwwyfspd $LjYfFr rkkhFk.
,lngnahT ,affk› Rowrp ,affk kwWk mjpht paffk Mfpatwiw csslffpa %yf$W ,affjjpdhy VwgLk Mwwy› mf ,aff Mwwy (EK) vdggLk.
%yf$WfSffpilNa VwgLk fthrrp kwWk tpyfF tpirahy vwgLk Mwwy› mf epiyahwwy (E_P) vdggLk.

vLjJffhlL: gpizgghwwy (Bond energy)
vdNt mf MwwyhdJ gpdtUkhW vOjggLfpwJ.

vdNt mf MwwyhdJ gpdtUkhW vOjggLfpwJ.

$$U = E_K + E_P$$

- eyypayG thA%yf$WfSffpilNa vttpjkhd ,iltpidAk ,yiy vdW fUJtjhy mtwwpd mf Mwwy KOtJk mf ,aff Mwwy tbtpNyNa ,UfFk. ,J ntggepiy› Jfsfspd vzzpfif Mfpatwiwr rhejpUfFk. Mdhy ,J gUkidr rhhejjyy. Mdhy thdlh thy] thAffs Nghdw ,ayG thAffSfF ,J nghUejhJ.

- mf Mwwy xU epiykhwp MFk. ,J ntgg ,aff mikggpd ,Wjepiy kwWk njhlffepiy ,twiw klLNk rhhejpUfFk. vLjJffhllhf jzzhpd ntgge piy 30°C ,y ,UeJ 30°C Mf ntggggLjJtjd %ykhfNth myyJ fyfFtjd %ykhfNth cahjjggLfpwJ. mjd ,Wjp mf MwwyhdJ› jzzH vtthW 40°C ntgge piyia milejJ vdw topKiwia rhhejpUffhky mjd ,Wjp ntgge piyia klLNk rhhejpUfFk.

ntgg ,afftpay mikggpd mf MwwyhdJ mikggpYss xtnthU %yf$wpd xoqfww ,affjjpdhy VwgLk ,aff MwwiyAk› mtwwpd Ntjpapay mikggpdhy VwgLk epiyahwwy ,twiw klLNk rhhejpUfFk vdgij edF GhpeJ nfhss NtzLk. mikgG KOtjwFkhd nkhjj ,aff Mwwy myyJ mikggpd <hgG epiy Mwwy Nghdwit mikggpd mf Mwwypd xU gFjp vdW jtwhff fUjf$lhJ.

a. xNu ntgge piy kwWk mf MwwYila ,uzL thA epuggggll nfhsfydfisf fUJf. mtwwpy xdW jiuapYk› kwnwhdW ,affjjpYss ,uapy tzbapYk itffggLfpwJ. ,uapy tzbapy css thAfnfhsfyd ,uapypd Ntfjjpy ,aqfpdhYk mjd csNs css thA %yf$Wfspd mf Mwwypy vttpj cahTk Vwgltpyiy.

b. xNu ntgge piy kwWk mf MwwYila ,uzL thA epuggggll nfhsfydfisf fUJf. mwwpy xdW jiuapYk› kwnwhdW h caujjpYk itffggLfpdwJ. h caujjpYss thAf nfhsfydpd <hgGepiy Mwwy mjpfnkdpDk ,ej mjpfhpG› thAtpd mf Mwwypy vttpj khwwjijAk vwgLjjhJ.

vLj¡Jf¡fhl¡L
xU thspKOtJk css rhjhuz eUld› xU Ftis RLeiu fyfFk NghJ ntggk vjjpirapy guTk?

cdJ tpilfF chpa tpsffk jUf.
thspapy css rhjhuz eiuffhlbYk› Ftisapy css #lhd eHpd ntgge piy mjpfk ,UggpDk Ftisapy css RLehpd mf Mwwiy tpl thspehpd mf Mwwy mjpfk.

Vndd;y mf Mwwy Xh msTr rhhGss ntgg ,afft;ay khw; MFk. mJ mikgg;d msT myyJ e;iwiar rhhejjhFk.

ths; eh;d mf Mwwy mj;fk vd;Dk> Ftisa;y css RLeh;y ,UeJ ntggk ths; eUfF ghAk. ,jwFffhuzk ntggk vgNghJk cah ntgge;iya;Yss nghUs;y;UeJ jho ntgge;iya;Yss nghUSfFg ghAk. NkYk ,J mikgg;d mf Mwwiyr rhhejjyy. nghUSfF ntggk khwwggll cld mtntggk nghUs;d mf Mwwyhf khw;t;Lk. vdNt nghUs ntggjij ngwWssJ vdgijt;l "nghUs xU Fw;gg;ll msT mf Mwwiyg ngwWssJ" vdW $WtNj rh;ahd KiwahFk. mikgG xdw;d mf Mwwiy mj;fh;ggjwF xU r;wej to;Kiw ntggggLjJtJ MFk. ,J g;dtUk gljj;y fhllggILssJ.

,qF k;f Kff;akhf ftdjj;y nfhss NtzbaJ ntggk vgNghJk mf Mwwiy mj;fh;ff NtzLk vdw mtr;ak ,yiy. ntgge;iy khwh e;fot;y (Isothermal eyy;ayG thAt;d csNs ntggk ghaejhYk mjd mf Mwwy;y vtt;j cahTk VwglhJ vdgij ehk g;ddhyf fwf csNshk.

[{y;d ntgg ,aej;ut;ay; rkhdk; (Joule's Mechanical Equivalent of Heat):

nghUnshdw;d ntgge;iyia mjid ntggggLjJtjd %yk cahjjyhk myyJ mgnghUs;d kJ Ntiy nratjd %yk cahjjyhk. gj;ndllhk E}wwhzby N[k] [{y vdw mw;t;ay mw;Qh ,aej;u Mwwiy mf MwwyhfTk> mf Mwwiy ,aej;u MwwyhfTk khww KbAk vdW e;&g;jjhh. mth;d Mat;d fhlbAssthW ,uzL e;iwfs fa;W xdw;d to;Na JLgG rffujJld (Paddle wheel) ,izffgglLssd. Gt;ahgG t;irahy ,uzL e;iwfSk h J}ujj;wF fNotUkNghJ 2 mgh msT e;iy Mwwiy ,uzL e;iwfSk ,off;dwd.

e;iwfs fNo tUk NghJ eh;Ds css JLgG rffuk RwWk. vdNt JLgG rffujj;wFk eUfFk ,ilNa XU cuhaT t;irjNjhdWk. ,J eh;d ntgge;iyia cahjJk. ,qF <hgG e;iy Mwwy (Gravitational potential energy) eh;d mf Mwwyhf khwwkiltij ,J czhjJf;wJ. Gt;ahgG t;irahy nraaggll Ntiya;dhy eh;d ntgge;iy caheJssJ. czika;y ntggjij nfhLggjhy VwgLk mNj t;isit ,aej;ujijf nfhzL nraaggLk Ntiya;dhy VwgLjj KbAk vdW [{y e;&g;jJsshh. 1 f;uhk e;iwAila eH;d ntgge;iyia 1°C cahjj 4.186 J Mwwy Njitggk vdW [{y fzlw;ejhh. goqfhyqfs;y ntggkhdJ fNyhh; (Calorie) vdw myf;dhy msffgglJ.

1 cal = 4.186 J

,jwF [{y;d ntgg ,aej;ut;ay rkhdJ vdW ngah.

N[k] [{y;d fhyjj;wF KdG> ntggk vdgJ fNyhh;f (Caloric) vdw ghaeNjhLk Xh j;utk vdWk kffs fUj;dhhfs. ,jj;utk cah ntgge;iya;y css nghUs;y;UeJ> Fiwej ntgge;iya;Yss nghUSfF ghAk vdTk fUj;dhhfs. fNyhh;f j;utf fUjj;dgb cah ntgge;iygnghUs;y mj;f fNyhh;f j;utKk> Fs;hrr;ahd nghUs;y Fiwej fNyhh;f j;utKk cssd. Vndd;y ntggk vdgJ Xh msT vdW mthfs fUj;aNjahFk. Mdhy jwfhyjj;y ehk ntggk vdgJ Xh msT myy mJ gh;khww;f nfhssggLk Xh gh;khww Mwwy vdW GheJ nfhzbUff;Nwhk. vdNt "ntgg ,aej;ut;ay rkhdk" vdgJ Xh jtwhd g;uNahfkhFk. Vndd;y ,aej;u Mwwy vdgJ Xh msthFk. vej xU nghUSk mj;fkhfNth myyJ FiwthfNth ,aej;u Mwwiyg ngww;Uffyhk. Mdhy ntggjj;wF ,J nghUejhJ. Vndd;y ntggk vdgJ XH msT myy. ,UejNghj;Yk ,ejg g;uNahfk njhdW njhlNl eilKiwa;y ,UeJtUtjhy mJ jwNghJk g;dgwwggLf;wJ. ,jd rh;ahdg g;uNahfk '[{y;d mf Mwwy -

,aejputpay Mwwy rkhdk" vdgNjahFk. mbggilapy [{y ,aejpu MwwiyNa mf Mwwyhf khwwpAsshh. [{ypd JLgG rffu Matpy epiwfspd <hgGepiy Mwwy› JLgG rffujjpd Roy ,aff Mwwyhf khwwkileJ› gpddh ehpd mf Mwwyhf khwwkilfpwJ.

vLj;Jf;fhl;L:

khzth xUth fhiyr rpwWzbahf 200 czT fNyhhp (foodcalorie) MwwYila czit czfpwhh. mth mtthwwiy fpzwwpypUeJ jzziu ,iwjJ gsspapy csskuqfSfF CwWtjd %yk nrytopffyhk vdf fUJfpwhh. mtthW nrytopff NtzLnkdwhy vjjid kuqfSfF mth jziu Cww KbAk? ,qF fpzwwpd Mok 25 m, Fljjpd nfhsssT 25 L, xtnthU kujjpwFk xU Flk eH Cww NtzLk vdf. (elfFk NghJ nrytopffggLk MwwiyAk› Fljjpd epiwiaAk Gwffzpffk) g = 10m s^{-2}vdf fUJf.

jhT:

fpzwwpypUeJ 25 L jzziu ,iwggjwF mthpd mf Mwwiyg gadgLjjp Gtpahg tpirfF vjpuhf Ntiy nraa NtzLk.

jzzhpd epiw = 25 L = 25 kg (1 L = 1 kg)

25 kg epiwAila jzziu ,iwff nraa Ntzba Ntiy = jzzuhy ngwggLk <hgG epiy Mwwy

$$W = mgh = 25 \times 10 \times 25 = 6250\ J$$

fhiyr rpwWzbahy ngwggll Mwwy = 200 czT fNyhhp = 200 kcal.

1 kcal = $10^3 \times 4.186$ J

$= 200 \times 10^3 \times 4.186\ J = 8.37 \times 10^5\ J$

,tthwwiyf nfhzL khzth 'n' Flqfs eiu fpzwwpypUeJ ,iwffpwhh vdf fUJf. khztuhy nrytopffggLk nkhjj Mwwy = 8.37×10^5 J = nmgh vdNt

$$n = \frac{8.37' 10^5 J}{6250 J} \text{»} 134$$

,qF n vdgJ jzzh Cwwggl Ntzba kuqfspd vzzpfifia $l Fwpffpwf.

fhiyr rpwWzb klLk czL tplL 134 Flk eiu ,iwff KbAkh? eprrak KbahJ. czikapy kdpj cly czT Mwwy KOtijAk Ntiyahf khwwhJ. Vnddpy Njhuhakhf kdpj clypd gaDWjpwd 20% MFk.mjhtJ 200 czT fNyhhpapy 20% klLNk Ntiyahf khwwkilAk. vdNt 134 Flqfspy 20% vdgJ 26 Flqfs klLNk. vdNt mkkhzth czl rpwWzbfF ,izahf nraa Kbej Ntiyapd msT 26 Flqfs eiu ,iwggNj MFk.

kjKss Mwwy ,ujj Xlljjpwfk kww clypd kww cWgGfspd ,affjjpwFk gadgLjjggLfpwJ. NkYk xU Fwpggpll msT czT Mwwy tzhf ,offggLk vdgij epidtpy nfhss NtzLk.

ekJ clypd gaDWjpwd Vd 100% ,yiy? ,jwfhd tpilia eqfs gphpT 8.9 ,y mwpeJ nfhsthfs.

ntgg ,af;ftpaypd; Kjy; tpjp:

Mwwy khwhtpjpapd $wNw ntgg ,afftpaypd Kjy tpjp MFk. epA+lldpd ,afftpaypy Mwwy khwhjjdik nghpa nghUsfspd ,aff Mwwy kwWk epiy Mwwiy csslffpAssJ. Mdhy ntgg ,afftpaypd Kjy tpjp ntggjijAk csslffpAssJ. ,ttpjapd gb mikggpd mf Mwwy khWghlhdJ (ΔU), mikggpwFf

nfhLffggll ntggjjwFk (Q) #oyd kJ mttikgG nraj NtiyfFk (W) css NtWghlbwFr rkkhFk. fzjnkhoay ,jidg gdtUkhW Fwggplyhk.

,jidg gdtUkhW Fwggplyhk.

$$\Delta U = Q - W$$

ntgg ,afftpay mikggd mf Mwwiy› ntggggLjjNah myyJ Ntiy nraNjh khww ,aYk. ,jid fNo css mlltizapy fhzyhk.

mikggd csNs ntggk ghajy	mf Mwwy mjfhfFk
mikggypUeJ ntggk ntspNaWjy	mf Mwwy FiwAk
mikggd kJ Ntiy nraaggLk NghJ	mf Mwwy mjfhfFk
mikggdhy Ntiy nraaggLk NghJ	mf Mwwy FiwAk

ntgg ,afftpayd Kjy tpjpia gadgLjJtjwfhd FwpalL kugpid mwpKfggLjjyhk. ,J fNo css mlltiz kwWk Fwpggplf fhllgglLssJ.

ntgg ,afftpay; Kjy; tpjpiag; gadgLj;Jtjw;fhd Fwpal;L kuG

mikgG ntggjijg ngWk NghJ	Q NehfFwp
mikgG ntggjij ,ofFk NghJ	Q vjphfFwp
mikggd kJ Ntiy nraaggLk NghJ	W vjphfFwp
mikgG Ntiy nraAk NghJ	W NehfFwp

nghJthf thAffisf nfhzNl› ntgg ,afftpayd Kjytpj tpsffggLfwJ. Mdhy ,ttpj vyyhtwwpwFk nghJthdJ. NkYk jutqfs kwWk jplgnghUsfsfFk ,ttpjpiag gadgLjj KbAk.

rpy Gjjfqfspy $\Delta U = Q + W$ vd ntgg ,afftpayd Kjytpj Fwpggplbufk. ,qF mikggdhy nraaggll Ntiy vjphfFwpahfTk› mikggd kJ nraaggll Ntiy NehfFwpahfTk fUjggLk. ,it ,uzLNk rhpahd Fwpal;L kuGfs jhd. ,twwpy VNjDk xU Fwpal;L kugpid ehk gdgwwyhk.

vLj;Jf;fhl;L

kdpjnuhUth 2 kg epiwAila ehpid JLgG rffujijf nfhzL fyfFtjd %yk 30 kJ Ntiyiar nrafpwhh. Vwjjho 5 kcal ntggk ehpypUeJ ntspggLfwJ› Q = -5 kcal = 5 × 4184 J = -20920 J

ntgg ,afftpayd Kjy tpjpiag gadgLjJkNghJ

$$\Delta U = Q - W$$

$$\Delta U = -20{,}920\ J - (-30{,}000)\ J$$

$$\Delta U = -20{,}920\ J + 30{,}000\ J = 9080\ J$$

jhT:

mikggd kJ nraaggll Ntiy (ehpidf fyfFtjd %yk kdpjuhy nraaggll Ntiy) W = -30 kJ = -30,000 J

mikggypUeJ ntggk ntspggLfwJ› Q = -5 kcal = 5 × 4184 J = -20920 J

,qF› mikggd kJ nraaggll Ntiyiatl ntgg ,ogG Fiwthf cssJ. vdNt mf Mwwy khWghL NehfFwahFk. ,J mikggd mf Mwwy mjfhjjijf fhlLfwJ.

vLj;Jf;fhl;L

nkyNyhllg gawrpia (Jogging) jdKk nratJ clyeyjij Ngzffhf Fk vdgJ ehkwejNj. eqfs nkyNyhllg gawrpay

<LgLk NghJ 500 kJ Ntiy cqfshy nraaggLfwJ. NkYk cqfs clypyUeJ 230 kJ ntggk ntspNawfwJ vdy› cqfs clypy VwgLk mf Mwwy khWghlilf fzffpLf.

jhT:

mikggpdhy nraaggll Ntiy (ekJ cliy mikgG vdW fUJf)

W = + 500 kJ

mikggpypUeJ (ekJ cly) ntspNawwggll ntggk Q = -230 kJ

clypy VwgLk mf Mwwy khWghL

= ∆ U = - 230 kJ – 500 kJ = - 730 kJ

vjhfFwpahdJ ekJ clypd mf Mwwy Fiwe jJ vdgijf fhlLfwJ.

knkJ epfo;T (Quasi – static Process) :

VgUkd›P mOjjk kwWk Tntggepiyapy csseyypayG thA mikggpidf fUJf. eyypayG thA milffggll cUisapd gp]ld ntspNehffp efhjJkNghJ eyypayG thAtpd gUkdpy khwwk vwgLk. ,jd tpisthf ntggepiyapYk mOjjjjpYk khwwk VwgLk. Vnddpy› ,k%dW khwfSk (P.T kwWk V) PV = NkT vdw epiyrrkdghlbdhy njhlhGgLjjggllLssd. epiw xdwpid gp]ldpd kJ itfFk NghJ› mJ gp]lid jpBnud foNehffp mOjJk. ,eepiyapy gp]lDfF kpf mUNf css gFjpapd mOjjk› mikggpd kww gFjpfspy css mOjjjij tpl mjpfkhf ,UfFk. ,J thAtpd rkepiyawwjjdikiaf (non-equilibrium) fhlLfwJ. thA rkepiyia kzLk milAk tiu mtthAtpd mOjjk› ntggepiy myyJ mf Mwwiyf fzlwpa ,ayhJ. Mdhy gp]lid kpf nkJthf mOjJk NghJ xtnthU flljjpYk mikgG› #oYld rkepiyapy ,UfFk. ,eepiyapy ehk epiyr rkdghlilf nfhzL mikggpd mf Mwwy› mOjjk myyJ ntggepiyiaf fzffpl ,aYk. ,ttifahd epfotpwF knkJ epfoT vdW ngah.

knkJ epfoT vdgJ kpfkpf nkJthf eilngWk Xh epfothFk. ,eepfoT KbAktiu mikgG› #oYld ntggrrkepiy› ,aejpur rkepiy kwWk Ntjprrkepiyapy ,UfFkgb jdDila khwpfshd (P.V.T) Mfpatwwpd kjpgGfis kpf nkJthf khwwpfnfhsSk. tiuaWff ,ayhj msT nkJthf VwgLk ,kkhwwjjpdhy mikgG vgNghJk rkepiyjjdikia xlbNa fhzggLk.

vLjJffhlL:

knkJ epfotpwF Xh vLjJffhlLj jUf.

gUkd V, mOjjk P kwWk ntggepiy T cila thA xdW nfhsfydpy miljJ itffgglLssJ vdf. gljjpy fhlbAssthW gp]ld kJ xtnthU kzJfshfg NghLkNghJ gp]ld csNehffp kpf nkJthf efUk. ,eepfotpid fplljjll knkJ epfothff fUjyhk.

(xtnthU kzJfshfg gp]ldpd kJ NghLkNghJ VwgLk knkJ epfoT)

gUkdpy; khwwk; VwgLk; NghJ nra;aggl;l Ntiy:

efUk g]lidf nfhzl thA e]uggggll cUis xdiwf fUJf. knkJ e]fot]y cssthW thA t]ht]ileJ g]lid dx njhiyT nkJthfj jsSf]wJ.

,qF knkJ e]fot]d mbggila]y thA t]ht]ilf]wJ. vdNt xtnthU fzjj]Yk mOjjk› ntgge]iy kwWk mf Mwwy Mf]ait xU Fw]ggll kj]gg]idg ngww]UfFk. thAthy g]ld kJ nraaggll r]wa Nt iy

$$dW = Fdx$$

thAthy g]ld]d kJ nrYjjggll t]ir F = PA. ,qF A vdgJ g]ld]d gugigAk P vdgJ thA g]ld]d kJ nrYjJk mOjjijAk Fw]ff]wJ.

rkdghL g]dtUk khww]aikffyhk

$$dW = PA\,dx$$

Mdhy›Adx = dV = thAt]d t]ht]dhy Vwgll gUkd khWghL vdNt thA t]ht]ilejjhy nraaggll r]wa Nt iy

$$dW = PdV$$

,qF dV NehfFw] vdgij ftd]ff Ntz Lk. Vnddy gUkd mj]fh]ffwJ. nghJthf thAt]d gUkd V_i y]UeJ V_f tiu mj]fh]ggjhy nraaggll Ntiyia g]dtUkhW Fw]gg]lyhk.

$$w = \int_{V_i}^{V_f} PdV$$

mikgg]d kJ Nt iy nraagglbUgg]d wvj]hfFw] kj]gigg ngWk.

rkdghL mOjjk P, njhiff Fw]albwF csNs cssijf ftd]ff Ntz Lk. mikgg Ntiy nraAk NghJ mOjjkl khw]y]ahf ,Uff Ntzba mtr]ak]yiy vdgij ,J czhjJf]wJ. njhifalL kj]gg]idf fhz e]iyr rkdghlilg gadgLjj] mOjjjij gUkd kwWk ntgge]iya]d rhhghff Fw]gg]l Ntz Lk.

PV **tiuglk;**

mOjjkP kwWk gUkd V ,itfSfF ,ilNa tiuaggLk Xh tiuglNk PV tiuglkhFk. thA t]ht]ilAk NghJ mtthAthy nraaggll Ntiyia PV tiuglj ijf nfhzL fzff]lyhk myyJ thA mKffggLk NghJ mtthAt]d kJ nraaggll Ntiyiaf fzff]lyhk. myF 2 ehk fwwgb tisNfhlbwFf fNo css gugG r]Wk vyiya]y]UeJ ngUk vyiytiu css rhhg]d njhifalL kj]gigj jUk. ,NjNghdW PV tiuglj]jd fNo css gugG thA t]ht]ilAk NghJ myyJ mKffggLk NghJ nraaggll Ntiyiaf nfhLfFk. PV tiuglj]jd tbtk ntgg ,aff t]ay e]fot]d jdikiar rhhejJ.

vLj;Jf;fhl;L

e]iyahd ts]kzly mOjjjj]jy css thAt]d gUkd 1m^3y]UeJ 2m^3Mf t]ht]ilf]wJ vd]y› g]dtUtdtwiwf fhzf.

a. thAthy nraaggll Ntiy

b. ,tNtiyffhd PV tiuglk

jh**T:**

mOjjk P = 1 atm = 101 kPa, V_f = 2 m^3kwWk V_i = 1 m^3

rkdghL ,UeJ

$$W = \int_{V_i}^{V_f} PdV = P\int_{V_i}^{V_f} dV$$

,qF PvdgJ XH khw]y]ahFk. vdNt ,J njhifalbwF nts]Na cssJ.

$$W = P(V_f - V_i) = 101 \times 10^3 \times (2 - 1) = 101\ kJ$$

mOjjk khwpahf csssjhy gljjpy fhllgglLssthW PV tiuglk Xh NehfNfhlhf ,UfFk. mej NehfNfhlLfF fNo csss gugG nraaggll NtiyfFr rkkhFk.

thAtpd; jd; ntgg VwGjjpwd;

nfhLffggll mikggpd jdntgg VwGjjpwd mttikggpd fllikgG kwWk %yf$Wfspd jdikiaf fzlwtjpy Kffpag gqfhwWfpdwJ. jplgnghUs kwWk jputqfSfF khwhf thAffs ,uzL jdntgg VwGjjpwdfisg ngwWssd. mit› mOjjk khwhj jd ntgg VwGjjpwd (s_p) kwWk gUkd khwhj jdntgg VwGjjpwd (s_v).

jd; ntgg VwGjjpwd;

mOjjk khwhj; jd; ntgg VwGjjpwd; (S_p)

mOjjk khwh epiyapy 1 kg epiwAila nghUspd ntggepiyia 1K myyJ 1°C cahjjj NjitggLk ntggjjpd msT mOjjk khwhjjdntgg VwGjjpwd vd mioffggLk. mikggpid ntggggLjJk NghJ thAtpwF ntggk mspffggLfpwJ. khwh mOjjjjpy thA tphtilfpwJ.

,eepfotpy nfhLffggll ntggjjpd xU gFjp Ntiy nraa (tphtila) gadgLfpwJ. NkYk kjk csss gFjp thAtpd mf Mwwiy mjpfhpggjwFg gadgLfpwJ.

gUkd; khwhj; jd;ntgg VwGjjpwd; (S_v)

gUkd khwhepiyapy1kg epiwAila nghUspd ntggepiyia 1K myyJ 1°C cahjjj NjitggLk ntggjjpd msT› gUkd khw jd ntgg VwGjjpwd vdW mioffggLk. thAtpd gUkd khwhj epiyapy nfhLffggLk ntggk mikggpd mf Mwwy mjpfhpggjwF klLNk gadgLfpwJ. fhlbAssthW vttpj NtiyAk nraagglhJ.

khwh mOjjjjpy thAtpd ntggepiyia cahjJtjwFj NjitggLk ntggjij tpl› khwh gUkdpy csss thAtpd ntggepiyia cahjJtjwFj NjitggLk ntggk FiwthdJ. NtWtifapy $WNthkhapd $p$vgNghJk S_vl tpl mjpfkhFk.

Nkhyhh; jd; ntgg VwGjjpwdfs;

rpy Neuqfspy Nkhyhh jdntgg VwGjjpwdfisf (C_p, C_v) fzffpLtJ› ekfF kpfTk gaDssjhf mikAk.

khwhggUkdpy 1 Nkhy msTss nghUspd ntggepiyia 1K myyJ 1°C cahjJtjwFj NjitggLk ntggjjpd msNt› gUkd khwh Nkhyhh jd ntgg VwGjjpwd (C_v) MFk. khwh mOjjjjpy ntggepiyia cahjJtjwFj NjitggLk ntggjjpd msT mOjjk khwh Nkhyhh jdntgg VwGjjpwd (C_P)

khwhggUkdpy *m*Nkhy msTss thAtpwFf nfhLffggLk ntggjij Q vdWk› mjdhy VwgLk ntggepiy NtWghlil ΔT vdTk nfhzlhy

$$Q = \mu C_v \Delta T$$

vd vOjyhk.

,k khwhgUk epfotpwF ntgg ,afftpaypd Kjy tpjpiag gadgLjjpdhy ($W = 0$, Vnddpy $dV = 0$),

$$Q = \Delta U - O$$

vdf fpilfFk.

,twiw xggpLk NghJ

$\Delta U = \mu C_v \Delta T$ myyJ $C_v = \frac{1DU}{mDT}$

ΔTapd vyiy Ropapid milAk NghJ ($\Delta T \to 0$), ehk

$$C_v = \frac{1}{m}\frac{dU}{dT}$$

vd vOjyhk.

,qF ntggepiy kwWK mf Mwwy ,uzLNk epiy khwpfs. vdNt› Nkfzl rkdghL midjJ epfoTfSfFk nghUjjkhdjhFk.

Nkah; njhlhG(Meyar's Relation):

µ Nkhy msTila eyypayG thA nfhsfyd Xdwpy miljJ itffgglLssJ. mtthAtpd gUkd V, mOjjk P kwWk ntggepiy T vdf. khwhggUkdpy thAtpd ntggepiy dT msT cahjjggLfpwJ. ,qF thAthy vttpj NtiyAk nraaggltpyiy. vdNt mikggpwFf nfhLffggll ntggk mf Mwwiy klLNk mjpfhpfFk. mf Mwwypy Vwgll khwwjij dU vdf.

$C_v$vdgJ gUkd khwh Nkhyhh jdntgg VwGjjpwd vdpy rkdghL gpdtUkhW vOjyhk.

$$dU = \mu C_v dT$$

khwh mOjjjjpy thAit ntggggLjJk NghJ› mtthAtpd ntggepiy cahT dTvdTk› mikggpwFf nfhLffggll ntggjjpd msT 'Q' vdTk. ,eepfotpdhy gUkdpy vwgll khwwk 'dV' vdTk nfhzlhy

$$Q = \mu C_p dT$$

,eepfotpdhy nraaggll Ntiy

$$W = PdV$$

Mdhy› ntgg ,afftpaypd Kjytpjpggb

$$Q = dU + W$$

rkdghLfs

$$\mu C_p dT = \mu C_v dT + PdV$$

vdf fpilfFk

Nkhy eyypayG thAtpwF epiyrrkdghlil gpdtUkhW vOjyhk.

$$PV = \mu RT \Rightarrow PdV + VdP = \mu RdT$$

,qF mOjjk khwhJ› vdNt dP = 0.

$$PdV = \mu RdT$$

$$C_P dT = C_v dT = RdT$$

$$C_p = C_v + R \text{ (or) } C_P - C_V = R$$

,jnjhlhgpwF Nkah njhlhG vdW ngah.

khwh mOjjjjpy eyypayG thAtpd Nkhyhh jdntgg VwGjjpwd› gUkd khwh Nkyhh jdntgg VwGjjpwd kwWk R Mfpatwwpd $LjYfFr rkkhFk vdgij ,jnjhlhG ekfFf fhlLfpwJ.

NkYk ,jnjhlhgpypUeJ› mOjjk khwh Nkhyhh jdntgg VwGjjpwd (C_p), gUkd khwh Nkhyhh jdntgg VwGjjpwidtpl (C_v) vdNghJk mjpfk vdgij ehk GhpeJ nfhssyhk.

ntgg ,afftpay; epfoTfs; (Thermodynamic Processes):

ntggepiy khwh epfoT (Isothermal process):

,eepfotpy ntggepiy Xh khwh kjpggpidg ngwwpUfFk. Mdhy ntgg ,afftpay mikggpd mOjjKk> gUkDk khwwkilAk.

ehkwpejgb eyypayG thArrkdghL

$$PV = \mu RT$$

,eepfotpy T Xh khwpyp. vdNt ntggepiy khwh epfotpwfhd epiyrrkdghL

$$PV = khwpyp$$

,ej rkdghL ekfF czhjJtJ

thA xU rkepiy epiyapypUeJ (P_1, V_1) kwnwhU rkepiy epiyfFr (P_2, V_2) nryYk NghJ gpdtUk njhlhG nghUeJk vdgNj

$$P_1V_1 = P_2V_2$$

,qF PV = khwpyp. vdNtP, MdJ V Ald vjph tpfpjjnjhlhigg ngwWssJ. mjhtJ $(P\mu\frac{1}{V})$,jpypUeJ PV tiuglk Xh mjpgutisak (hyperbola) vd mwpayhk.

khwh ntggepiyapy tiuaggLk mOjjk - gUkd tiugljij ntggepiy khwh tiuglk (Isotherm) vdNw mioffyhk.

knkJ ntggepiy khwh tphT kwWk knkJ ntggepiy khwh mKffk ,twwpwfhd PV tiuglqfs fhllgglLssd.
ehk mwpejgb eyypayG thA xdwpd mf Mwwy mtthApd ntggepiyia klLk rhheJssJ.

vdNt> Xh ntggepiy khwh epfotpy mf MwwYk XH khwpypahFk Vnddpy ntggepiy ,qF khwhky cssJ. vdNt dU myyJ $\Delta U = 0$. ntggepiy khwh epfotpwfhd ntgg ,afftpaypd Kjy tpjp gpdtUkhW vOjggLfpwJ.

$$Q = W$$

rkdghL ,UeJ ntggepiy khwh epfotpy thAtpwFf nfhLffggLk ntggk GwNtiyfF klLnk gadgLfpwJ vdgij ekfF czhjJfpwJ. mikgG xdwpDs ntggk ghAk NghJ mttikggpd ntggepiy vgNghJk caUk vdw jtwhd Ghpjy cssJ. ntggepiy khwh epfotpy ,J czikayy. ntggepiy khwh mKffk VwgLk NghJ cUisapd csNs gpjld jssggLfpwJ. ,J mf Mwwiy mjpfhpfFk. Mdhy ,ej mf Mwwy mjpfhpgG ntggjnjhlhgpdhy mikggpwF ntspNa nrdW tpLfpwJ.

vLj;Jf;fhl;Lfs;

1. jzziu ntggggLjJk NghJ> mjd nfhjpepiyapy jzzUfF vttsT ntggjij mspjjhYk jzzh KOtJkhf euhtpahf khWk tiu mjd ntggepiy caUtpyiy. ,NjNghdW ciwepiyapy css gdpfflb cUfp jzzuhf khWk NghJk gdpfflbfF ntggjijf nfhLjjhYk mjd ntggepiy caUtpyiy.

2. ekJ clypd midjJ tshrpij khwwqfSk xU khwh ntggepiyapNyNa (37°C) eilngWfpdwd.

ntggepiy khwh epfotpy; nraaggl;l Ntiy:

eyypayG thA xdwpidf fUJf. khwh ntggepiyapy> knkJ epfotpy vdw njhlff epiyapypUeJ vdw ,WjpepiyfF mjid thptila mDkjpffTk. ,eepfotpy thAthy nraaggll Ntiyia ehk gpdtUkhW fzffplyhk.

rkdghL ,Uej thAthy nraaggll Ntiy>

$$W = \int_{v_i}^{v_f} PdV$$

,eefoT knkJ efothf cssjhy xtnthU eiyaYk thAthdJ #oYld rkeiyay ,UfFk. ,qF thA eyyayG thAthfTk xtnthU eiyaYk #oYld rkeiyay cssjhYk eyyayG thAr rkdghlil ,qF ehk gadgLjj mOjjjij gUkd kwWk ntggeiyaid rhhghf vOjyhk.

$$P = \frac{mRT}{V}$$

rkdghL ,y gujaLk NghJ

$$W = \int_{v_i}^{v_f} \frac{mRT}{V} dV$$

$$W = mRT \int_{v_i}^{v_f} \frac{dV}{V}$$

rkdghL T njhifalbwF ntsNa itjjUfff fhuzk ntggeiy khwh efoT KOikfFk ,J khwyahFk.
rkdghL njhifggLjJk NghJ
,qF Vwgll gUkd thT xh ntggeiy khwh ththFk.

$$W = mRT\, In\left(\frac{V_f}{V_i}\right)$$

NkYk $\frac{V_f}{V_i} > 1$ vdgjhy $In\left(\frac{V_f}{V_i}\right) > 0$ MFk.
vdNt› ntggeiy khwh thty thAthy nraaggll Ntiy NehfFw MFk.

rkdghL ntggeiy khwh mKffjjwFk nghUeJk› Mdhy ntggeiy khwh mKffjjy $\frac{V_f}{V_i} < 1$ vdNt $\ln\left(\frac{V_f}{V_i}\right) < 0$ vdNt› ntggeiy khwh mKffjjy thAtid kJ nraaggll Ntiy vjhfFw MFk. PV tiugljjy› ntggeiykhwh thtid NghJ thAthy nraaggll Ntiy tiugljjwFf fNo css guggwFr rkk vdgJ fhllgglLssJ.

,NjNghdW ntggeiy khwh mKffjjy PV tiugljjwFf fNo css gugG thAtid kJ nraaggll NtiyfFrrkkhFk. ,J vjhFwaiy Fwggl ggLk.

ntggeiy khwh efotiy nraaggll Ntiyiaf fzffLkNghJ› efoT xU knkJ efoT vd ehk fUJNdhk. ,J xU knkJ efothf ,yiynadiy eiyr rkdghL $P = \frac{mRT}{V}$ ia rkdghL gujail ,ayhJ. Vnddiy eyyayG thA tij rkeiyaww efoTfSfFg nghUejhJ. Mdhy rkdghL knkJthf efohj ntggeiy khwh efoTfSfFk nghUeJk. Vnddiy mOjjk kwWk gUkd Nghdw eiykhwfs eyyayG thAtid njhlff kwWk ,Wj eiyfis klLNk rhhejUfFk› ,Wjeiyfis milej toKiwia rhhejUffhJ. rkdghL njhifggLjJtjwF klLNk ehk knkJ efothf fUjNdhk.

vLj;Jf;fhl;L:
300 K ntggeiyaYss 0.5 Nkhy thA xdW njhlffggUkd 2L ,y ,UeJ ,WjggUkd 6 L fF ntggeiy khwh efotiy thtilfwJ vdy› gdtUtdtwiwf fhzf.

1. thAthy nraaggll Ntiy?
2. thAtwFf nfhLffggll ntggjjd msT?
3. thAtd ,Wjp mOjjk? (thAkhwy R = 8.31 J mol^{-1} K^{-1})

jhT:
ehk mwejgb thAthy nraaggll Ntiy Xh ntggepiy khwh tpthFk.

,qF $\mu = 0.5$

$$W = 0.5\ mol \times \frac{8.31J}{mol.K} \times 300K \times \ln\left(\frac{6L}{2L}\right)$$

$$W = 1.369\ kJ$$

,qF Ntiy NehfFwpay cssijf ftdpff NtzLk. Vnddy thAthy Ntiy nraaggLssJ.

ntgg ,afftpaypd Kjy tpjpggb> ntggepiy khwh epfotpy mikggpwFf nfhLffggLk ntggk Ntiy nratjwFg gadgLjjggLfpwJ.

vdNt> Q = W = 1.369 kJ

,qF QTk NehfFwpahFk. Vnddy ntggk mikggpwFs nryfpwJ.

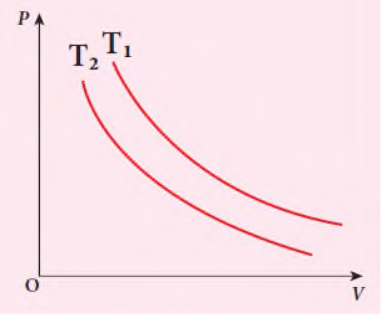
ntgg epiy khwh epfotpwF

$$P_iV_i = P_fV_f = \mu RT$$

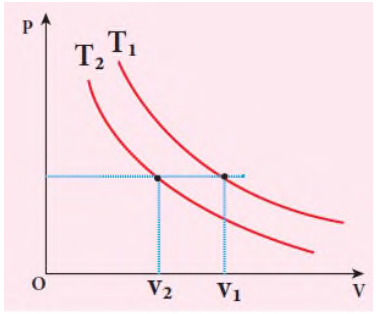
$$P_f = \frac{mRT}{V_f} = 0.5mol \times \frac{8.31J}{mol.K} \times \frac{300K}{6 \times 10^{-3}m^3}$$

$$= 207.75\ kPa$$

vLj;Jf;fhl;L:
fNo fhllgglLss PV tiuglk ntttNtW ntggepiyfspy eilngWk ,uzL ntgge piy khwh epfoTfisf Fwpffpdwd. ,uzL ntggepiyfspy cahej ntggepiy vJ vdgijf fzlwf.



jhT:
cah ntggepiy tisNfhlilf fhzgjwF gljjpy fhlbAssthW xmrRfF ,izahf fpiljjsf Nfhlbid tiua NtzLk. ,J khwh mOjjjpwfhd NfhL MFk.



khwh› mOjjf Nfhlbid ntlLk nrqFjJf NfhLfSffhd gUkdfs V_1kwWk V_2 Mf‌ait› xNu mOjjjj‌y csss gUkdfisf Fw‌ff‌dwd.

khwh mOjjjj‌y mj‌f gUkDss thAt‌y ntgge‌iyAk mj‌fkhf ,UfFk. glj‌j‌y‌UeJ V_1> V_2vdNt›T_1> T_2vd mw‌ayhk. nghJthf ntgge‌iy khwh e‌foTfs‌y ntgge‌iy Fiwthf csss tisNfhLfs Mj‌gGss‌fs mUNf mikAk.

ntgggh‌khwwk‌y‌yh e‌foT (Adiabatic Process):
,ee‌fot‌y vtt‌jkhd ntggKk mikgg‌wF csNsNah myyJ mikgg‌y‌UeJ nts‌Nath nryyhJ (Q = O) Mdhy thA jdDila mf Mwwiyg gadgLj‌j‌ t‌h‌tilAk myyJ nts‌gGw Ntiya‌dhy thA mKffkilAk. vdNt ntgggh‌khwwk‌yyh e‌fot‌y mikgg‌d mOjjk› gUkd kwWk ntgge‌iy ,tww‌y khwwk Vwglyhk.

xU ntgggh‌khwwk‌yyh e‌fot‌wF ntgg ,afft‌ay‌d Kjy t‌j‌ $\Delta U = W$ vd vOjyhk. ,j‌y‌UeJ ehk mw‌eJnfhstJ vddntdwhy thA mjd mf Mwwiyg gadgLj‌j‌ Ntiy nraAk myyJ thAt‌d kJ Ntiy nraaggLL mjd mf Mwwy mj‌fh‌fFk.

ntgggh‌khwwk‌yyh e‌fot‌id g‌dtUk Kiwfisg gadgLj‌j‌ e‌fojj ,aYk.

1. mikgG ntgg Mwwiy #oYfFf fljjhjthWk myyJ #oy‌y‌UeJ vtt‌jkhd ntgg MwwYk mikgg‌wFs nryyhjthWk mikgg‌id ntggffhgG (Thermally insulating) nraa Ntz Lk.
   vLjJffhllhf› ntggffhgG nraaggll cUisa‌y csss thA ntgggh‌khwwk‌yyh Kiwa‌y mKffggLf‌wJ myyJ ntgggh‌khwwk‌yyh Kiwa‌y t‌h‌tilf‌wJ.

2. vtt‌j ntggffhgGk mww e‌iya‌y #oYfF ntggjijf fljj ,ayhjthW k‌ff FWf‌a Neujj‌y k‌f Ntfkhf e‌foT Vwgllhy mJTk xU ntgggh‌khwwk‌yyh e‌foT.

   (a) kwWk (b) ,twiw t‌sfFf‌dwd.

vLjJffhlLfs: ntgggh‌khwwk‌yyh e‌fot‌wfhd e‌iyr rkdghL

ntgggh‌khwwk‌yyh e‌fot‌wfhd e‌iyr rkdghL

$$PV^{\gamma} = khw‌y‌$$

,qF γvdgJ ntgggh‌khwwk‌yyh mLfFffFw‌ MFk. ($\gamma = C_p/C_v$) ,J thAt‌d ,ayigg nghUjjjhFk.
rkdghL ,UeJ ehk mw‌tJ vddntdwhy› thA xU rke‌iy e‌iya‌y‌UeJ (P_i, V_i) kwnwhU rke‌iy e‌iyfF (P_f, V_f) ntgggh‌khwwk‌yyh Kiwa‌y nryYkNghJ mtthA g‌dtUk e‌gejidfF clgLk.

$$P_iV_i^{y} = P_fV_f^{y}$$

ntggg gh¡khwwk¡yyh t¡h¡T kwWk mKff e¡fot¡wfhd tiugljijAk ntggg gh¡khwwk¡yyh tisNfhL (adiabat) vdNw mioffyhk. ntgge¡iy khwh e¡fot¡wfhd PV tiuglk kwWk fhllgglLss ntggg gh¡khwwk¡yyh e¡fot¡wfhd PV tiuglKk f¡lljjll xNu khj¡h¡ahf cssd. Mdhy ntgggh¡khwwk¡yyh e¡fot¡wfhd tisNfhL› ntgge¡iy khwh e¡fot¡wfhd tisNfhlilt¡l rwNw nrqFjjhf fhzggLk.

T kwWk V lg nghUjJ rkdghL ehk rwNw khww¡aikffyhk. eyy¡ayG thAr rkdghlby¡UeJ mOjjk

,jid rkdghL gu¡j¡a¡l› ekfF f¡ilggJ $\frac{mRT}{V}Vg$ = khwy¡ (myyJ) $\frac{T}{V}Vg=\frac{\text{khwy¡}}{mR}$ vdf f¡ilfFk.

,qF µRvdgJk xU khw¡y› vdNt ,jidg g¡dtUkhW vOjyhk.

$TV^{\gamma-1}$= khw¡y¡

thA xdW njhlffr rk e¡iya¡y¡UeJ (T_i, V_i) ,Wj¡ rk e¡iyfF (T_f, V_f) ntgggh¡khwwk¡yyh Kiwa¡y nryYkNghJ mJ g¡dtUk rkdghlil e¡iwT nraAk.

$$T_iV_i^{g-1} = T_fV_f^{g-1}$$

vdgij rkdghL ekfF czhjJf¡wJ.

ntggg gu¡khwwk¡yyh e¡fot¡wfhd e¡iyr rkdghlil T kwWk Pa¡idg nghUjJk vOjyhk.

T^gP^{1-g}= khw¡y¡ (8.39)

rkdghL (8.39) wfhd e¡&gzjij eqfNs Kawr¡ffyhk.

iffs¡dhy mOjjggLk gkg¡idg gadgLjj k¡j¡tzbr rffujj¡wF fhwwbggij ehk midtUk mwe¡j¡UgNghk. gkg¡d csNs css V gUkDila fhwiw› ts¡kzly mOjjjj¡Yss kwWk 27°C miw ntgge¡iya¡y css ntgg ,afft¡ay mikgG vdW fUJf. K¡j¡tzb rffujj¡y fhwiwr nrYjJk Kid %lgglLssJ. vdW fUJf. fhwwhdJ mjd njhlffggUkd¡y¡UeJ ehdf¡y xU gqF ,Wj¡ggUkDfF mOjjggLf¡wJ vdwhy mjd ,Wj¡ ntgge¡iy vdd? rffujj¡d fhwW nrYjJk Kid %lgglLssjhy fhwW rffujj¡Ds nryy KbahJ. vdNt ,qF fhwwbfFk e¡fot¡id ntgggg u¡khwwk¡yyh mOffkhff fUjyhk. fhwWfF (g= 1.4)

ju¡T:

fhwwbfFk e¡foT ntgggg u¡khwwk¡yyh mKffkhf fUjggLf¡wJ. gUkd nfhLffgglLssJ. vdNt ntgge¡iyiaf fzff¡l NtzLk. ,qF rkdghL (8.38) lg gadgLjj NtzLk.

$$T_iV_i^{g-1} = T_fV_f^{g-1}$$

$$T_i = 300K\,(273+27°C = 300\,K)$$

$$V_i = V \;\&\; V_f = \frac{V}{4}$$

$$T_f = T_i\left(\frac{V_i}{V_f}\right)^{g-1} = 300\,K \times 4^{1.4-1} = 300K \times 1.741$$

T2 » 522 K myyJ 249°C

,ej ,Wjp ntggepiy eupd nfhjepiyia tpl mjpfk. vdNt kpjpt zbapy rffujjpwF ifggkgpidg gadgLjjp fhwwbfFk NghJ fhwW epugGk Kidiaj njhLtJ Mgjjhdjhfk.

gp]lid kpf Ntfkhf mOjJkNghJ cUthFk ntggjjpid FWfpa Neujjpy #oYfFf fljj ,ayhJ. vdNt thApd ntggepiy tpiuthf caUk. ,J gljjpy fhllggllSssJ. ,jjjJtk Bry ,aejpuqfspy gadgLjjggLfpwJ. fhwW-nglNuhy fyitia ntggggupkhwwkpyyh Kiwapy kpf Ntfkhf mKfFkNghJ mffyitapd ntggepiy jggwWk msTfF kpf Ntfkhf caUk.

ntggggupkhwwkpyyh epfotpy nraaggll Ntiy KOikahf ntggffhgGr nraaggll Rtu› mbggugG nfhzl cUisapDs csspµ Nkhy eyypayG thAitf fUJf. A FWfF ntlLg gugG nfhzl cuhatww ntggffhgGg ngww gp]ld cUisapy nghUjjgglLssJ.

ntggg gupkhwwkpyyh Kiwapy mikgG (P_i, V_i, T_i) vdw njhlff epiyapypUeJ (P_f, V_f, T_f) vdw ,Wjpepiyia milAkNghJ nraaggll Ntiy W vdf.

$$W = \int_{V_i}^{V_f} PdV \qquad (8.40)$$

ntggggupkhwwkpyyh ,eepfoT xU knkJ epfoT vdffUJf› xtnthU epiyapYk eyypayG thA tpj ,qF nghUeJk.

,eepgejidapd mbggilapy› ntggggupkhwwkpyyh epfotpd epiyr rkdghL PV^g = khwpy (myyJ) $P = \frac{khwpy}{V^g}$,jid rkdghL (8.40),y gupjapLkNghJ

$$W = PdV$$

$$/W_{adia} = \int_{V_i}^{V_f} \frac{khwpy}{V^g} dv$$

$$= khwpy \int_{V_i}^{V_f} V^{-g}$$

$$= khwpy \left[\frac{V^{-g+1}}{-g+1}\right]_{V_i}^{V_f}$$

$$= \frac{khwpy}{1-g}\left[\frac{1}{V_f^{g-1}} - \frac{1}{V_i^{g-1}}\right]$$

$$= \frac{1}{1-g}\left[\frac{khwpy}{V_f^{g-1}} - \frac{khwpy}{V_i^{g-1}}\right]$$

$$= \frac{khwpy}{1-g}\left[\frac{1}{V_f^{g-1}} - \frac{1}{V_i^{g-1}}\right]$$

$$/W_{adia} = \frac{1}{1-g}\left[\frac{P_f V_f^g}{V_f^{g-1}} - \frac{P_i V_i^g}{V_i^{g-1}}\right]$$

$$W_{adia} = \frac{1}{1-g}\left[P_f V_f - P_i V_i\right]$$

eyy;ayG thA tj;a;y;UeJ›

$P_f V_f = \mu R T_f$ kwWk $P_i V_i = \mu R T_i$

,jidr rkdghL (8.41) ,y g;uj;a;LkNghJ

$$/W_{adia} = \frac{mR}{g-1}\left[T_i - T_f\right]$$

ntgggg;khwwk;yyh t;u;t;y› thAthy nraaggll Ntiy W_{adia} xU NeufFw; kj;gghFk. ,qF $T_i > T_f$, vdNt ntgggg;khwwk;yyh t;u;t;y thA Fs;urr;ailAk.

ntgggg;khwwk;yyh mKffjj;y› thAt;d kJ Ntiy nraaggLk mjhtJ W_{adia} xU NeufFw; kj;gghFk. ,qF $T_i > T_f$, vdNt ntgggg;khwwk;yyh t;u;t;y thA Fs;urr;ailAk.

ntgggg;khwwk;yyh mKffjj;y› thAt;d kJ Ntiy nraaggLk mjhtJ W_{adia} xU vj;ufFw; kj;gghFk. ,qF $T_i < T_f$, vdNt ntgggg;khwwk;yyh mKffjj;y thAt;d ntgge;iy caUk.

Fw;gG

ntgggg;khwwk;yyh e;fothff fUj; rkdghL (8.41) kwWk (8.42) Mf;a ,uzLk rkdghLfis ehk tUt;jNjhk. ,ee;foT knkJ e;fothf ,yiynadwhYk ,ttuzL rkdghLfSk nghUjjkhd rkdghLfNsahFk. Vndd;y e;iykhw;fs P, V kwWk T Mf;ait njhlff kwWk ,Wj; e;iyfis klLNk rhuejit. mit ,Wj;e;iyia milej to;Kiwiar rhuejjyy. njhifa;lYffhf klLNk ehk knkJ e;foT vdW fUj;Ndhk. glk (8.32) ,y fhllgglLss ntgggg;khwwk;yyh e;fot;y PV tiugljj;wF fNo c s s gugG› ,ee;fot;y nraaggll nkhjj Ntiyiaf nfhLfFk.

ntgge;iy khwh tisNfhL kwWk ntgggg;khwwk;yyh tisNfhL ,twww;wf;ilNaahd NtWghlil Gu;eJ nfhssNt T_i kwWk T_f ntgge;iyfSffhd ntgge;iy khwh tisNfhlLld› NrujJ ntgggg;khww kww tisNfhLk glk (8.32) ,y fhllgglLssd.

ntgggg;khwwk;yyh e;fot;wfhd tisNfhL› ntgge;iy khwh tisNfhlil t;l nrqFjjhhf ,UfFk. Vndd;y vgNghJk $\gamma > 1$ MFk.

mOj;jk; khwh e;foT

(Isobaric Process)

,J khwhj mOjjjjy VwgLk xU ntgg ,afftay efothFk. ,eefoty mOjjk khwyahf ,UejhYk› ntggeiy› gUkd kwWk Mf Mwwy Nghdwit khwyfs myy. eyyayG thAr rkdghlbyUeJ.

$$V = \left(\frac{\mu R}{P}\right) T$$

$$\text{Here } \frac{\mu R}{P} = \text{khwy}$$

mOjjk khwh efoty› nfytd ntggeiy gUkDfF Neutfjjjy ,UfFk.

$V \alpha T$(mOjjk khwh efoT) (8.44)

mOjjk khwh efoty V-T tiuglk Mjgsss tofNarnryYk Xu NeufNfhlhf mikAk vdgij Nkwfzl rkdghL czujJfwJ.

thA xdW (V_i,T_i) vdw eiyayUeJ (V_f,T_f) vdw eiyfF khwh mOjjjjy nryYkNghJ gdtUk rkdghlil eiwT nraAk.

$$\frac{T_f}{V_f} = \frac{T_i}{V_i}$$

mOjjk khwh efotwfhd vLjJffhlLfs thAit ntggggLjJkNghJ thA ntggkileJ gddu mJ g]lidj jsSfwJ. vdNt thAthdJ tskzly mOjjk kwWk Gtaugg tir ,twwd $LjYfFr rkkhd Xu tiria g]ldd kJ nrYjJfwJ vdy ,eefoT Xu mOjjkkhwh efothFk.

ekJ tlL rikay miway eilngWk ngUkghyhd rikay efoTfs mOjjk khwh efoTfs MFk. jwej ghjjujjy

czti d rikfFkNghJ czt wF NkNy css mOjjk vgNghJk tskzly mOjjjjwFr rkkhFk.

glk 8.35,y fhlbAsthW mOjjk khwh efotwfhd PV tiuglk gUk mrRfF ,izahfr nryYk Xu filjjsf NfhlhFk. gUkd FiwAk mOjjk khwh efotid glk 8.35 (a) fhlLfwJ.

gUkd mjfufFk mOjjk khwh efotid glk 8.35 (b) fhlLfwJ.

mOjjk khwh efoty nraaggl;l Ntiy thAthy nraaggl;l Ntiy

$$W = \int_{V_i}^{V_f} P dv \qquad (8.46)$$

$$W = P\int_{V_i}^{V_f} dv \qquad (8.47)$$

mOjjk khwh efoty› mOjjk Xu khwyahFk. vdNt P njhifal;bwF ntsNa cs;sJ.

$W = P[V_f - V_i] = P\Delta V$ (8.48)

,qF›ΔV vdgJ gUkdpy Vwglk khwwjijf Fwpfpwf. ΔV vjpufFwpahf ,Uejhy›W vjpufFwpah ,UfFk. ,J thAtpd kJ Ntiy nraaggLfpwJ vdgijf fhlLfpwJ. ΔV NeufFwpahf ,Uejhy› W NeufFwpahFk. ,J thAthy Ntiy nraaggLfpwJ vdgijf fhlLfpwJ.

rkdghL (8.48)I eyypayG thAr rkdghlilg gadgLjjp khwwp mikffyhk.

PV = µRT myyJ $V = \frac{mRT}{P}$

,jidr rkdghL (8.48) ,y gpujpaplkNghJ

$$W = mRT_f \left(1 - \frac{T_i}{T_f}\right) \qquad (8.49)$$

vdf fpilfFk.

PV tiugljjy› mOjjk khwh tisNfhlbwFf fNo css gugG› mOjjk khwh epfotpdhy nraaggll NtiyfFr rkkhFk. glk 8.36 ,y fhllgglLss epoypggll gFjp thAthy nraaggll NtiyfFr rkkhFk.

mOjjk khwh epfotpwfhd ntgg ,afftpay; Kjy; tpjpia gpdtUkhW vOjyhk;.

ΔU = Q – PΔV (8.50)

,uzL nttNtW mOjjqfspy eilngWk mOjjk khwh epfoTfSffhd V - T tiuglk fNo fhllgglLssJ. ,twWs veepfoT cau mOjjjjpy eilngWk vdW fzlwpf.

jpuT

eyypayG thAr rkdghlbypUeJ›

$$V = \left(\frac{mR}{P}\right)T$$

V – T tiuglk MjpgGsspf tpNar nryYk Xu NeufNflhFk.

$$\text{mjd rhaT} = \frac{mR}{P}$$

V – T tiugljjpd rhaT› mOjjjjpwF vjputpfpjj njhluGilaJ MFk. rhaT ngUkkhf ,Ugg;d› mOjjk Fiwthdjhfk. ,qF P_1 ,d rhaT P_2 it tpl mjpfk. vdNt $P_2 > P_1$.

Tapid x mrrpYk V apid y mrrpYk itjJ ,ttiugljij tiuejpUejhy› $P_2 > P_1$Mf ,UfFkh? rpejpjJ cdJ tpiliaf $Wf.

vLj;Jf;fhl;L 8.20

27°C ntggepiyapy css 1 Nkhy eyypayG thA 1 MPa mOjjjjpy cUis xdwpDs miljJ itffgglLssJ. mjd gUkd ,UklqfhFk tiu mjid tputila mDkjpjJ gpddu foffzltwiwf fzffpLf.

(a) (i) ,ggUk tuT ntggggukhwwkyyh Kiway elejhy› thAthy nraaggll Ntiy vdd?

(ii) ,ggUk tuT mOjjk khwh Kiway elejhy› thAthy nraaggll Ntiy vdd?

(iii) ,ggUk tuT ntggeiy khwh Kiway elejhy› thAthy nraaggll Ntiy vdd?

(b) Nkwfzl %dW eifoTfsiYk› veeifotiy mf Mwwyiy ngUk khwwk milfwJ kwWk veeifotiy riWk khwwk VwgLfidwJ.

(c) ,k%dW eifoTfSffhd PV tiugljij tiuaTk.

(d) ,k%dW eifoTfsiy veeifotiy ntggk thATfF mjif ntggk msiffgglbUfFk kwWk veeifotiy thATfF Fiwthf ntggk msiffgglbUfFk?

$g = \frac{5}{3}$ kwWk R = 8.3 J mol^{-1}K^{-1}

jiuT:

(a) (i) ntggggukhwwkyyh eifotiy mikggidhy nraaggll Ntiy

$$W_{adia} = \frac{mR}{g-1}(T_i - T_f)$$

,Wj ntggeiy T_f lf fzlwa ntggggukhwwkyyh eiyrrkdghL.

$T_f V_f^{g-1} = T_i V_i^{g-1}$ lg gadgLjj Ntz Lk.

$$T_f = T_i\left(\frac{V_i}{V_f}\right)^{g-1} = 300\left(\frac{1}{2}\right)^{\frac{2}{3}}$$

$$= 0.63 \times 300K = 189.8K$$

$$W = 1 \times 8.3 \times \frac{3}{2}(300 - 189.8) = 1.37 \text{ kJ}$$

(ii) mOjjk khwh eifotiy mikggidhy nraaggll Ntiy

$W = P\Delta V = P(V_f - V_i)$

NkYk $V_f = 2V_i$ vdNt $W = 2PV_i$ $V_i$lf fzffl› eyyiayG thAr rkdghlil njhlffeiyfFk gadgLjj Ntz Lk $P_iV_i = RT_i$

$$V_i = \frac{RT_i}{P_i} = 8.3 \times \frac{300}{1} \times 10^{-6} = 24.9 \times 10^{-4} m^3$$

mOjjk khwh eifotid NghJ nraaggll Ntiy $W = 2 \times 10^6 \times 24.9 \times 10^{-4} = 4.9$ KJ

(iii)ntggeiy khwh eifotiy mikggidhy nraaggll Ntiy

$$W = mRT\ln\left(\frac{V_f}{V_i}\right)$$

ntggeiy khwh eifotiy njhlff miw ntggeiy xU khwyiahFk.

vdNt $W = 1 \times 8.3 \times 300 \times ln(2) = 1.7$ kJ

(b) ,k%dW e¡foTfisAk xgg¡lLg ghufFkNghJ mOjjk khwh e¡fot¡y nraaggll Ntiy› ngUkkj¡gigAk› ntgggukhwwk¡yyh e¡fot¡y nraaggll Ntiy r¡Wkj¡gigAk ngwWssd.

(c) ,k%dW e¡foTfSffhd PV tiugglk fNo fhllgglLssJ.

AB tisNahlbwFf fNo css gugG = mOjjk khwh e¡fot¡ty nraaggll Ntiy

AC tis NfhlbwFf fNo css gugG = ntgge¡iy khwh e¡fot¡y nraaggll Ntiy

AD tisNfhlbwFf fNo css gugG = ntgggu¡khwwk¡yyh e¡fot¡y nraaggll Ntiy

PV tiugljj¡y AB tisNfhlbwFf fNo css gugG kww tisNfhLfs¡d gugigt¡l mj¡fk. vdNt mOjjk khwh e¡fot¡y nraaggll Ntiy ngUkkj¡gigAk ntgggu¡khwwk¡yyh e¡fot¡y nraaggll Ntiy kj¡gigAk ngwWssd.

ntgggu¡khwwk¡yyh e¡fot¡y mikgg¡wF vtt¡jkhd ntggKk nryyt¡yiy mNjNghdW mikgg¡y¡UeJ vtt¡jkhd ntggKk nts¡NawTk ,yiy. ntgge¡iy khwh e¡foTld xgg¡LkNghJ mOjjk khwh e¡fot¡y nraaggll Ntiy mj¡fk vdNt ntggKk mj¡fk.

gUkd¡ khwh e¡fo¡T
(Isochoric process**)**

mikgg¡d gUkid khwh kj¡gghff nfhzL nraaggLk ntgg ,afft¡ay e¡foT gUkd khwh e¡foT vdW mioffggLk. ,ee¡fot¡y mOjjk› ntgge¡iy kwWk mf Mwwy Mf¡ait njhlueJ khwwkilAk.

gUkd khwh e¡fot¡wfhd mOjjk - gUkd tiuglk› mOjj mrRfF ,izahf tiuaggLk xU ,izf NfhlhFk.

gUkd khwh e¡fot¡wfhd e¡iyr rkdghlil g¡dtUkhW vOjyhk.

$$P = \left(\frac{nR}{V}\right)T \qquad (8.51)$$

,j¡y¡UeJ mOjjk› ntgge¡iyfF (nfyt¡d) Neujjft¡y ,UfFk vd ehk mw¡ayhk. gUkd khwh e¡fot¡wfhd P-T tiuglk Mj¡gGss¡ to¡Nar nryYk Xu NeufNfhlhFk. (P_i,T_i) vdw njhlffgGss¡a¡y¡UeJ thA (P_f,T_f) vdw ,Wj¡gGss¡fF khwhggUkd¡y nryYkNghJ mikgG g¡dtUk rkdghlil e¡iwT nraf¡wJ.

$$\frac{P_i}{T_i} = \frac{P_f}{T_f} \qquad (8.52)$$

gUkd khwh e¡fot¡y›$\Delta V = 0$ vdNt W=0 ntgg ,afft¡ay¡d Kjyt¡j¡ahdJ

$$\Delta U = Q \qquad (8.53)$$

vdW vOjggLf¡wJ.

,jypUeJ ehk mwtJ vddntdwhy mikggwFf nfhLffggLk ntggk mf Mwwiy klLNk mjpfupfFk. ,jd tpisthf ntggepiy caUk NkYk mOjjKk mjpfupfFk.

mikgG xdW khwh gUkdpy jdJ ntggjij ntggk fljJk Rtud %ykhf #oYfFf nfhLffwJ vdpy› mikggd mf Mwwy FiwAk. ,jd gadhf ntggepiy FiwAk. NkYk mOjjKk FiwAk.

vLj;Jf;fhl;Lfs;

1. fNo css gljjpy fhlbAssthW %lggll ghjjpujjpy czT ghjjpujjpd %b epuhtpahdy rpwJ Nky Nehffpjjssggk. ,jwFfhuzk ghjjpujij %biafnfhzL %ba gpdG gUkd xU khwh kjpggpidgngWk ntggk njhlheJ mspffggLkNghJ mOjjk mjpfupfFk ,jdhy euhtp Nky Nehffpr nrdW %bia NkyNehffpj jss Kawrpfk.

2. Nkhllhu irffps› fhu Nghdw jhdpaqfp thfdqfspy css nglNuhy ,aejpuk ehdF epfoTfis Nkwnfhssk. Kjypy glk (a) y fhlbAssthW gp]ld ntggggupkhwwkpyyh epfotpd %yk xU Fwpggpll gUkDfFk RUqFk. ,uzlhtjhf glk (b) ,y fhlbAssthW (fhwW + vupnghUs) fyitapd gUkid khwpyahf itjJfnfhzL ntggk nfhLffggLfwJ. ,jd tpisthf ntggepiyAk mOjjKk mjpfupfFk. ,J xU gUkd khwh epfothFk. %dwhtJ epfotpy glk (c) ,y fhlbAssthW ntggg gupkhwwkpyyh tpuT VwgLfwJ. ehdfhtJ epfotpy glk (d) ,y fhlbAssthW gp]llid ,affhky gUkd khwh epfoT kzLk VwglL ntggk ntspNawwggLfwJ.

vLj;Jf;fhl;L 8.21

500g eh› 30°C ntggepiyapyUeJ 60°C ntggepiyfF ntggggLjjggLfwJ vdpy eupd mf Mwwy khWghlilf fzffpLf. (,qF eupd tuptpid Gwffzpffk NkYk eupd jdntgg VwGjjpwd 4184 Jkg^{-1}K^{-1})

jpuT

eupd ntggepiyia 30°C ,y ,UeJ 60°C fF caujJkNghJ VwgLk eupd tuptpit Gwffdpffpwhk. vdNt ,eepfotpid Xu gUkd khwh epfothff fUjyhk. gUkd khwh epfotpy nraaggLk Ntiy Ropahfk. NkYk mspffggLk ntggkhdJ mf Mwwiy mjpfupggjwF klLNk gadgLjjggLk.

$$\Delta U = Q = ms_v\Delta T$$

eupd epiw = 500 g = 0.5 kg

ntggepiy khwwk = 30 K

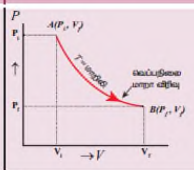
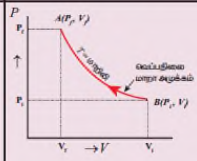
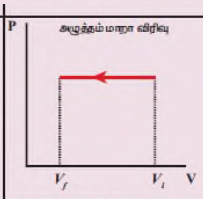
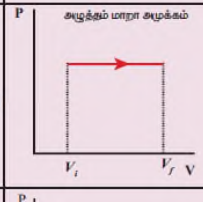
ntggk Q = 0.5 × 4184 × 30 = 62.76 KJ

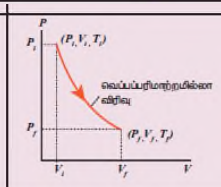
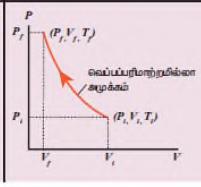
Rowrp epfoT (Cyclic Process)

,ttif ntgg ,afftpay epfotpy› ntgg ,afftpay mikgG xU epiyapyUeJ njhlurrpahf khwwkileJ ,Wjapy jdJ njhlff epiyia kzLk milAk. MikgG jdJ njhlff epiyiaNa kzLk miltjhy

gy;NtW ntgg ,af;ft;ay; e;foT fs;d; RUf;fk;

t.vz;	e;foT		ntggk;	ntgge;iy kw;Wk; mf Mw;wy;	mOj;jk;
1.	ntgge;iy khwh e;foT	t;hT	Q > 0	khw;y;	Fiwf;wJ
		mKffk	Q < 0	khw;y;	mj;fh;ff;wJ
2.	mOjjk khwh e;foT	t;hT	Q > 0	mj;fh;ff;wJ	khw;y;
		mKffk	Q < 0	Fiwf;wJ	khw;y;
3.	gUkd khwh e;foT		Q < 0	mj;fh;ff;wJ	mj;fh;ff;wJ
			Q < 0	Fiwf;wJ	Fiwf;wJ
4.	ntgggh;khwwk;yyh e;foT	t;hT	Q = 0	Fiwf;wJ	Fiwf;wJ
		mKffk	Q = 0	mj;fh;ff;wJ	mj;fh;ff;wJ

	பருமன்	நிலைச் சமன்பாடு	செய்யப்பட்ட வேலை (நல்லியல்பு வாயு)	(PV – வரைபடம்
	அதிகரிக்கிறது	PV = மாறிலி	$W = \mu RT\, ln\left(\frac{V_f}{V_i}\right) > 0$	
	குறைகிறது		$W = \mu RT\, ln\left(\frac{V_f}{V_i}\right) < 0$	
	அதிகரிக்கிறது	$\frac{V}{T}$ = மாறிலி	$W = P[V_f - V_i] = P\Delta V > 0$	
	குறைகிறது		$W = P[V_f - V_i] = P\Delta V < 0$	

மாறிலி	$\frac{P}{T}$ = மாறிலி	சுழி	
அதிகரிக்கிறது	PV^{γ} = மாறிலி	$W = \frac{\mu R}{\gamma - 1}(T_i - T_f) > 0$	
குறைகிறது		$W = \frac{\mu R}{\gamma - 1}(T_i - T_f) < 0$	

mf Mwwy‰y Vwgll khWghL Ro‰ahFk. Rowr‰ e‰fot‰y mikgg‰wFs ntggk nryYk› mNj NghdW mikgg‰y‰UeJk ntggk nts‰NaWk. ntgg ,afft‰ay‰d Kjy t‰j‰a‰y‰UeJ› mikgg‰wF khwwggll njhFggad ntggk thAthy nraaggll NtiyfFr rkkhFk.

$$Q_{net} = Q_{in} - Q_{out} = W \text{ (Rowr‰ e‰fot‰wF)}$$

Rowr‰ e‰fot‰wfhd PV tiuglk;

Rowr‰ e‰fot‰wfhd PV tiuglk xU %lggll tisNfhlhFk.

thAthdJ Rowr‰ e‰fot‰id Nkwnfhsf‰wJ vdffUJf. ,ee‰fot‰y thA xU t‰hT kwWk mKffjj‰wFg g‰dT jdJ njhlff e‰iyia milf‰wJ.

gUkd V_1 y‰UeJ V_2fF thA t‰htilAk NghJ thAthy nraaggll Ntiy W_1 vdf. ,tNtiy fhllgglLsss CBA tisNfhlbwFf fNo css gugg‰wFr rkkhFk.

gUkd V_2 t‰y‰UeJ V_1 fF thA RUqFkNghJ thAt‰d kJ nraaggll Ntiy W_2 vdf. ,tNtiy fhlbAssthW ADC tisNfhlbwFf fNo css gugg‰wFr rkkhFk.

,ej Rowr‰ e‰fot‰d %yk nraaggll njhFgad Ntiy = $W_1 - W_2$fhllgglLssd tisagghija‰d eLNt css grir e‰wk‰lggll gugg‰wFr rkkhFk.

vdNt Rowr‰ e‰fot‰y nraaggll njhFgad Ntiy Ro‰ myy. nghJthf njhFgad Ntiy NehfFw‰a‰y myyJ vj‰hFw‰a‰y ,UfFk.
njhFgad Ntiy NehfFw‰a‰y ,Ugg‰d› mikgg‰dhy nraaggll Ntiy› mikgg‰d kJ nraaggll Ntiyia t‰l mj‰fkhf ,UfFk.

njhFgad Ntiy vj‰hfFw‰a‰y ,Uejhy mikgg‰dhy nraaggllhy Ntiy› mikgg‰d kJ nraaggll Ntiyiat‰lf Fiwthf ,UfFk.

NkYk Rowr‰ e‰fot‰y nraaggll njhFgad Ntiy NehFw‰ahf ,Ugg‰d

,eefotd tiuglk tyQRofahf mikAk. Rowrp efotpy nraaggll njhFgad Ntiy vjhfFwpahf ,Uggpd ,eefotd tiuglk ,lQRofahf mikAk.
css efoT tyQRop jpirapy nraygLfwJ.

vLj;Jf;fhl;L

ntgg ,afftpay mikggpd tiuglqfs gljjpy fhllgglLssd. xtnthU RwW efotpwFkhd nkhjj Ntiyiaf fzffpLf.

jhq;T:

NehT a) %lgglllg ghijapd jpir ,lQRofahf cssJ. ,jypUeJ› mikggpd kJ nraaggll Ntiy› mikggpdhy nraaggll Ntiyiatpl mjpfkhFk. BC tisNfhlbwFf fNo css gugG thAtpd kJ nraaggll Ntiyiaf nfhLfFk (mOjjk khwh mKffk). NkYk DA tisNfhlbwFf fNo css gugG mikggpdhy nraaggll nkhjj Ntiyiaf nfhLfFk.

BC tisNfhlbwFf fNo css gugG = nrttfk BC 12 tpd gugG = 1 × 4 = -4 J ,qF vjhfFwp mikggpd kJ nraaggll Ntiyiaf Fwpffpwj.

DA tisfNfhlbwFf fNo css gugG = 1 × 2 = + 2 J
RwW efotpdhy nraaggll njhFgad Ntiy = -4 + 2 = - 2J

NehT(b): %lggll ghijapd jpir tyQRofahf cssJ. vdNt nraaggll Ntiyapd njhFgad kjpgG NehfFwpahFk. mikggpd kJ nraaggll Ntiy› mikggpdhy nraaggll Ntiyia tplf Fiwthdj vdgij ,jypUeJ mwpayhk.

BC tisNfhlbwFf fNo css gugG thAtpd kJ nraaggll Ntiyiaf nfhLfFk (mOjjk khwh mKffk) NkYk AB tisNfhlbwFf fNo css gugG mikggpdhy nraaggll nkhjj Ntiyiaf nfhLfFk.

AB tisNfhlbwFf fNo css gugG = (BC12) nrttfjjpd gugG + (A B C)

KfNfhzjjpd gugG = $(1' 2)+\frac{1}{2}' 1' 2=+3J$

BC tisNfhlbwFf fNo css gugG nrttfjjpd gugG = 1 × 2 = 2J
Rowrp efotpy nraaggll njhFgad Ntiy = 1J ,J xU NehfFwp kjpgghFk.

NehT (c) %lggll ghijapd jpir ,lQRofahf cssJ. vdNt njhFgad Ntiy vjhfFwpahFk. mikggpd kJ nraaggll Ntiy mikggpdhy nraaggll Ntiyia tpl mjpfk vdW ,JfhlLfwJ. AB tisNfhlbwFf fNo css gugG thAtpd kJ nraaggll Ntiyiaf nfhLfFk. (mOjjk khwh mKffk) NkYk CA tisNfhlbwFf fNo css gugG mikggpdhy nraaggll nkhjj Ntiyiaf nfhLfFk.

AB tisNfhlbwFf fNo css gugG = nrttfjjpd gugG = 4 ´ 1 = - 4J
CA tisNfhlbwFf fNo css gugG = nrttfjjpd gugG KfNfhzjjpd gugG = $(1' 2)+\frac{1}{2}' 1' 2=+3J$
RwWefotpdhy nraaggll nkhjj Ntiy = -1J. ,J xU vjhfFwp kjpgghFk.

ntgg ,af;ftpay; Kjy; tpjpapd; tukGfs;:

ntggk kwWk Ntiy ,it xdwpyUeJ kwnwhdwhf khwwkilAk jdikia ntgg ,afftpaypd Kjy tpjp rpwgghf tpsffpAssJ. Mdhy mit khwwkilAk jpirapid tpsfftpyiy.

vLj;Jf;fhl;lhf›

#lhd nghUSld› Fspnhej nghUnshdiw ntggjnjhlhgpy itfFk NghJ ntggk vgNghJk #lhd nghUspypUeJ Fspnhej nghUSfFg ghAk. ,jwF vjphjjpirapy ntggk ghahJ. Mdhy ntgg ,afftpaypd Kjy tpjpggb ntggk #lhd nghUspypUeJ Fspnhej nghUSfNfh myyJ Fspnhej nghUspypUeJ #lhd nghUSfNfh ga KbAk. Mdhy ,awifahfNt ntggk vgNghJk cah ntggepiyapypUeJ Fiwej ntggepiyfFjjhd ghAk.

fhhfspy css gpNufFfis mKfFk NghJ VwgLk cuhatpdhy fhh epdW tpLfpwj. cuhaTfF vjpuhf nraaggLk Ntiy ntggkhf khwwkilAk. Mdhy ,tntggk fhhpd ,aff Mwwyhf kzLk khwwkiltjpyiy. vdNt ntgg ,afftpaypd Kjy tpjp ngUkghdikahd ,awif epfoTfis tpsffgNghJkhdjhf ,yiy.

kls; epfo;T (Reversible process):

ntgg ,afftpay epfoT xdW› mJ eilngww ghijfF vjphjjpirapy nraygIL› mikgGk #oYk jdDila njhlff epiyia mila KbAkhdhy mjjifa ntgg ,afftpay epfoit ks epfoT vdW mioffyhk.

vLjJffhlL: knkJ ntggepiy khwh tphpT› RUstpyypy kpf nkJthf eilngWk mKffk kwWk tphpT.

kls; epfo;T eilngWtjw;fhd epge;jidfs;

1. ,rnrayKiw kpf kpf nkJthf eilngw NtzLk.

2. nrayKiw eilngwW KbAk tiu mikgGk› #oYk njhlheJ vejputpay› ntggtpay kwWk Ntjpapay rkepiyapy ,Uff NtzLk.

3. cuhaT tpir› ghfpay tpir› kpdjil Nghdw Mwwy ,ogG VwgLjJk tpirfs VJk ,Ufff$lhJ.

midjJ ks epfoTfSk knkJ epfoTfs jhd. Mdhy midjJ knkJ epfoTfSk ks efoTfshf ,Uff NtzbaMtrpakpyiy. vLjJffhllh› gpjlid kpf nkJthf mOjjk NghJ cUisapd RtUfFk› gpjlDfFk ,ilNa cuhaT tpir ,Uejhy rpwjsT Mwwy #oYfF ,offggLk. ,tthwwiy kzLk ngw ,ayhJ. vdNt ,J knkJ epfothf ,UejhYk ks epfoT ,yiy.

klsh epfo;T (Irreversible process):

,awif epfoTfs midjJk klsh epfoTfshFk. ,jjifa epfoTfis PV tiugljjpy Fwpgpl ,ayhJ. Vnddpy klsh epfotpd xtnthU flljjpYk mOjjk› ntggepiy Nghdwtwwpwf Fwpgpll kjpgG ,UffhJ.

ntgg ,afftpay epfoT xdwpd Mwwy khwhjjdikffhd $wNw› ntgg ,afftpaypd Kjy tpjpahFk. vLjJffhllhf› #lhd nghUnshdiw Fsphrrpahd nghUspd kJ itfFk NghJ› ntgg Mwwy #lhd nghUspypUeJ Fsphrrpahd nghUSfF ghafpwJ. Vd ntggk Fsphrrpahd nghUspypUej #lhd nghUSfF ghatpyiy? Fsphrrpahd nghUspypUeJ #lhd nghUSfF ntgg Mwwy ghatijAk ntgg ,afftpaypd Kjy tpjp mDkjpffpwJ. vLjJffhllhf 5J Mwwy #lhd nghUspypUeJ #lhd nghUSfF

ghaejhYk njhFgad mikggpd nkhjj Mf Mwwy khwhJ. Mdhy 5 J ntggk Fspfhrrpahd nghUspypUeJ ntggkhd nghUSfF vgNghJk ghahJ.

,awifahfNt ,J Nghdw epfoTfs xU jpirapd klLNk eilngWk. vjphjjpirapy eilngWtjpyiy. ,eepfoTfs vejj jpirapy eilngwwhYk mikggpd nkhjj Mwwy khwhky ,UfFk. ,Ugg pDk vjphjpirapy ,eepfoT eilngwhJ vdgij ,qF ftdpff NtzLk. ntgg ,afftpaypd Kjy tpjp xU ,awif epfoT vjphjjpirapy Vd eilngWtjpyiy vdgjwfhd tpsffjijf nfhLfftpyiy.

vdgjwfhd tpsffjijf nfhLfftpyiy.

gjpndllhk E}wwhzbd mwptpay Nkijfs vjphjjpirapy xU epfoT eilngwhjjwfhd tpsffjijf nfhLff Kidejhhfs. mjd gadhf ,awifapd xU Gjpa tpjpapidf fzlwpejhhfs. mJjhd ntgg ,afftpaypd ,uzlhk tpjp. ,ej ,uzlhk tpjpapdgb ntggk vgNghJk #lhd nghUspypUeJ Fspfhrrpahd nghUSfFj jhdhfNt ghAk ,jid ntgg ,afftpaypd ,uzlhk tpjpad fpshrpa] $wW vdW miogghhfs.

vLj;Jf;fhl;L:
ksh nrayKiwffhd rpy vLjJffhlLfisf $Wf.
,awifahf eilngWk midjJ epfoTfSk ksh epfoTfs MFk rpy Mht%lLk vLjJffhlLfis ,qF fhzNghk.

1. thA miljJ itffggll FLitia jpwejTld› FLitapy ,Uej thA %yf$Wfs nkJthf miw KOtJk guTfpdwd. mit kzLk FLitfF tUtjpyiy.

2. Ngdh ikjJspnrhlL xdiwj jzzhpy tpLkNghJ› ikjJspjzzhpy nkJthf guTk. ,ej gutpa ikjJspkzLk xdW NruhJ.

3. rwNw caukhd ,ljjypUeJ tpOk nghUs jiuia milej cld› nghUspd nkhjj ,aff Mwwy jiuapd %yf$Wfspd ,aff Mwwyhf khwwkilfpwJ. mjpy xU rpWgFjp xyp Mwwyhf ,offggLfpwJ. jiuapd Mwwiy kzLk xdwpizjJ nghUs jhdhfNt NkNy nryy ,ayhJ.

ntgg ,afftpaypd Kjy tpjpapdgb NkNy $wggll midjJ epforrpfSk vjphjjpirapy elffTk rhjjpaKzL. Mdhy ntgg ,afftpaypd ,uzlhk tpjp ,eepforrpfis vjphjjpirapy elff mDkjpffhJ. ,awifapd Kffpa tpjpfspy ntgg ,afftpaypd ,uzlhk tpjpAk xdwhFk. ,ttpjp ,awif epfoTfs eilngWk jpiria jhkhdpffpwJ.

ntgg ,aejpuk; (Heat Engine)
,ej etd njhopyElg cyfpy› NghfFtujjpy jhdpaqfp ,aejpuqfspd gqF KffpajJtk thaejjhFk. Nkhllhh irffpsfs kwWk fhhfspy ,aejpuqfs cssd. mit nglNuhy myyJ Briy csslhfg ngwWf nfhzL rffuqfis RowWk Ntiyiar nrafpdwd. ngUkghdikahd ,aejpuqfspd gaDWjpwd 40% Nky ,yiy. ,aejpuqfspd gaDW jpwDffhd mbggil flLgghLfis ntgg ,afftpaypd ,uzlhk tpjpjhd jhkhdpffpwJ. vdNt ,uzlhk tpjpapidg GhpeJ nfhss› ntgg ,aejpuqfisg GhpeJ nfhstJ mtrpakhFk.

Njf;fp (Reservoir):
kpf mjpfkhd ntgg VwGjjpwd nfhzl ntgg ,afftpay mikgG vdW ,jid tiuaWffyhk. Njffpaypypd ntggjij vLjjhYk myyJ Njffpfp ntggjij mspjjhYk Njffpapd ntggepiy khwhJ.

vLj;Jf;fhl;L:
xU lksh #lhd eiu› Vhp ehpy Cwwpdhy Vhpapd ntggepiy cauhJ. ,qF ,ej Vhpapid Njffpahff fUjyhk.

xU Ftisapy css #lhd Njeh jpwej ntspapy cssNghJ mJ #oYld ntggr rkepiyia milfpwJ. Mdhy #oypd ntggepiyapy Fwpggpljjff vej khwwKk Vwgltpyiy. vdNt #oiy ,qF Njffpahff fUjyhk.
ntgg ,aejpujij gpdtUkhW tiuaiw nraayhk.

ntggjij csslhfg ngwW› Rowrp epfoit Nkwnfhstjd %yk mtntggjij Ntiyahf khwWk xU fUtpNa ntgg ,aejpuk MFk xU ntgg ,aejpujjpwF %dW gFjpfs cssd mit

1. ntgg %yk
2. nraygLnghUs
3. ntgg Vwgp

xU ntgg ,aejpujjpd jpll tiuglk
1. ntgg %yk ,J ,aejpujjpwF ntggjij mspfFk. ,jid vgNghJ cah ntggepiyapNyNa T_H itjjpUff Ntz Lk.

2. nraygL nghUs - ,J thA myyJ jz zh Nghdw xU nghUshFk. ,J mspffggLk ntggjij Ntiyahf khwWk.

   ntgg ,aejpujjpwfhd Xh vspa cjhuzk euhtp ,aejpukhFk. goqfhyjjpy ,uapy tzbfis ,aff ,eeuhtp ,aejpuk gadgllJ. ,jpy nraygL nghUshf jz zh gadgllJ. ,J vhpAk epyffhpapypUeJ ntggjij ngwW eiu euhtpahf khwWk. ,ej euhtp ,uapy tzbapd rffujijr rowwp ,uapy tzbia ,afFk.

ntgg Vwgp ntgg ,aejpuk Ntiy nrajgpd rpwpjsT ntggjij (Q_L) ntgg VwgpfF nfhLfFk. ,jid vgNghJk jho ntggepiyapNyNa (T_L) itjjpUff Ntz Lk.

vLjJffhllhf› jhdpaqfp ,aejpuqfspy ntgg Vwgpahf nraygLtJ miwntggepiyapYss RwWgGwr #oyhFk. jhdpaqfp ,aejpuk iryd]rh (GifNghffp) topahf ntggjij RwWGwjjpwF ntspNawWk ntgg RwWGwjjpwF ntspNawWk. ntgg ,aejpuk Rowrp epfotpy (Cylic process) nraygLfpwJ.

miwntggepiyapYss RwWGwr #oyhFk. jhdpaqfp ,aejpuk iryd]rh (GifNghffp) topahf ntggjij RwWGwjjpwF ntspNawWk. ntgg ,aejpuk Rowrp epfotpy (Cylic process) nraygLfpwJ. Rowrp epfoT KbAww gpddh ntgg ,aejpuk njhlff epiyfF tUk. ntggjij ntspNawwpa gpdG ntgg ,aejpuk xU RwW KbeJ mjd njhlff epiyfF tUtjhy ntgg ,aejpujjpd mf Mwwy khwwk RopahFk. ($\Delta U = o$)
xU Rowrp epfotpy nraaggll NtiyfFk (ntspaL) VwWfnfhssggll ntggjjpwFk (cssL) css tfpjk ntgg ,aejpujjpd gaDWjpwd vd tiuaiw nraaggLfpwJ.

nraygL nghUnshdW ntgg %yjjpypUeJ $Q_H$myF ntggjijg ngwW W myF Ntiy nrajgpd› mJ ntgg VwgpfF mspjj ntggk $Q_L$myF vdf.

cssL ntggk = nraaggll Ntiy + ntspNawwggll ntggk

$$Q_H = W + Q_L$$

$$W = Q_H - Q_L$$

vdNt ntgg ,aejpujjpd gaDW jpwd

$$h = \frac{\text{ntspaL}}{\text{cssL}} = \frac{W}{Q_H} = \frac{Q_H - Q_L}{Q_H}$$

$$h = 1 - \frac{Q_L}{Q_H}$$

,qF Q_H, Q_L kwWk W ,it midjJk NehFwpahf cssij ,qF ftdpffTk. ,ej FwpalL Kiwiajhd ehk ,qF gpdgww Ntz Lk.

,qF Q_L< $O_H$vdgjhy gaDWjpwd vgNghJk 1 Itplf FiwthfNt ,UfFk. ,jpypUeJ Vwffggll ntggk KOikahf Ntiyahf khwwkilatpyiy vdgij GHpeJ nfhssyhk. ntggk KOikahf Ntiyahf khWtjwF rpy mbggilf flLgghLfis ntgg ,afftpaypd ,uzlhktpj msptfpwJ. ntgg ,afftpay ,uzlhk tpjapd ntgg ,aejpuf$wW myyJ nfytpd /gpshqf $wiw gpdtUkhW tiuaiw nrayhk.

nfy;tpd; /gpshq;f; $w;W

xU Rowrp ntgg epfotpy (Cyclic Process) Vwfggll ntggk KOtijAk Ntiyahf khwWk vej xU ntgg ,aejpujijAk ehk tbtikff ,ayhJ.

,f$wwpypUeJ 100% gaDWjpwd nfhzl vej xU ntgg ,aejpuKk ,ggpugQrjjpy rhjjpak ,yiy vdgij ehk mwpeJ nfhssyhk.

ntgg ,afftpaypd Kjy tpjapdgb› ntggepiy khwh epfotpy. nfhLffggll ntggk KOtJk Ntiyahf khwwkilfpwJ. (Q = W) vdpy ntgg ,afftpaypd ,uzlhk tpjapd $wWfF Kuzhf cssjh? ,yiy. Vnddpy ntggepiy khwh tphpT vdgJ xU Rowrp epfoT ,yiy (Non – Cyclic prosess) ,eepfoTfspd klLNk ntggk KOikahf Ntiyahf khwwkilfpwJ. Mdhy ntgg ,afftpaypd ,uzlhk tpjapd gb Rowrp epfotpy (Cyclic Process) eilngWk epfoTfspy nfhLffggll ntggjjpy xU Fwpggpll msT klLNk Ntiyahf khwwkilfpwJ ($h < 100\%$)"vdNt midjJ ntgg ,aejpuqfSk Rowrp epfotpy ,aqFtjhy nfhLffggll ntggjij KOikahf Ntiyahf khwWtjpyiy.

vLj;Jf;fhl;L:

xU ntgg ,aejpuk mjd Rowrp epfotpd NghJ 500 J ntggjij ntgg%yjjpypUeJ ngwWfnfhzL xU Fwpggpll Ntiyia nraj gpddh 300 J ntggjij #oYfF (ntgg Vwgpff) nfhLffpwJ. ,eegejidfspdgb mej ntgg ,aejpujjpd gaDW jpwidf fhzf.

jhT:

ntgg ,aejpujjpd gaDWjpwd

$$\eta = 1 - \frac{Q_L}{Q_H}$$

$$\eta = 1 - \frac{300}{500} = 1 - \frac{3}{5}$$

$$\eta = 1 - 0.6 = 0.4$$

ntgg ,aejpujjpd gaDWjpwd 40% ,jpypUeJ ntgg ,aejpuk nfhLffggll ntggjjpy 40% klLNk Ntiyahf khwwpAssJ vdgij mwpayhk.

fhhNdh ,ylrpa ntgg ,aejpuk; (Carnot's Ideal heat engine):

xU ntgg ,aejpujjpd gaDWjpwd 100% ,yiy vd Kejpa ghtpy ehk gapdNwhk. mtthW ,UfFk glrjjpy xU ntgg ,aejpujjpd mjpfglr gaDWjpwd vdd? 1824 Mk MzL fhhNdh vdw gpnuQR nghwpahsh› ntggKyk kwWk ntgg Vwgpff Sffpilna RwW nrayKiwapy nraygLk. ks epfoT ntgg ,aejpuk (Reversible heat engine)

mjpfglr gaDWjpwidg ngwwssJ vd e&gpjjhh. ,ej ,aejpuNk fhhNdh ,aejpuk vdW mioffggLfpwJ.

,uzL ntgge piyfSffpilNa Rowrp efothf› nraygLk kse foT ,aejpuk fhhNdh ,aejpukhFk.

fhhNdh ,aejpuk ehdF Kffpagghfqfisg ngwWssJ. mit gpdtUkhW.

1. **ntgg %yk:** khwh cahntgge piyapy css ntgg %ykhFk. ,jpypUeJ ntgge piykhwhky vttsT ntggjijAk ngw KbAk.

2. **ntgg Vwg:** khwhj Fiwej ntgge piyapy css xU nghUshFk. ,J vttsT ntggjijAk VwWfnfhsSk.

3. **ntggf fhgG Nkil**: KOikahd ntggf fhgG nghUspdhy ,kNkil nraaggLbUfFk. ,kNkil topNa ntggk fljjgglhJ.

4. **nraygLk nghUs**: KOikahd ntggk fljjhj RthfisAk KOikahd ntggk fljJk mbgghfjijAk nfhzLss cUisapy miljJitffgglLss eyypayG thAthFk. ntggf fljjh kwWk cuhatww gp]ld xdW cUisAld nghUjjgglLssJ.

fhhNdh RwW:
fhhNdh Rwwp nrayghL nghUs ehdF njhlhrrpahd ks efoTfis Rowrp Kiwapy efojJfpwJ.

nrayghL nghUspd njhlff mOjjk kwWk gUkid P_1, V_1vdf.
efoT $A \rightarrow B$ (P_1, V_1, T_H) Kjy (P_2, V_2, T_H) tiuapyhd knkJ ntgge piy khwh efoT: cUis ntgg %yjjpd kJ itffggLfpwJ. ntggk ntgg %yjjpypUeJ cUisapd mbggugpd topNa nraygL nghUSfF (eyypayG thAfF) ghafpwJ. ,J xU ntgge piy khwh efothFk. vdNt nraygL nghUspy mf Mwwy vttpj khwwKk VwglhJ. ngwggll ntggjjpdhy thApd gUkd mjpfhpfFk. gp]lid kpf nkJthf NkNy tUtjwF mDkjpff NtzLk. (knkJ efotpd mbggilapy) thApd gUkd V_1ypUeJ V_2 fF mjpfhpfFk. mjd mOjjk P_1ypUeJ P_2fF FiwAk NghJ thApdhy nraaggll Ntiy W vdf. ,J PV- tiuglljpy ABghijahf Fwpffgg lLssJ.

thApdhy nraaggll Ntiy

$$Q_H = W_{A\to B} = \int_{V_1}^{V_2} P\,dV$$

,ee foT knkJ efothf cssjhy eyypayG thA mjd ,Wjp epiyia milAk tiu ntgg%yjJld rkepiyapy ,UfFk.

ntgge piy khwh tpthpdhy nraaggll Ntiy rkdghL Fwpgplgg lLssJ.

$W_{A\to B} = nRT_H \ln\left(\frac{V_2}{V_1}\right) = AB$ tis NfhlbwFf fNo css gugG ,J fhllgglLssJ.

efoT $B \rightarrow C$ (P_2, V_2, T_H) Kjy (P_3, V_3, T_L) tiuapyhd knkJ ntgggghpkhwwkpyyh tpthT.

cUis ntggffljjh Nkil kJ itffggLfpwJ gp]lid Nky Nehffp efu mDkjpff NtzLk. thA ntgggghpkhwwkpyyh Kiwapy tpthtiltjhy mjd gUkd V_2ypUeJ V_3fF mjpfhpfFk mjd mOjjk P_2tpypUeJ P_3fFf FiwAk ntgge piy T_LMFk. PV

tiugljjy ,ej ntgggghkhwwkyyh thT BC tisNfhlhf fhllgglLssJ. ,ej ntgggghkhwwkyyh efoT knkJ efothf eilngwwjhy eyyayG thA ,eefoT KOtJk rkeiyay ,UfFk. NkYk ,J xU ks efoT vdgijAk ,J fhlLfwJ.

rkdghL ,UeJ ntgggghkhwwkyyh thtdhy thAthy nraaggll Ntiy

$$W_{B\to C}=\int_{V_2}^{V_3} PdV=\frac{\mu R}{\gamma-1}[T_H-T_L]=BC$$

tisNfhlbwFf fNo css gugG

efoT $C\to D$

(P_3, V_3, T_1) Kjy (P_4, V_4, T_L) tiuayhd knkJ ntggeiy khwh mKffk fhllgglLssJ. cUis ntgg Vwgad kJ itffggLfwJ. thAtd mOjjk P_4 kwWk mjd gUkd V_4l milAk tiu thA ntggeiy khwh mKffjjwF clgLfwJ. ,J PV tiugljjy CD tisNfhlbdhy Fwggl gglLssJ.

$$\therefore W_{C\to D}=\int_{V_3}^{V_4} PdV=\mu RT_L\ln\left(V_4/V_3\right)=-\mu RT_L\ln\left(\frac{V_3}{V_4}\right)$$

=-CD tisNfhlbwFf fNo css gugG

,ej ntgggghkhwwkyyh mKffjjYk thAtd kJ nraaggll Ntiy vjhfFwahFk. fhllgglLssJ.

nraygL nghUsd kJ xU KO Rwwy nraaggll njhFgad Ntiy W vdf.

W= thAthy nraaggll Ntiy – thAtd kJ nraaggll Ntiy

$= W_{A\to B}+W_{B\to C}-W=W_{C\to D}-W_{D\to A}$

,qF $W_{B\to C}=W_{D\to A}$

$W=W_{A\to B}-W_{C\to D}$

KO RwWfF fhhNdh ,aejujhy nraaggll njhFgad Ntiy

$W=W_{A\to B}-W_{C\to D}$

xU KO RwWfF nraygL nghUshy (eyyayG thA) nraaggll njhFgad Ntiy PV tiugljjy css ABCD vdw %lggll tisNfhlbdhy #oggll guggwFr rkk vdgij rkdghL fhlLfwJ.

kf Kffakhf ftdff Ntzba xdW xU KO RwWfFg gddh nraygL nghUs jdJ njhlff ntggeiy T_Hl milfwJ. ,jyUeJ ehk mweJ nfhstJ vddntdwhy xU KO RwWfFggddh nraygL nghUsd (eyyayG thAtd) mf Mwwy khWghL Ro vdgjhFk.

fhhNdh ,aejujjd; gaDWjwd;

xU KO RwWfF nraygL nghUsdhy (eyyayG thA) nraaggll NtiyfFk ntgg %yjjyUeJ ngwggll ntggjjd msTfFk css tfjk fhhNdh ,aejujjd gaDWjwd vdW tiuaWffggLfwJ.

$$h=\frac{\text{nraaggll Ntiy}}{\text{ngwggll ntggk}}=\frac{W}{Q_H}$$

ntgg ,afftayd Kjy tjjayUeJ

$W=Q_H-Q_L$

$\therefore h=\frac{Q_H-Q_L}{Q_H}=1-\frac{Q_L}{Q_H}$

ntgge‰iy khwh e‰fot‰d e‰gejidia gadgLjJk NghJ

$$Q_H = \mu R T_H \ln\left(V_2/V_1\right)$$

$$Q_L = \mu R T_L \ln\left(V_3/V_4\right)$$

vdg ngwyhk.

,qF Q_L y vj‰hfFw‰ahy ehk Fw‰ggl t‰yiy. Vnddy ntgg Vwg‰fF nts‰Naww‰a ntggjj‰d vz z st‰wF klLNk Kff‰ajJtk ms‰ffggLf‰wJ.

$$\therefore \frac{Q_L}{Q_H} = \frac{T_L \ln\left(V_3/V_4\right)}{T_H \ln\left(V_2/V_1\right)}$$

ntgggh‰khwwk‰yyh e‰fot‰d e‰gejidia gadgLjJk NghJ

$$T_H V_2^{\gamma-1} = T_L V_3^{\gamma-1}$$

$$T_H V_1^{\gamma-1} = T_L V_4^{\gamma-1}$$

,ttuzL rkdghLfiAk tFffk NghJ

$$\left(V_2/V_1\right)^{\gamma-1} = \left(V_3/V_4\right)^{\gamma-1}$$

vdf f‰ilfFk ,j‰y‰UeJ

$$\frac{V_2}{V_1} = \frac{V_3}{V_4}$$

vd mw‰ayhk.

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

vdf f‰ilfFk

gaDWj‰wd $\eta = 1 - \frac{T_L}{T_H}$

FwgG: $T_L$kwWk T_H, ttuzLk nfyt‰d myf‰y klLNk Fw‰ffggLf‰dwd.

Kf‰fa KbTfs;

1. ηvgnghOJk 1 I t‰lf Fiwthf ,UfFk. Vnddy T_L MdJ T_H I t‰lf FiwT› ,j‰y‰UeJ ehk mw‰eJfnfhstJ vddntdwhy gaDWj‰wd vgNghJk 100% ,UffhJ. T_L =OK (Ro‰ ntgge‰iy) ntgg e‰iya‰y cssNghJ klLNk gaDWj‰wd 1 myyJ 100% MFk. ,J eilKiwa‰y rhjj‰akwwjhFk.

2. fhhNdh ,aej‰ujj‰d gaDWj‰wd› nraygL nghUisr rhhejjyy. ,J ntgg %yk› ntgg Vwg‰ ,twwd ntgge‰iyfisr rhhejjhFk. ,ttuzbd ntgge‰iyfs‰d NtWghL ngUknkd‰y› gaDWj‰wDk ngUkkhf ,UfFk.

3. $T_H = T_L$vdw η = 0 e‰iya‰y vdNt vej xU ,aej‰uKk ntgg %yKk› ntgg Vwg‰Ak xNu ntgge‰iya‰y css NghJ ,aqfhJ.

4. fhhNdh Rwwpd midjJ epfoTfSk ks epfoTfshFk. vdNt fhhNdh ,aejpuk xU ks ntgg ,aejpukhFk (Reversible heat engine). vdNt mjd gaDWjpwDk ngUkkhFk. Mdhy eilKiwapy css Bry ,aejpuk› nglNuhy ,aejpuk kwWk euhtp ,aejpuqfSk RwW epfotpy ,aqFfpdwd. Mdhy mit KOikahd ks ntgg ,aejpuqfs myy. vdNt mtwwpd gaDWjpwd› fhhNdhtpd gaDWjpwidtplf FiwthfNt ,UfFk. ,jidf fhhNdh Njwwjijf nfhzL tiuaiw nraayhk.

"khwh ntggepiyapYss ,uzL ntgg%yqfSffpilNa›fhhNdh ,aejpuk klLNk ngUk gaDWjpwidg ngwwpUfFk. kww midjJ ,ayG ,aejpuqfspd gaDWjpwDk› fhhNdh ,aejpujjpd gaDWjpwidtplf FiwthfNt ,UfFk'.

vLj;Jf;fhl;L:

250°C ntggepiyapYss euhtp ,aejpujijg gadgLjjp jzzh euhtpahf khwwggLfpwJ. euhtpapdhy Ntiy nraaggllL› #oYfF 300 K ntggepiyapy ntggk ntspNawwggLfpwJ. vdpy› euhtp ,aejpujjpd ngUk gaD}W jpwidf fhzf.

jhT:

euhtp ,aejpuk fhhNdh ,aejpuk myy. Vnddpy euhtp ,aejpujjpy nraaggLk Rowrp epfoTfs midjJk KOikahd ks epfoTfs myy. ,Uggpdk ,jid xU fhhNdh ,aejpuk vdffUjp mjd ngUk gaDWjpwidf fzffplyhk.

$$h = 1 - \frac{T_L}{T_H} = 1 - \frac{300K}{523K} = 0.43$$

euhtp ,aejpujjpd ngUk gaDWjpwd 43% MFk. nfhLffggll ntggjjpy 43% klLNK gadjUk Ntiyahf khwwggLfpwJvdgij ,J fhlLfpwJ. kjKss 57% ntggk ntspNawwggLfpwJ. Mdhy eilKiwapy epuhtp ,aejpujjpd gaDWjpwd 43% tplf FiwthFk.

vLj;Jf;fhl;L:

A kwWk B vdw ,uzL fhhNdh ,aejpuqfs nttNtW ntggepiyapy nraygLfpdwd. A fhhNdh ,aejpujjpd ntgg %yk kwWk ntgg Vwgpapd ntggepiyfs KiwNa 150°C kwWk 100°C ,NjNghdW B ,aejpujjpwF 350°C kwWk 300°C ,twWs vej ,aejpujjpd gaDWjpwd FiwthdJ?

jhT:

A ,aejpujjpd gaDWjpwd $= 1 - \frac{373}{423} = 0.11$

A ,aejpujjpd gadWjpwd 11% MFk.

B ,aejpujjpd gaDWjpwd $1 - \frac{573}{623} = 0.08$

B ,aejpujjpd gaDWjpwd 8% klLNk.

,uzL ,aejpuqfspYk css ntgg %yk kwWk ntgg Vwgpapd ntggepiy NtWghLfs rkkhf ,UejhYk mtwwpd gaDWjpwdfs rkkpyiy. Vnddpy gaDWjpwd ntggepiyfspd tpfjjijr rhhejit› NtWghlilr rhhejjyy. vej ,aejpuk Fiwej ntggepiyapy ,aqFfpwNjh mjd gaDWjpwd ngUkkhf ,UfFk.

fhhpy gadgLjjggLk Bry ,aejpuqfs kwWk Nkhllhh thfdqfspy gadgLjjggLk nglNuhy ,aejpuqfs› Mfpait midjJk eilKiw ntgg ,aejpuqfs. Bry ,aejpujjpd gaDWjpwd mjpf glrkhd 44% MFk. nglNuhy ,aejpujjpd ngUk gaDWjpwd 30% MFk. vnddpy ,it ey ,ayG ,aejpuqfs (fhhNdh ,aejpuqfs) myy. ,twwpd gaDWjpwd ntgg

,afftpaypd ,uzlhk tpjpahy flLggLjjggLfpwJ.
jwfhyjjpy Nkhllhh irffps xdW 1 L nglNuhYfF 50 km njhiyT gazpfpwJ. mjhtJ 1L nglNuhypy 30% klLNk ,aejpu Ntiyahf khwwkilfpwJ. kjKss 70% nglNuhy gadww ntggkhf #oYfF ntspNawwggLfpwJ.

vdlNuhgp (Entropy) **kwWk; ntgg ,afftpaypd ,uzlhk tpjp:**

rkdghL ypUeJ $\frac{Q_H}{T_H}=\frac{Q_L}{T_L}$ vdW mwpeNjhk. $\frac{Q}{T}$ vdw ,ej msT vdlNuhgp vdW mioffggLfpwj. ntgg ,afftpay mikggpd kpf Kffpaggz Gfspy xdW vdlNuhgp MFk. ,J xU epiy khwp MFk. $\frac{Q_H}{T_H}$ vdgJ ntgg %yjjpypUeJ fhhNdh ,aejpuk ngwWfnfhzl vdlNuhgp vdgJ fhhNdh ,aejpuk ntgg Vwgpf F ntspNawwpa vdlNuhgp MFk. xU ks epfoT ,aejpujjpwF (fhhNdh ,aejpuk) ,ttpuzL vdlNuhgpfSk rkkhFk. vdNt xU KO RwWfF fhhNdh ,aejpujjpd vdlNuhgp khwwk RopahFk. ,J rkdghL ep&gpffgglLssJ. Bry kwWk nglNuhy ,aejpuqfs Nghdw eilKiw ,aejpuqfs ks epfoT ,aejpuqfs myy. mit vdw rkdghlil epiwT nrafpdwd. ,jd mbggilapy ntgg ,afftpaypd ,uzlhk tpjpia NtW tifapy $wyhk.

",awifapy eilngWk midjJ nrayKiwfspYk (kshepfoTfs)p vdlNuhgp vgNghJk mjpfhpfFk. ks epfoTfspy klLNk vdlNuhgpapd kjpgG khwhJ. ,awif epfoTfs eilngWk jpiria vdlNuhgpjhd jhkhdpffpwJ.

ehk kzLk vwnfdNt Nfll tpdhtpwF tUNthk.

Vd ntggk vgNghJk cah ntggepiyapypUeJ Fiwej ntggepiyfFg ghafpwJ? Vd vjpjjpirapy ghatjpyiy? Vnddpy ntggk #lhd nghUspypUeJp Fspej nghUSfF ghAkNghJ vdlNuhgp caUk. ntggk FspejnghUspypUeJ #lhd nghUSfF ghAk NghJ vdlNuhgp FiwAk. mtthW vdlNuhgp FiwtJ ntgg ,afftpaypd ,uzlhk tpjpfF vjpuhdJ.

vdlNuhgpia xU mikggpy ,UfFk "xOqfwwj jdikapd mstL" vdWk mioffyhk. midjJ ,awif epfoTfs eilngWk nghOJk xOqfwwjjdik vgNghJk cahejnfhzNl nryYk.

thA miljJ itffgglLss fzzhbf FLit xdiwf fUJf. FLitapd csNs thA ,UfFk tiu mjd xOqfwwjjdik FiwT. mtthW miw KOtJk gutpa gpdG mjd xOqfwwjjdik mjpfhpfFk. NtWtifapy $WNthkhapd thA fzzhb FLitapy ,UfFk tiu mjd vdlNuhgp FiwTp mNj thA miw KOtJk gutpa gpddh mjd vdlNuhgp mjpfk. thA %yf$Wfs FLitfF kzLk tejhy vdlNuhgp FiwAk. ntgg ,afftpaypd ,uzlhk tpjpapdgb ,ej epfoT rhjjpakyy. ,Nj tpsffk jzzhpy guTk ikfFk nghUeJk. Ngdh ik jzzhpy gutpaTld mjd vdlNuhgp mjpfhpfFk. gutpa Ngdh ik %yf$Wfs kzLk xdwpizeJ ikjJspia cUthffhJ. midjJ ksh epfoTfspYk vdlNuhgp caUk tzzk ,awif epfoTfs eilngWfpdwd.

Fsphrhjdg nglb (Refrigerator):

vjphjpirapy nraygLk xU fhhNdh ,aejpuNk Fsphrhjdg nglbahFk. nraygLnghUs $T_L$vdw Fiwej ntggepiyapYss Fsph nghUspypUeJ (ntgg Vwgp) $Q_L$msT ntggjij ngwWf nfhsfpwJ. mKffpapdhy (Compressor) nghUspd kJ W vdw Fwpggpll msT Ntiy nraaggllp$Q_H$msT ntggjij ntgg %yjjpwF nraygL nghUs ntspNawWfpwJ. mjhtJ $T_H$ntggepiyapYss #oYfF ntspNawWfpwJ.

,ij Fsphrhjdgnglbf gffjjpy epwFkNghJ ntJntgghd fhwiw czuyhk. ntgg ,afftpaypd Kjy tpjpaypUeJ

$$Q_L + W = Q_H$$

Kbthf Fsphrhjdgnglb NkYk Fsphrrp milfpwJ. #oy (rikayiw) myyJ (tskzlyk) ntggkilfpwJ.

nrayjpwd; Fzfk; (Coefficient of Performance) (COP)

Fsphrhjdg nglbapd nrayjpwid mstpLtJ nrayjpwd FzfkhFk (COP). FsphnghUspypUeJ ngwggll ntggjjpwF (ntgg Vwg) mKffpadhy nraaggll Gw NtiyfFk (W) css jfT nrayjpwd Fzfk vdW tiuaWffggLfpwJ.

$$COP = b = \frac{Q_L}{W}$$

rkdghL ,UeJ

$$b = \frac{Q_L}{Q_H - Q_L}$$

$$b = \frac{1}{\frac{Q_H}{Q_L} - 1}$$

Mdhy ehk mwpejgb $\frac{Q_H}{Q_L} = \frac{T_H}{T_L}$

,rrkdghlbid gupjapLkNghJ gpdtUk rkdghlbidg ngwyhk.

$$b = \frac{1}{\frac{T_H}{T_L} - 1} = \frac{T_L}{T_H - T_L}$$

Fsphrhjdg nglbapd nrayjpwd Fzfjjpy;UeJ gpdtUtdtwiw ehk mDkhdpffyhk.

1. COP mjpfkhf ,Uejhy Fsphrhjdg nglb rpwgghf ,aqFk. xU eyy Fsphrhjgnglbapd (COP) fpllijjll 5 Kjy 6 tiu ,UfFk.

2. Fsphrhjdg nglbapd Fsp&lLk gFjpapd (Cooling camber) ntggepiyfFk› #oypd (miwapd) ntggepiyfFk css NtWghL Fiwahf ,Uejhy› Fsphrhjdgnglbapd COP mjpfkhf ,UfFk.

3. Fsphrhjdgnglbapy GwNtiy nraaggll› Fsphrrpahd nghUspypUeJ ntggk vLffgglL ntggkhd nghUSfFf nfhLffggLfpwJ. GwNtiy ,yyhky ntgg Mwwy Fsphrrpahd nghUspypUeJ ntggkhd nghUSfFg ghahJ. ,J ntgg ,afftpaypd ,uzlhk tpjpfF vjpuhdJ myy. Vnddpy ntggk RwWgGwjjpYss fhwWfFf nfhLffggLfpwJ. NkYk nkhjj vdlNuhgp (Fsphrhjdgnglb + #oy) vgNghJk caUk.

Fsphrhjdgnglb xdwpd COP ahdJ 3 MFk. 200 J ntggjij Fsphrhjdgnglbapypy;UeJ ntspNaww NtzLnkdpy vttsT Ntiy nraaggl NtzLk?

jhT:

$$\text{COP} = b = \frac{Q_L}{W}$$

$$W = \frac{Q_L}{COP} = \frac{200}{3} = 66.67J$$

Nfhilffhyjjpy ehk kzghidj jzziu Fbffggad gLjJfpNwhk. kzghidahdJ mjDsNs Cwwggll jzzhpd ntggepiyia FiwffpwJ. kzghidia Fsphrhjdgnglbahff (Refrigerator) fUjyhkh? fUjKbahJ. Vnddwhy ntgg vejpujjpwNfh myyJ Fsphrhjdgnglbf Nfh Rowrp epfoT (Cyclic process) kpf Kffpa Njit MFk. kzghidapy elfFk Fspht pffk epfothdJ xU Rowrp epfotyy. gzghid Rtwwpy css Ezzpa Jisfspypuej eh %yf$Wfs ntspNaWtjhy csspUfFk euhdJ Fspht pffggLfpwJ. eh %yf$Wfs Jistopahf RwWgGw#oYfF ntspNawpagpd jpUkgTk gzghidfFs tUtjpyiy. kzghidapy ntggkhdJ Fsphej ehpypUeJ. ntspgGw tspkzlyjJfF fljjgglhYk. ,J ntgg ,afftpaypd ,uzlhk tpjpfF Kuzhf ,yiy. VNddpy kzghidfFs ,UfFk (jzzH + ntspgGw tspkzlyk) Nrhej xU ntgg ,afftpay mikgghf fUjpdhy ,jd vdlNuhgp vgNghJk mjpfhpffpwJ.

gRik ,yy tpisT (Green house effect)

Gtpapy kdpjd caph thotjwF Gtpiar #oeJss tspkzlyjjpd gqF msggwpaJ tspkzlyjjpd NkwgFjpapd ntggepiy -19°C mjd mbggFjpapd ntggepiy +14°C. tspkzlyjjpd Nkwgugg pypUeJ mbggugGfF tUkNghJ ntgg epiy 33°C msTfF caUfpdwJ. ,jwFf fhuzk tspkzlyjjpYss rpy thAffshFk. ,tthAffSfF gRik ,yy thAffs vdW ngah› ,ttpistpwF gRik ,yy tpisT vdW ngah.

gRik ,yy thAffspy Kjdikahdit CO_2, eH %yf$W›Ne, He, NO_2, CH_4, Xe, Kr, XNrhd kwWk NH_3Nghdwitahfk. CO_2, kwWk ehk %yf$wpidj jtphjJ kww %yf$Wfs nrhwg mstpNyNa tspkzlyjjpy cssd. #hpadpy ,UeJ tUk epwkhiyapy #hpaffjphtrR fz ZU gFjpapy (Visible region) ,UffpwJ. ,ffjphtrRfis Gtp clftheJ kzLk mfrrptgG fjphfshf ntspaLfpwJ.

CO_2kwWk ehk %yf$Wfs mfrrptgGf fjphfis edF clftUk. Vnddpy mit ielu[d kwWk Mfp[Dld xggpLk NghJ mjpf mjphTW Rjejpu ,afff$Wfisg ngwWssd mit mfrrptgGf fjphfis clfthtjhy jhd tspkzlyk ntJ ntJgghf cssJ.

1900 ,y ,UeJ kdpjdpd nrayghLfshy tspkzlyjjpYss CO_2 tpd msT 20% Kjy 40% tiu mjpfhpjJssJ. CO_2 cUthtjwfhd Kjdikahd %yk Gijgbk vhpnghUsfis vhpggjhFk. cyfk KOtJk jhdpaqfp ,aejpuqfspd gadghL mjpfhpjjpUggNj ,jwFf fhuzkhFk. tspkzlyjjpy ,ej CO_2 tpd msT mjpfhpjjpUggjhy› Gtpapd ruhrhp ntggk 1°C caheJssJ. ,jwF cyfntggkakhjy (Global warming) vdW ngah. Mhlbf kwWk mzlhhbf gFjpfspy css gdpgghiwfs cUFtjwF ,ej cyf ntggkakhjNy fhuzkhFk. NkYk CO_2 tpd msT flypYk mjpfhpjJssJ. ,J flytho caphpdqfSfF kpfTk Mgjjhdjhfk.

CO_2cld NrhjJ kwnwhU kpf Kffpakhd gRik ,yy thA FNshNuh GNshNuh fhhgdhFk (CFC) ,J Fsphrhjgnglbfspy Fspht gghdhf cyfk KOtJk gadgLjjggLfpwJ. kdpjd cUthfFk gRik ,yy thAffs 55 rjtjk CO^2, 24 rjtjk CFC thAffs›6 rjtjk ielu[d Mfi]L kwWk 15 rjtjk kjNjd MFk. CFC thAffs XNrhd glyjjpy mjpf ghjpgGfis VwgLjJfpdwd.

CO_2, kwWk CFC thAffspd msitf flLggLjJtjwfhd Kawrpfspy cyfpYss gyNtW ehLfs <LglLsd. Gijgbk vhpnghUsfSfF khwwhf Gijgbkww vhpnghUsfis jhdpaqfp vejpuqfspy gadgLjJtjwfhd

Muharrpfs njhlheJ eilngwW tUfpdwd. tshrrpailej ehLfshd USA kwWk lNuhggpa A+dpad ehLfs ngUksT CO_2l ntspaLfpdwd.

2020 fFs CO_2, ckpoit ngUksT Fiwggjwfhf cyf ehLfSffpilNa gyNtW xggejqfs Nghlgg lLssd. ,Uggpdk cyf ntggkakhjy xU jqF tpistpfFk epfoT vd ngUkghyhd ehLfs czutpyiy.

- #lhd nghUspypUeJ› Fspharrpahd nghUSfF ghAk ,Utif ghpkhww MwwNy ntggkhFk. ,Uggpdk ntggk Nrkpjj itffggLk Xh Mwwy mstyy.
- xU nghUspypUeJ kwnwhU nghUSfF Mwwiy khwwf$ba nryNy Ntiy vdggLk.
- nghUspd ntgg msit (Hotness) mstpLtJ ntgge piyahFk. ntgge piyahdJ ntggk ghAk jpiriaj jhkhdpffpwJ.
- eyypayG thA tpjp PV = NkT myyJ PV = µRT MFk. ntgg ,affr rkepiyfF klLNk eyypayG thA tpjp nghUeJk. ntgg ,affr rkepiyaww epfoTfSfF ,ttpjp nghUejhJ.
- eyypayG thA tpjp PV = NkT myyJ PV = µRT MFk. ntgg ,affr rkepiyfF klLNk eyypayG thA tpjp nghUeJk. ntgg ,affr rkepiyapy epfoTfSfF ,ttpjp nghUejhJ.
- nghUnshdwpd ntgge piyia 1°C myyJ 1K cahjJtjwFj Njitggk ntggjjpd msNt ntgg VwGjjpwd vdggLk. ,JS Fwpgg lggLfpwJ.
- 1 Nkhy msTss nghUspd ntgge piyia 1°C myyJ 1Kcahjjtjwfj Njitggk ntggjjpd msNt Nkhyhh jdntgg VwGjjpwd MFk. mJC vdf Fwpgg lggLfpwJ.
- ntgge piy khWghlbdhy nghUspd tbtk› gugG kwWk gUkd Nghdwtwwhy VwgLk khwwk ntgg tpiT vdggLk.
- jzzh Kuzgll tpiTggz igg ngwWssJ.
- nghUspd epiykhwwjjpwFj Njitggk Mwwypd msT mgnghUspd kiwntgg VwGjjpwd vdggLk.
- ntgg ,aff mikgG xdwpid ntggggLjJk NghJ› mttikgG VwWfnfhzl myyJ mttikggpypUeJ ntspNawwggll ntggjjpd msit mstpLk KiwfF› ntgg mstlby vdW ngah.
- ntggkhwwkhdJ ntggffljjy› ntggrrydk kwWk ntggffjphtrR Mfpa %dW Kiwfspy eilngWfpwJ.
-]nl/ghd - Nghylnkd tpjp: $E = s\ T^4$kwWk tpad tpjp $\lambda_{max} T = b$
- ntgg ,affr rkepiyfs: ntggrrkepiy› ,ejputpay rkepiy kwWk Ntjprrkepiy.
- ntgg ,aff khwpfs: mOjjk› ntgge piy› gUkd› mf Mwwy kwWk vdlNuhgp.
- ntgg ,afftpaypd Roptpjp: ,uzL nttNtW nghUsfs jdpjjdpNa %dwhtJ nghUSld ntggr rkepiyapy ,Uejhy› mttpuzL nghUsfSk jdfFsNsNa

ntggrrkeiyay cssJ vdf fUjyhk. ,ttuzL mikgGfsd ntggeiy rkkhFk.

- ntgg ,aff mikggYss %yf$Wfsd ,aff Mwwy kwWk eiyahwwy ,twwd $LjNy mf MwwyhFk.
- [{y ,aeju Mwwiy› ntgg ,aff mikggd mf Mwwyhf khwwffhlbdhh.
- Mwwy khwhf $wwd xU tbtNk ntgg ,afftayd Kjy tjjahFk. ,ttjj ntgg ,aff mikggd ntggjij csslffjAssJ.
- knkJ efoT vdgJ tiuaWff ,ayhj msT nkJthf eilngWk Xh efothFk. ,eefotiy mikgG vgNghJk #oYld rkeiyay ,UfFk.
- mikggd gUkd khWkNghJ mikggdhy nraaggll Ntiy $W = \int PdV$
- PV tiugljjjy tis NfhlbwFf fNo css gugG› mikggdhy nraaggll Ntiy myyJ mikggd kJ nraaggll NtiyfFr rkkhFk.
- Mwwy khwhf $wwd xU tbtNk
- ntggeiy khwh efoT T = khwy
- mOjjk khwh efoT P = khwy
- gUkd khwh efoT: V = khwy
- ntggggh khwwkyyh efoT Q = 0
- mOjjk khwh efotiy nraaggll Ntiy ngUkk kwWk ntggggh khwwkyyh efotiy nraaggll Ntiy rWkkhFk.
- Rowr efoT xdwd mf Mwwy khWghL RoahFk
- Rowr efotiy nraaggll njhFgad Ntiy›PV tiugljjDs %lggll tisNfhlbd gugGfFr rkkhFk.
- ks efoT Xh ,ylra nrayKiwahFk. eilKiway rhjjayiy.
- ,awif efoTfs midjJk ksh efoTfshFk.
- xU ntgg ,aejuk ntgg %yjjyUeJ ntggjijgngwW Ntiy nraJ› Fiwej msT ntgg Mwwiy ntgg Vwgf Ff nfhLffwJ.
- fhhNdh ,aejuk Xh ks efoT ,aejukhFk ,jd gaDW jwd kf mjfk. NtW vej eilKiw ,aejuqfSfFk fhhNdh ,aejujijg Nghdw gaDWjwd ,yiy.

· Fs/hgjdgnglb vdgJ vj/hjj/iray nraygLk xh fhhNdh ,aej/ukhFk eilKiwa/y gadgLjjggLk Fs/hgjdgnglba/d nrayj/wd Fzfk (COP), ,ylr/af Fs/hgjdnglba/d nrayj/wd Fzfjijt/lf FiwthFk.

11th ,awgpay;
njhFjp 2
myF – 10
miyTfs;

jQrhTh eldg nghkikia (jQrhTh jiyahlbg nghkik) ,J Xh cyfg Gfongww jkpoff fyhrrhug nghkikahFk. ,ej nghkikia Mlbtpllhy epfotJ vdd? nghkikapd jiy kwWk cly njhlhrrpahf KdDk gpddDk ,aqfp gpddh ,affk gbggbahf FiweJ epwfpwJ. ,Nj Nghy ehk rhiyapy elfFk nghOJ> ekKila iffSk> fhyfSk KdDk gpddDk ,affjij Nkwnfhs Sk NghJ epfOk. jha jd Foeijia J}qf itggjwfhf njhlbiy MlLkngh OJ njhlbyhdJ KdDk gpddDk ,affkilAk. Kddh tpthjpjj ,affqfspypUeJ ,ttifahd midjJ ,affqfSk NtWgllit. ,ej ,affqfs ,jjifa ,affqfis miyTW ,affk myyJ mjhTW ,affk vdW mioffpdNwhk. ,kkhjhpahd ,affk mZffspy $l epfofpdwJ.

xU jplgnghUspd ntggepiy caUk nghOJ mZffs mjDila eLepiy myyJ rkepiyiag nghUjJ mjhtilfpwJ. flblqfspd fllikgG kwWk vejputpay fUtpfis Mfpatwiw tbtikjjy Nghdw nghwpapay gadghLfspy mjhT ,affk gwwpa fwwy kpfTk Kffpajtjij ngWfpwJ.

rpuiyT kwWk; rpuww miyT ,af;fk;

,awgpaypy ,affkhdJ> kzLk> kzLk epfOk ,affk ruiyT ,affk> vdTk kzLk> kzLk epfohj ,affk ruww miyT ,affk vdTk ,Utifahf tifggLjjggLfpwJ.

1. **rpuiyT ,af;fk;** (Periodic motion):
   ruhd fhy ,ilntspapy jhdhfNt kzLk> kzLk epfOk vej xU ,affKk ruiyT ,affk vdggLk. vLjJffhlL Cry fbfhujjpy css Klfs> njhlbypd miyTfs> #hpaidr Rwwptuk Gtpapd ,affk> tsUk kwWk NjAk rejpud kwWk rpy.

2. **rpuww miyT ,af;fk;**
   ruhd fhy ,ilntspapy jhdhfNt kzLk> kzLk epfohj vej xU ,affKk ruww miyT ,affk vdggLk. vLjJffhlL epy eLff epfoT> vhpkiy ntbgG Nghdwit.

miyTW ,af;fk; (Oscillatory motion):

xU nghUs myyJ Jfshd J Fwpggpll fhy ,ilntspapy kzLk kzLk KdDk gpddDk ,affjij mjhtpaffk) vdggLk.

vLjJffhlLfs ekJ ,jaJbgG> Grrpapd rpwfpd ,affk> jhjjhtpd fbfhuk (Grand father's clock) Cry fbfhuk) Nghdwit.

midjJ miyTW ,affKk ruiyT ,affkhFk. Mdhy midjJ ruiyT ,affqfSk miyTW ,affkhfhJ vdgij ftdjjpy nfhssTk.

jdprrhpir ,af;fk; (SHM):

jdprrhpir ,affk miyTW ,affjjpd rpwgG tifahFk. ,jpy Jfspd KLffk myyJ tpirahdJ epiyahd Gsspapypy UeJ mJ milej ,lngahrrpfF Nehjjftpyk. vgnghOJk epiyahd Gsspia Nehffpak ,UfFk vdyhk.

xU ghpkhz ,affjjpy x vdgJ Jfs milej ,lngahrrp kwWk axvdgJ mjJfspd KLffk vdpy>

$a_x \mu x$

$a_x = -bx$

,qF b vdgJ khwpy. ,J KLffk kwWk ,lngahrrpffpilNaahd jftpdhy mstplggLfpwJ. ,jd ghpkhzk T^{-2} fFr rkk.

,UGwKk Jfspd epiw m– My ngUffp epA+lldpd ,uzlhtJ tpjpiaggadgLjj› tpirahdJ›

$F_x = -kx$

,qF k vdgJ tpir khwpy MFk. ,kkhwpy XuyF esjjpwfhd tpir vd tiuaWffggLfpwJ. ,lngahrrpAk› tpirAk (myyJ KLffk) xdWfnfhdW vjphjjpirapy cssij vjphfFwp fhlLfpwJ. Jfspd ,lngahrrp rkepiy Gsspapypuej tyJGwk (x NehfFwp kjpgG) Nehffp cssNghJ tpirahdJ (myyJ KLffk) rkepiygGsspia Nehffpna (,lgGwk Nehffp) ,UfFk. ,NjNghy Jfspd ,lngahrrpahdJ rkepiyg Gsspapypuej ,lJGwk Nehffp css NghJ (x vjphfFwp kjpgG)› tpirahdJ (myyJ KLffk) rkepiygGsspia Nehffpna (tyJGwk Nehffp) ,UfFk. ,ttifahd tpirahdJ ks tpir vdggLk. Vnddpy jdprrhpir ,affjij Nkwnfhssk Jfis› kstpirahdJ vgnghOJk njhlff epiyfNf (rkepiy myyJ eLepiy) nfhzL tUk. ,ttpirahdJ xUikatpir MFk. ,J rkepiygGsspia Nehffp nraygLk ika fthrrp tpirahFk.

,Ughpkhzk kwWk Kgghpkhzjjpy ,jid ehk ntflh Fwpalby vOjyhk.

$$\vec{F} = -k\vec{r}$$

,qF $\vec{r}$ vdgJ vLjJfnfhzl MjpgGsspapypuej Jfspd ,lngahrrpahFk. tpirAk› ,lngahrrpAk NehNghfF njhlhG nfhzlJ vdgJ Fwpggpljjffj. mjhtJ tpirapd mLfFk› ,lngahrrpapd mLfFk xdWfnfhdWr rkk.

(tpirapd vzkjpgG $|\vec{F}|$) kwWk tpisT (,lngahrrpapd vz kjpgG $|\vec{r}|$) ,twwpwF ,ilNaahd njhlhig tiugljjpy Fwpjjhy› ,uzlhk kwWk ehdfhk fhygFjfs topNa nryYkl NehNfhlhf mikAk. mfNfhlbd rhpT kia mseJ› tpirkhwpy $\frac{1}{k}$-,d vzkjpgig fzlwpayhk.

ruhd tpl ,afpfjpjpd; tpl;ljpjpd; kjhd tpoy; xU jdprrhpir ,afpfk;

m epiw nfhzl Jfs xdW v vdw ruhd jpirNtfjjpy r Muk nfhzl tlljjpd ghpjp topNa ,lQRopjjpirapy ,aqFtjhff fUJNthk. Ma mrR mikggpd MjpgGsspahdJ tlljjpd ikak O Tld nghUeJtjhff nfhsf. Jfspd Nfhzjjpirntfk vdTk xU Fwpggpll Neuk *t* ,y mjJfspd Nfhz ,lngahrrp θ vdTk nfhzlhy ruhd tll ,affjjpy ,UfFk xU Jfspd epiyia (Position), mej tlljjpDila tplljjpy tpornrajhy mej toy (Projection) xU jdpr rhpir ,affjij Nkwnfhssk. ,jd %yk ruhd tll ,affk kwWk mjphTWk ,affk Mfpatwwffp ,ilNa css njhlhgpid ehk ,izff KbAk.

,NjNghdW vej xU mjphTW ,affk myyJ Roy ,affjjpid› ruhd tll ,affjJld ,izff KbAk. NtWtpjkhf $wpdhy ,ttpU ,affqfSk xNu ,ayig ngwWssJ.

tllgghijapy ,aqFk Jfspd epiyia (position) mttllgghijapd nrqFjJ tplljjpd kJ myyJ nrqFjJ tplljjpwF ,izahd Nfhlbd kJ toy (projection) nraNthk.

,NjNghy› Nkw$wpa epfoit fpiljjs mrR myyJ fpiljjs mrRfF ,izahd Nfhlby ehk torrpailar nraa KbAk.

xU RUstpy - epiw mikgig (myyJ miyAWk Cry) xU Fwpggpll vLjJffhllhff fUJNthk. RUstpy NkYk fOk ,afFk NghJ (myyJ Cry KdDk gpdDk miyTWk NghJ) mjd epiw myyJ Cry Fzbd ,affk tll ,affjjpy css Gsspfsld ,izjJ fhllgglLssJ.

vdNt ruhd tll ,affjjpy Jfspd epiyia mej tlljjpDila tpljjpd kJ (myyJ tpljjpwF ,izahd Nfhlbd kJ) tpor nrajhy (Projection) mttpaffk NehNfhlL ,affkhf mikAk. ,jidNa jdprrhpir ,affk vdf fUJfpNwhk. ,ttllk jdprrhpir ,affjjpd NkwNfhs tllk (circle of reference) vdggLk.

jdprrhpir ,affkhdJ xU Fwpggpll tlljjpd vej xU tpljjpd kJk ,aqFk Jfs epiyapd toT (Projection of position) vdTk tiuaWffggLfpwJ.

jdprrhpir ,affjjpy; ,lgngahrrp jpirNtfk› KLfpfk; kwWk; mtwwpwfhd tiugl tpsfpfk;

xU Fwpggpll fz Neuk t ,y mjphtilAk JfshdJ rkepiygGsspapypUeJ flej njhiyT ,lgngahrrp vdggLk.

xU Fwpggpll fz Neuk t ,y›A Muk nfhzl tlljjpd kjhd Jfspd epiy Pvdf. t vdw fzjjpy mjd ,lgngahrrp y-ia foffzlthW jUtpffyhk.

ΔOPN ,y

$$\sin\theta = \frac{ON}{OP} \text{Þ } ON = OP\sin\theta$$

Mdhy $q = wt, ON = y$ kwWk OP = A

$$y = A\sin wt$$

$\sin wt = 1$vDk nghOJ ,lgngahrrp y MdJ ngUk kjpgig ngWk (,ej kjpgG A – fFr rkk)

eLepiyapypUeJ mjphtilAk Jfs milej ngUk ,lgngahrrp trR (A) vdggLk. jdprrhpir ,affjjpy trR khwpyahFk. nghJthf jdprrhpir ,affjij jtpu kww vej ,affjjpwFk trR khwpyahf ,Uff Njitapyiy› ,J fhyjijg nghWjJ khwyhk.

jpirNtfk;

,lgngahrrp khWk tjk jpirNtfk MFk. fhyjij rhheJ tifggLjj ehk ngWtJ

$$v = \frac{dy}{dt} = \frac{d}{dt}(A\sin wt)$$

tll ,affjjpy (khwh Muk) trR A khwpy› NkYk ruhd tll ,affjjpwF Nfhzjjpirntfk *w* khwpy› vdNt

$$v = \frac{dy}{dt} = Aw\cos wt$$

$$\sin^2 wt + \cos^2 wt = 1 \text{Þ } \cos wt = \sqrt{1 - \sin^2 wt}$$

vdw jphNfhz KwnwhUikiag gadgLjj

$$v = Aw\sqrt{1 - \sin^2 wt}$$

rkdghL ypUeJ

$$\sin \omega t = \frac{y}{A}$$

$$v = A\omega\sqrt{1 - \left(\frac{y}{A}\right)^2}$$

$$v = \omega\sqrt{A^2 - y^2}$$

,lgngahrr y = O vdy mjd jirNtfk v = wA (ngUkk) kwWk ngUk ,lgngahrr y = A> vdy mjd jirNtfk = v = O (rWkk). ,lgngahrrahdJ Roaiyay;UeJ ngUkjjwF mjfhjjhy jirNtfk ngUkjjy;UeJ RofF FiwAk. ,J vjhjiray kzLk efOk.

jirNtfk xU ntflh msT Mifahy> rkdghL ntflh $Wfisf fzlwtjd %yKk ngwyhk.

NtWgl;l fzNeuj;jy; ,lgngahrrp jirNtfk kwWk; KLf;fk;

fhyk	0	$\frac{T}{4}$	$\frac{2T}{4}$	$\frac{3T}{4}$	$\frac{4T}{4}=T$
ωt	0	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π
,lgngahrr $y = A\sin\omega t$	0	A	0	-A	0
jirNtfk $v = A\omega\cos\omega t$	$A\omega$	0	$-A\omega$	0	$A\omega$
KLffka = a = $-A\omega^2\sin\omega t$	0	$-A\omega^2$	0	$A\omega^2$	0

KLf;fk;

jirNtf khWghL KLffk vdggLk. fhyjijg nghUjJ tifggLjj> ehk ngWtJ

$$a = \frac{dv}{dt} = \frac{d}{dt}(A\omega\cos\omega t)$$

$$a = -\omega^2 A\sin\omega t = -\omega^2 y$$

$$a = \frac{d^2y}{dt^2} = \omega^2 y$$

ehk mwtJ eLeiygGss;ay (y = 0) Jfsd jirNtfk ngUkk Mdhy Jfsd KLffk Roahfk. ngUk eiyay (y = ±A), Jfsd jirNtfk Ro Mdhy KLffk ngUk kjgGld (±Aω^2) vjhjjiray nraygLfwJ.

jdrrhir ,afjj;jd; miyTNeuk> mjhntz> fl;lk> fl;l NtWghL kwWk; njhlf;ff; fl;lk;

1. miyTNeuk;

JfnshdW xU KO miytwF vLjJfnfhsSk fhyk miyTNeuk vd tiuaWffggLfwJ. ,J toffkhf T vdw vOjjhy FwffggLfwJ. xU KOrRwWfF vLjJfnfhzl t=T, fhyk vdy

$$wT = 2p \Rightarrow T = \frac{2p}{w}$$

jdrrhir ,affjjwF clgLk Jfsd ,lngahrria ird (sine) myyJ nfhird (cosine) rhhGfshf Fwggl yhk.

$$y(t) = A \sin \frac{2p}{T} t \text{ myyJ } y(t) = A \cos \frac{2p}{T} t$$

,qFTvdgJmiyTNeuk. fhyk tfFgjyhft+Tvdg gujallhy mjd rhhghdJ›

$$y(t+T) = A\sin\frac{2p}{T}(t+T)$$

$$= A\sin(\frac{2p}{T}t + 2p)$$

$$= A\sin\frac{2p}{T}t + y(t)$$

$$y(t+T) = y(t)$$

vdNt ,rrhhGxUmiyTNeujjwFgwFk kzLk kzLk efOk rhhGMFk. ,ej *y(t)* vdgJrhirr rhhGffhdvLjJffhllhFk.

mjhntz; kwWk; Nfhzmjhntz;

JfnshdWxUnehbay VwgLjJk miyTfsd vzzfifmjhntz vdggLk. ,Jfvdwv Ojjhy Fwffggl fwJ. ,jd SImyFS-1myyJn`hl] MFk. (FwaLHz)

fzjKiway mjhntz›miyTfhyjJld foffzlthWnjhlhGgLjjggLfwJ.

,jd SImyFs-1myyJn`hl] MFk. (FwaLHz).

fzjKiway mjhntz›miyTfhyjJld foffzlthWnjhlhGgLjjggLfwJ.

$$f = \frac{1}{T}$$

xUnehbay VwgLk RwWfsd vzzfifNfhzmjhntz vdggLk. ,Jtoffkhf *w* (omega) vdwfNuffr rwavOjjhy Fwggl ggLfwJ.

rkdghLMfatwiwxggLk nghOJ›Nfhzmjhntz kwWk mjhntz zd njhlhG.

$$w = pf$$

Nfhzmjhntz zd SImyFrads-1(Nubad ngh nrfzl vdthrffTk)

fl;lk;

xUFwggllfzjjy mjhtilAk Jfsd fllk›mffzjjy mjJfsd eiyiaKOikahff Fwggl tjhFk.

Fwggllfzjjy rkeiyiag nghUeJmjJfsd eiy (Position)kwWk ,affjjirMfatwiwfllk tthffwJ.

$$y = A \sin (wt + j_0)$$

,qF $wt + j_0 = j$ vdgJmjhtilAk Jfsd fllk vdmioffggLfwJ.

t = 0s (njhlfffhyk) ,y› Jfsd fllk njhlfff fllk ($j = j_0$) vdmioffggLfwJ. vdgJ j_0 njhlfff flljjd Nfhzk (angle ofepoch)vdmioffggLfwJ.

fllNtWghL: jdrrupir ,affjij Nkwnfhs Sk ,U Jfsfisf fUJNthk.

mtwwpd rkdghLfs $y_1 = A\sin(wt + j_1)$ kwWk $y_2 = A\sin(wt + j_2)$ vdpy mtwWf fpilNaahd fllNtWghLD$j = (wt + j_2) - (wt + j_1) = j_2 - j_1$

Nfhzrhpir ,afyfk;
Nfhzrhpira pafyfj;jpd; miy Neuk; kwWk; mjpfhnt z;

nfhLffggllmrirggwwpjdpjJRoYk nghUspd miyTfs>Nfhzmiy Tfs vdggLk.

vejxUGsspay; nghUspd kJnraygLk njhFgad jpUgGtpirRopahfpdwNjhmgGsspy; rkepiygGsspy; vdggLk.

nghUs rkepiygGsspay;UeJ ,lngahrrpfFsshFk NghJ>nraygLk gaDWnjhFgad jpUgGtpirNfhz ,lgngahrrpfFNehjftpy ,UfFk kwWk ,jjpUgGtpirahd JmgnghUisrkepiyfFnfhz LtuKawrpfFk.

nghUspd Nfhz ,lngahrrpq' vdTk nghUspd kJnraygLk njhFgad jpUgGtpirt' vdTk nfhzlhy>

$$t' \mu a'$$
$$t' = -kq'$$

,qFk vdgJkspjpUgGtpirkhwpy. ,JXuyFNfhz ,lgngahrrpffhdjpUgGtpirahFk. IvdgJxUnghUspd epiykjjpUgGjjpwd kwWk a vdgJNfhz KLffk vdpy

$$t' = Ia' = -kq'$$

Mdhy $a' = \frac{d^2q'}{dt^2}$

vdNt>

$$\frac{d^2q'}{dt^2} = -\frac{k}{I}q'$$

,rrkdghLjdrrhpirtiffnfOr rkdghLNghy cssJ. Mifahy jdrrhpir ,affrkdghLcld xggpLehk ngWtJ

$$w = \sqrt{\frac{k}{I}}\, rad\, s^{-1}$$ vdehk ngwyhk.

Nfhzrrhpir ,afyfj;jpd; mjpfhnt z;

$$f = \frac{1}{2p}\sqrt{\frac{K}{I}}Hz$$

miyT Neuk;

$$T = 2p\sqrt{\frac{I}{K}}$$

jdprrhpir ,afyfk; kwWk; Nfhzrrhpir ,afyfk; xggLk:

NehNfhlLjdprrhpir ,affjjpy>nghUspd ,lngahrrpahd JNehNfhlL ,lngahrrpr' Mymstplggl fwJ.

kstpir $\vec{F} = -k\vec{r}$,qF k vdgJ RUs khwypmyyJtpirkhwypahFk. ,JXuyF ,lngahrrpffhdtpirfFr rkk. NehNfhlLrhpir ,affjjpy nghUspd epiykffhuzpvdgJnghUspd epiwMFk.

Nfhzrhpirmiy ,affjjpy>nghUspd ,lngahrrpq Nfhz ,lngahrrp My mstplggLfpwJ. ,qFRUsfhuzpvdgJjpUgGtpirkhwypMFk. mjhtJxuyFNfhz ,lngahrrpffhd ,ulilapd jpUgGj jpwdhFk myyJxuyFNfhz

jdprrhpir ,afpfk; kwWk; Nfhzrrhpir ,afpfk; xggL:

t.vz;	jdprrhpir ,afpfk;	Nfhzrrhpir ,afpfk;
1.	Jfspd ,lngahrrpNehfNfhlL ,lngahrrpr My mstplggLfpwJ.	Jfspd ,lngahrrpNfhz ,lngahrrpq My mstplggLfpwJ. (Rowrp Nfhzk vdTk miofffggLfpwJ)
2.	Jfspd KLffk $a = -w^2 r$	Jfspd Nfhz KLffk $a = -w^2 q$
3.	tpir> $\vec{F} = -m\vec{a}$,qF m vdgJ Jfspd epiwMFk	jpUgGtpir> ,qF vdgJnghUspd epiykjjpUgGjjpwd
4.	kstpir $\vec{F} = -k\vec{r}$, ,qF k vdgJkstpirkhwyp	ks jpUgGtpir $t = I\vec{a}$, ,qFK vdgJjpUgGtpirkhwyp (fpNuffvOjJK I 'kappa' vdWcrrhpffTk) ,kkhwypxUFwpggplIKWfF ,ioianghUjJmikAk.
5.	Nfhz $w = \sqrt{\frac{k}{m}} rads^{-1}$ mjphntz	Nfhz $w = \sqrt{\frac{k}{I}}$ mjphntz

,lngahrrpffhdks jpUgGtpirahFk. Nfhzrhpir ,affjjpwF clgLk nghUspd epiykf fhuzpvdgJnghUspd epiykj jpUgGj jpwd MFk.

NehNghf;Frhpirmiyapawp(LHO):
RUs;tpy; - epiwmikggpd; fpilj;jsmiyTfs;

epiwawwRUstpyYld mepiwnfhzlnghUs ,izffgglLssJ. ,ejRUstpy - epiwmikgghdJcuhatwwfpiljjsjjpd kJitffgglLssJvdfnfhsf. RUstpyypd tpiwGkhwypmyyJtpirkhwypmyyJRUstpy khwypkMFk. ,ejmikggpd kJtpirnrYjjgglhjNghJepiwm d rkepiygGsspmyyJeLepiygGsspx0vdf. epiwia>rkepiyapy ,UeJtygGwkhfxnjhiytpwF ,lkngaur nraJgpdGtpLtpjjhy>epiwahdJeLepiygGsspx0 lg nghUjJKddDk gpdDk miyAWk.

RUstpyypd elrpahy VwgLk kstpirFvdf. ,ttpirahdJepiwapd ,lngahrrpfFNehjjftpy ,UfFk.

xUghpkhz ,affjjpwF

F µ x

F = - kx

vdf fz¡jt¡ay Kiwa¡y ehk ngwyhk. ,qF›kst¡irahdJ vgnghOJk ,lngahrr¡fFvj¡hj¡ira¡y nraygLk vdgijvj¡hfFw¡fhlLf¡wJ.

,rrkdghL `f t¡j¡vdWmioffggLf¡wJ ,qFkst¡irahdJ ,lngahrr¡Ald NehNghff¡y cssijftdjj¡y nfhsf (mjhtJ t¡irkwWk ,lngahrr¡a¡d mLfF(exponent) xdwhFk). ,JvgnghOJk rh¡ahf ,Uggj¡y iy›Vnddwhy r¡yNehTfs¡y mj¡fkhdmsT ,Ot¡iriaehk nrYjJk NghJ›miyTfs¡d trRfs mj¡fkhfmikAk. (mjhtJ t¡irAk› ,lngahrr¡Ak xd mj¡fmLfFfSfFNehjjfthfmikAk) vdNt ,ejmikgg¡d miyTfs NehNghfFmiyTfshf ,Uggj¡y iyvdgjhy ,it NehNghfFmyyhjmiyTfshFk. ,JtiuekKilat¡thjqfs¡d gbNehNghfFmiyTfs klLNkt¡thj¡ffgglLssJ. ,jd mbggila¡y `f t¡j¡VwGilajhfmikf¡dwJ. mjhtJ (t¡irkwWk ,lngahrr¡Neh NghfFnjhlhGilait)

e¡A+lld¡d ,uzlhk ,afft¡j¡a¡y¡UeJjd¡rrh¡ir ,affjj¡wFclgLk Jfs¡d rkdghlilfoffzlthWehk vOjKbAk.

$$m\frac{d^2x}{dt^2} = - kx$$

$$\frac{d^2x}{dt^2} = - \frac{k}{m}x$$

jd¡rrh¡ir ,affr rkdghL cld xgg¡l› ehk ngWtJ

$$w^2 = \frac{k}{m}$$

mjhtJ miya¡aww¡a¡d Nfhz mj¡hntz myyJ ,ayG mj¡hntz

$$w = \sqrt{\frac{k}{m}} rad\, s^{-1}$$

miya¡aww¡a¡d mj¡hntz

$$f = \frac{w}{2p} = \frac{1}{2p}\sqrt{\frac{k}{m}} Hz$$

kwWk miyTfs¡d miyTNeuk

$$T = \frac{1}{f} = 2p\sqrt{\frac{m}{k}} s$$

jd¡rrh¡ir ,affjj¡y miyTfs¡d miyTNeuk trirg nghUjjJ myy vdgijf fUjj¡y nfhsf. ,J miyTfs Njhuhakhf r¡w¡a mst¡y css NghJ klLNk nghUeJk. jd¡rrh¡ir ,affjj¡d tiffnfOr rkdghlbd jhitg g¡dtUkhW vOjyhk.

$$x(t) = A\sin(wt + j)$$

myyJ

$$x(t) = A\cos(wt + j)$$

,qF A,*w* kwWk *j* Mf¡ait khwy¡fs. tiffnfOr rkdghL nghJjjhT

$x(t) = A\sin(wt + j)\, B\cos(wt + j)$ MFk. ,qF A, B khwy¡fs.

e¡iwaww t¡ir khw¡y¡ myyJ RUst¡y khw¡y¡ *k*(spring constant) nfhzl RUst¡yyhdJ $iua¡d NkwgFj¡a¡y ,izffggLtjwF KdG RUst¡yyd¡d esk *L* vdf. RUst¡yyd¡d kwnwhU Kida¡y e¡iw *m* ,izffggLkNghJ RUst¡yy¡dhJ *l* esjj¡wF t¡ht¡ilf¡wJ. RUst¡yyd¡d elr¡ fhuzkhf VwgLk kst¡ir F_1 vdf.

e¡iw m– y nraygLk <hgG t¡irahdJ nrqFjjhf foNehff¡ nraygLk.

,ej mikggwF jdjj nghUsd tirgglk ehk tiua KbAk.

fhllggILssJ. mikgghdJ rkeiyaay css NghJ›

$F_1 + mg = 0$

Mdhy RUs tiy *l*, lgngahrrfF elraileJssJ. vdNt

$F_1 \mu l \Rightarrow F_1 = -kl$

gujaal ehk ngWtJ

$-kl + mg = 0$

myyJ

$\frac{m}{k} = \frac{l}{g}$

kfrrwa msstyhd Gw tiria eiwkJ ehk nrYjjdhy› mej eiw NkYk› foNehffa jiray ,lngahrri y– fF esfwJ. gwF mJ NkYk› fOk miyTWfwJ. ,gnghOJ RUs tiyyid elri (*y* + *l*) RUs tiyyid nkhjj elri fhuzkhf VwgLk kstir.

$F_2 \mu (y + l)$

$F_2 = -k(y + l) = -ky - kl$

$\frac{d^2y}{dt^2}$ vdw KLffjJld ,aqFk eiwfF jdjj tirgglk tiuejhy› ehk ngWtJ

$-ky - kl + mg = m\frac{d^2y}{dt^2}$

elraid fhuzkhf eiw kJ nraygLk nkhjj tir

$F = F_2 + mg$

$F = -ky - kl + mg$

<hgGtirahdJkstirfFvjuhfmikAk›gujaal›ehk ngWtJ

$F = -ky - kl + kl = -ky$

eiA+lldid ,uzlhk tjjiag gadgLjj

$m\frac{d^2y}{dt^2} = -ky$

$\frac{d^2y}{dt^2} = -\frac{k}{m}y$

,rrkdghLjdirrhir ,affjjd tiffnfOr rkdghlbd tbtkhFk. vdNt

miyTNeuk $T = 2p\sqrt{\frac{m}{k}}s$

gadgLjj›miyTNeuj ijNtWtbtiy vOjdhy

NtWtbtiy; vOjdhy;

miyT Neuk $T = 2p\sqrt{\frac{m}{k}} = 2p\sqrt{\frac{l}{g}}$

,rrkdghlbyiUeJGt<hgGKLffk gaid kjgigngwyhk.

$g = 4p^2\left(\frac{l}{T^2}\right) ms^{-2}$

RUs;tiy;fsd; njhFgGfs;

RUstpyypd tpiwgGj jdikahdJ›RUskhwpypmyyJtpirkhwpypmyyJtpiwgGkhwpyahy msTlggLfpwJ.

RUskhwpyapd kjpgGmjpfnkdpy RUstpyyhdJtpiwgghf ,UfFk. RUstpyiyelrpailar nraaNthmyyJmKffr nraaNthmjpftpirianrYjjNtzLk vdgij ,J czhjJfpdwJ. ,NjNghy RUskhwpyapd kjpgGFiwntdpy FiwejtpirianrYjjpRUstpyiyelrpailar nraaNthmyyJmKffNthKbAk.

,URUstpyfis ,U topfspy ,izffKbAk. xdWnjhlhpizggpy ,izjjy kwnwhdWgff ,izggpy ,izjjy.

1. RUstpyfs njhlhpizggpy cssNghJk
2. RUstpyfs gff ,izggpy cssNghJk

njhFgad RUskhwpyiafoffhZk Jizggphpy Tfspy ehk fzffplyhk.

njhlhpizggpy; ,izf;fggl;Ls;sRUstpy;fs;

,uzLmyyJmjwFNkwgllRUstpyfs njhlhpizggpy ,izffgglLssdvdf. njhlhpizggpy cssRUstpyfs VwgLjJk epfutpistpwFr rkkhdtpisitVwgLjJk xURUstpyiy (njhFgad RUstpy) mrRUstpy njhFgGfFgjpyhfehk gadgLjjyhk.

jdpjjdpRUskhwpyfspd kjpgGfs k_1, k_2, k_3, (njhejmsTfs)›kwWk njhFgad RUskhwpyks (njhahjmsTfs) Mfpatwffpilnafzpjtpay njhlhgpidehk ngwyhk. vspikffhfk k_1, k_2 RUs khwpynfhzl ,U RUstpyfisklLk fUJNthk. m vdwepiwAld ,izffgglLssjhfnfhsf. ,jd %yk ngwggLk Kbtpidg gadgLjjpnjhlhpizggpy vejxUvz zpfifapYk ,izffggLk RUs tpyfSffhdnghJthdKbitg ngwyhk.

Gwtpirftyjgwk NehffpnrYjjggltjhff nfhsNthk. xtnthURUstpyypd RUskhwpypntntwhditNkYk mwWffpilNaadhgpizgG ,Wffkhf(rigid) ,Uggjpyiy. Mjyhy mitnttNtWesjjpwFelrpailfpdwd.

nrYjjggllTpirF– d fhuzkhfRUsfs mjDilarkepiyapypUeJ (elrpailahepiy) elrpailejnjhiyTfs KiwNax$_1$kwWk x$_2$vdf.

vdNt›epiwg Gsspapd nkhjj ,lngahrrp

$$x = x_1 + x_2$$

`{ffpd tpjapypUeJ

$$F = -k_s(x_1 + x_2) \text{ Þ } x_1 + x_2 = -\text{ Þ } \frac{F}{k_s}$$

RUstpyfs njhlhpizggpy cssjhy

$$-k_1x_1 = -k_2x_2 = F$$

$$\text{Þ } x_1 = -\frac{F}{x_1} and\ x_2 = -\frac{F}{k_2}$$

vdNtrkdghLgpujpaplLnjhFgad RUskhwpyiaf fzffplKbAk.

$$-\frac{F}{k_1} - \frac{F}{k_2} = -\frac{F}{k_s}$$

$$\frac{1}{k_s} = \frac{1}{k_1} + \frac{2}{k_2}$$

myyJ

$$k_s = \frac{k_1 k_2}{k_1 + k_2} Nm^{-1}$$

“n” RUstyfisnjhlhizggy ,izggjhff nfhzlhy njhlhizggd njhFgad RUs khwyp

midjJ RUs khwypfSk rkk vdy mjhtJ

$$k_s = \frac{n}{k} \text{Þ } k_s = \frac{k}{n}$$

njhFgad RUskhwyp“n”klqFFiwAk vdgij ,J fhlLfwJ.

MfNt› RUstyfs njhlhizggy ,izffggLk nghOJ njhFgad RUskhwypahdJ jdpjj RUs khwypiatpl Fiwthf ,UfFk.

rkdghL ypUeJ ehk ngWtJ

$$k_1x_1 = k_2x_2$$

,Wffggll esk myyJ elrpailej esk $x_1$kwWk x_2-ffhd jfT

$$\frac{x_2}{x_1} = \frac{k_1}{k_2}$$

Kjy kwWk ,uzlhtJ RUstpyypy Njffp itffgglLss ks epiyahwwy KiwNa $U_1 = \frac{1}{2}k_1x_1^2$ kwWk $U_2 = \frac{1}{2}k_2x_2^2$ vdpy mtwwpd jfT

$$\frac{U_1}{U_2} = \frac{\frac{1}{2}k_1x_1^2}{\frac{1}{2}k_2x_2^2} = \frac{k_1}{k_2}\left(\frac{x_1}{x_2}\right)^2 = \frac{k_2}{k_1}$$

gfpf ,izggpy; RUstpyfs;

,uzL myyJ mjwF Nkwgll RUstpyfs gff ,izggpy ,izffgglLssd gff ,izggpy css RUstpyfs VwgLjJk epfu tpistpwFr rkkhd tpisit VwgLjJk xU RUstpyiy (njhFgad RUstpy) mrRUstpy njhFgGfSfF gjpyhf ehk gadgLjjyhk.

jdpjjdp RUs khwypfspd kjpgGfs k_1, k_2, k_3, (njhpej kjpgGfs› kwWk njhFgad RUs khwyp k_p (njhpahj msT) MfpatwWffpilNaahd fzpjtpapy njhlhgpid ehk ngw KbAk.

vspikffhf k_1 kwWk k_2 RUs khwyp nfhzl ,U RUstpyfsfis klLk fUJNthk. m vdw epiwAld ,izffgglLssjhff nfhsf.

,jd %yk ngwggLk Kbtpidg gadgLjjp gff ,izggpy vej xU vz zpfifapYk ,izffggLk RUstpyfSffhd nghJthd Kbitg ngwyhk.

tpir F– l tyJ Gwkhf nrYjJtjhf nfhsNthk.
,eNehtpy› ,U RUsfSk xNu mstpyhd elrp myyJ ,Wffjjpid milfpdwJ.
epiw m milej ,lgngahrrp vdpy

$$F = -k_px$$

,qF $k_p$vdgJ njhFgad RUskhwyp MFk. Kjy RUspy x elrpia VwgLjJk tpir F_1 vdTk. ,uzlhtJ RUspy mNj msT x elrpia VwgLjJk tpir F_2 vdTk nfhzlhy› njhFgad tpirahdJ.

$$F = k_1x - k_2x$$

rkdghL kwWk Mf;atwiw rkdnraa ehk ngWtJ

$k_p = k_1 + k_2$

nghJthf n RUst;yfs gff ,izgg;y ,iz ffgglbUgg;d›

$$k_p = \sum_{i=1}^{n} k_i$$

midjJ RUst;y khw;y;ad kj;gGk rknkd;y mjhtJ

$k_1 = k_2 = \ldots = k_n = k$

$k_p = n\,k$

njhFgad RUskhw;y; n klqFmj;fh;fFk vdgij ,J fhlLf;wJ. MfNtRUst;yfs gff ,izgg;y ,iz ffgglbUgg;d njhFgad RUs khw;yjd;jjd; RUs khw;y;ad kj;ggidt;lmj;fkhf ,UfFk.

jd;rh;ir ,af;fj;jy; jd; Cry;d; miyTfs; kw;Wk; jd; Cry;d; t;j;fs; jd; Cry;:

jd; Cry vdgJ ruiyT ,affjij Nkwnfhs;Sk xU ,aej;ut;ay mikgghFk. eskhd fa;ww;y (e;iwaww klr;j jdikawwjhf fUJf) m e;iw nfhzl CryFzL xU Kida;y njhqft;lggll e;iya;y kW KidahdJ fhlbAssthW jhqf;a;y nghUjjgglLssJ. rke;iya;y› jd; Cry miyTwhky nrqFjjhf foNehff; njhqf;f nfhzbUfFk. ,ee;iy rk e;iygGs;s myyJ eLe;iygGs;s vdggLk. jd; Cryhd rke;iyg Gs;sa;y;UeJ r;wa ,lngahrr;fF clgLjjgglL t;lggLk NghJ› Cry FzlhdJ KdDk g;dDk ,affjij Nkwnfhs;Sk. jd; Cry;d esk /vdgJ njhqft;lggll Gs;sfFk Cry Fzbd <hgG ikaj;wFk ,ilggll njhiyT MFk.

Cry Fzbd kJ vej xU ,lk ngahej e;iya;Yk ,U t;irfs nraygLf;dwd.

1. <hgg;ay t;ir $\vec{F} = m\vec{g}$ nrqFjjhf foNehff; nraygLf;wJ.
2. njhqft;lggll Gs;s;ia Nehff; fa;ww;d to;ahf nraygLk ,Ot;ir $\vec{T}$

<hgg;ay; t;ira;d; ,U$Wfshtd

1. nrqFjJ $W: fa;ww;d to;ahf ,Ot;irfF vj;hj;ira;y nraygLk $W. F_{as}= mg $\cos\theta$
2. njhLt;ay $W: fa;ww;wF nrqFjjhf css $W mjhtJ t;yy;d njhLNfhlL j;ira;y css $W $F_{ps} = mg\sin\theta$

vdNt›
fa;ww;d to;Na t;ira;d nrqFjJf $W

$$T - F_{as} = m\frac{v_2}{l}$$

,qF vvdgJ Cry Fzbd Ntfk

$$T - mg\cos\theta = m\frac{v^2}{l}$$

ehk cwW NehfFkNghJ <hgg;ay t;ira;d njhLNfhlL $whdJ vgnghOJk rke;iy Nehff;Na mikAk. mjhtJ <hgg;ay t;irahdJ› Cry Fzbd rke;iygGs;sa;y;UeJ milej ,lngahrr;a;d vj;hj;ira;y mikAk. ,ej njhLt;ay t;irNa ks t;irahFk. njhLt;ay t;iria e;A:lld;d ,uzlhk t;j;a;d %yk ehk ngwyhk.

$$m\frac{d^2s}{dt^2} + F_{ps} = 0 \Rightarrow m\frac{d^2s}{dt^2} = -F_{ps}$$

$$m\frac{d^2s}{dt^2} = -mg\sin q$$

,qF s vdgJ Cry Fzbs ,lg ngahrr;ahFk. ,J tllt;yy;d to;Na ms t;lggLf;wJ.

tll t;yy;d esjij Nfhz ,lgngahrr;a;d tha;yhf ngwyhk. mjhtJ

$s = l\theta$

,jd KLffk

$$\frac{d^2s}{dt^2} = l\frac{d^2q}{dt^2}$$

rkdghL g;uj;a;l

$$l\frac{d^2q}{dt^2} = -g\sin q$$

$$\frac{d^2q}{dt^2} = -\frac{g}{l}\sin q$$

Nkwfzl tiffnfO rkdghlby sinθ ,Uggjdhy› ,rrkdghL NehNghffww (,uzlhk th;ir xUgbjjhd) rkdghlhFk. r;wa miyTfSfF Njhuhakhf sin θ »θ vdgjhy Nkwnfhzl tiffnfO rkdghL NehNghfF tiffnfOr rkdghlhf;wJ.

$$\frac{d^2q}{dt^2} = -\frac{g}{l}q$$

,JedFmw;ejmiya;affjj;wfhd tiffnfOrkdghL. vdNtmiya;aww;a;d Nfhzmj;hntz zhdJ (mikgg;d ,ayGmj;hntz)

$$w^2 = \frac{g}{l}$$

$$w = \sqrt{\frac{g}{l}}\, rad\, s^{-1}$$

miya;af;fj;j;d; mj;hntz;

$$f = \frac{1}{2p}\sqrt{\frac{g}{l}}\, Hz$$

miya;af;fj;j;d; miyT Neuk;

$$T = 2p\sqrt{\frac{l}{g}}\, s$$

jd;Cry;d; t;jj;fs;
jd;Cry;d miyTNeukhdJ

foffz lt;j;fs;d mbggila;y mikeJssJ.

esj;j;d; t;jj;:
nfhLffggllGt;<hgGKLffjj;d kj;gg;wF›jd;Cry;d miyTNeuk jd;Cry;d esj;j;d ,Ukb %yj;j;wFNehjjft;y mikAk.

$$T \mu \sqrt{l}$$

KLf;fj;jpd; tpjp

nfhLffgglljd;Cry;d esk khwhj;UfFk NghJ Cry;d miyTNeuk Gt;<hgGKLffjjpd ,Ukb %yjjwFvjhjftpy mikAk.

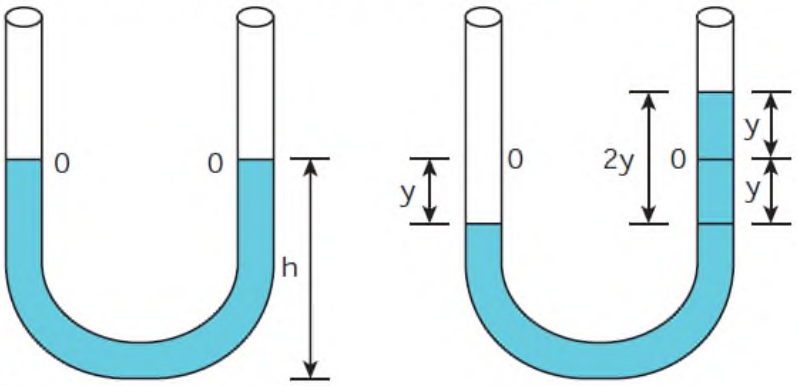
$$T \mu \frac{1}{\sqrt{g}}$$

gpd;tUk; fhuz;fisr; rhhe;jpUf;fhJ

1. **Cry; Fzbd; epiw:**
   jdpCry;y Cry Fzbd miyTNeuk epiwiarhhe;juhJ. ,JjhNdfNotpOk nghUspd ,affjijNghdwJ. vdNtkhwhjesk nfhzljdpCry;y Cry Fzlhfahid CrYwwhYk vWkGCrYwwhYk miyTf fhyk ghj;ffhJ. ,uzLk xNu miyTffhyjijngwwpUfFk.

2. **miyTfspd; tlrR:**
   rpwpaNfhzmsTfspy jdp Cry (Nfhz ,lgngahrrpwpajhfcssNghJ) miyTwwhy miyTNeuk trrpidrhhe;juhJ.

3. **Uவடிவக் குழாயின் திரவத்தம்பத்தின் அலைவுகள்:**



படம் 10.22 U– வடிவ கண்ணாடிக் குழாய்

xUruhdFWfFntlLggugGAnfhzljpwejGaqfisf nfhzlU tbt fzzhbf FohiafUJf. ghFepiyaww›mKff ,ayhjρmlhjjpnfhzljputkhdJUtbtf Fohapd gaqfspy h caujpwFepuggggLsshfnfhsf. FohAk jputKk mirtwwepiyapy cssnjdpy jputjjk kllk rkepiyg Gsspotpy ,UfFk. jputjjpd kJvejxUGsspapy mOjjjijmstplhYk rkkhf ,UfFk. NkYk Gaqfspd NkwgFjapYk mOjjk (Fohapd ,UGwqfspd csskidfspy) rkkhf ,UfFk. ,ttOjjk tsp kzlymOjjjjpwFr rkk. ,jdhy Fohapd Gaqfspy jputkllqfs rkepiyapy ,UfFk. VNjDk xUGajjpy ehk fhwiwCJtjd %yk Njitahdtpirianr YjJtjhy rkepiyg Gsspotpy;UeJjputkllk khWgLfpwJ. mjhtJxUGajjpy Cjgglfhwwpd mOjjk kwnwhUGajijtplmjpfk. ,ejmOjjkhWghLjutjijeLmyyJrkepiyg nghUjJrpwJ Neuk miyTfiscUthfFfpwJ gpd ,Wjpahfmikjepiyf Fjpukgfpwj. ,jd miyTNeuk.

$$T = T = 2p\sqrt{\frac{l}{2g}}$$ tpehb

,qNf/vdgJU tbt Fohapy csspjutjjkgjjpd nkhjjesk

jd;rrh;ir ,af;fj;jp; Mwwy;:

e;iyMwwYf;fhdrkdghL

jd;rrh;ir ,affjjpy tpirfFk ,lgngahrrpfFk ,ilNaahdnjhlhG `{f tpjpapdgb

$$\vec{F} = -kr$$

nghJthft;irvdgJntflh msTMjyhy Kggh;khzjjpy ,J %dW $Wfisnfhzl;J. NkYk Nkwfzlrkdghlby tpirahdJMwwy khwwht;irahFk. ,ejtpiriaxU$Wnfhzl]Nfyhh rhhgpypUeJjUtpffKbAk. xUgh;khz ,affjjpy

$$F = -kx$$

njhFjp 1>myF4 ,y tpthjpjjJNghy Mwwy khwwht;irgGyjjpdhy nraaggllNtiyghijiar rhhejpuhJ. foffzlrkdghlbypUeJmjd e;iyahwwiyf fzffplKbAk.

njhFjp 1>myF4 ,y tpthjpjjJNghy Mwwy khwwht;irgGyjjpdhy nraaggllNtiyghijiar rhhejpuhJ. foffzlrkdghlbypUeJmjd e;iyahwwiyf fzffplKbAk.

$$F = \frac{dU}{dx}$$

njhFjp 1>myF4 ,y tpthjpjjJNghy Mwwy khwwht;irgGyjjpdhy nraaggllNtiyghijiar rhhejpuhJ.

$$-\frac{dU}{dx} = -kx$$

$$dU = k\,x\,dx$$

XgGkhw;

njhifalLkhw;ypx'vdgJxgGkhw;ahFk.

$$\int_0^y t\,dt = \int_0^y x\,dx = \int_0^y p\,dp = \frac{y^2}{2}$$

khw;t, xkwWk p vdgdxgGkhw;fs Vnddpy njhifalbd NghJt, xmyyJp Mf;avejkhw;fisitjJnjhifalilehk nraAkNghJxNut;ilf;ilffgngWk.

r;wa ,lgngahrrpdx– l Nkwnfhs;sFvdwt;iradhy nraaggllNtiye;iyMwwyhfNrfh;ffggLf;wJ.

$$U(x) = \int_0^x k\,x'\,dx' = \frac{1}{2}k(x')^2\Big|_0^x = \frac{1}{2}kx^2$$

t;ir khw;ypad kjpgG k = m w^2ia rkdghL ehk gujpapl

$$U(x) = \frac{1}{2}mw^2x^2$$

,qF>wvdgJ miyTW mikggpd ,ayG mjhntz. rh;ir ,affjij Nkwnfhs;Sk JfsfSfF> ehk ngWtJ

$$x = A\sin wt$$

$$U(t) = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t$$

,af;f MwwY f;fhd rkdghL

,aff Mwwy

$$KE = \frac{1}{2} m v_x^2 = \frac{1}{2} m \left(\frac{dx}{dt}\right)^2$$

Jfshd J rh;ir ,affjij Nkwnfhsf;wJ vd;y> rkdghL y;UeJ

$$x = A \sin \omega t$$

vdNt j;irNtfkhd J

$$v_x = \frac{dx}{dt} = A\omega \cos \omega t$$

$$= = A\omega \sqrt{1 - \left(\frac{x}{A}\right)^2}$$

vdNt>

KE = $$KE = \frac{1}{2} m v_x^2 = \frac{1}{2} m\omega^2 (A^2 - x^2)$$

KE = $$KE = \frac{1}{2} m\omega^2 A^2 \cos^2 \omega t$$

nkhj;j MwwY f;fhd rkdghL

,aff Mwwy kwWk e;iy Mwwy ,twwd $Ljy nkhjj Mwwy MFk.

$$E = KE + U$$

$$E = \frac{1}{2} m\omega^2 (A^2 - x^2) + \frac{1}{2} m\omega^2 x^2$$

vdNt>x² I eff>

$$E = \frac{1}{2} m\omega^2 A^2 = khw;y;$$

kWjiyahf rkdghL kwWk rkdghL y;UeJ ehk ngWk nkhjj Mwwy

y;UeJ ehk ngWk nkhjj Mwwy

$$E = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t + \frac{1}{2} m\omega^2 A^2 \cos^2 \omega t$$

$$= = \frac{1}{2} m\omega^2 A^2 (\sin^2 \omega t + \cos^2 \omega t)$$

j;hNfhzk;j; KwnwhU ika;y;UeJ>

$$(\sin^2 \omega t + \cos^2 \omega t) = 1$$

$$E = \frac{1}{2} m\omega^2 A^2 = khw;y;$$

U(*t*) + K(*t*)

vdNt nkhjj Mwwiyf nfhzLngwggLk rh;irmiya;awwa;d trR

$$A = \sqrt{\frac{2E}{m\omega^2}} = \sqrt{\frac{2E}{k}}$$

miyTfs;d; tiffs;

fl;lwwmiyTfs;

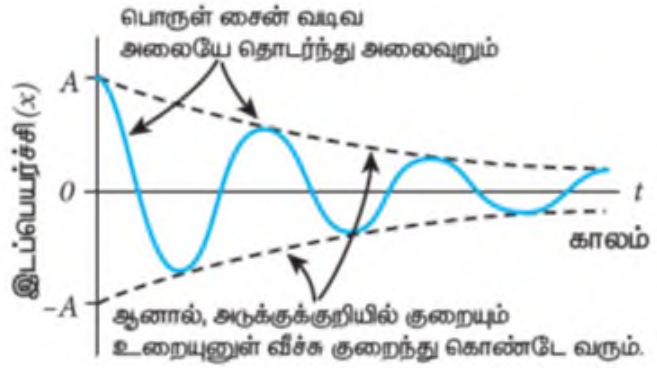
miyaawwiamjd rkeiygGssayUeJ ,lkngaur nraJmiyTwr nrajhy mJmiyTWk mjhntz zhdJ ,ayGmjhntz zwFrkkhf ,UfFk. ,ttifmiyTfs myyJmjhTfs fllwwmiyTfs myyJfllwwmjhTfs vdggLk.

vLj;Jf;fhl;Lfs;

1. ,irffitad mjhTfs
2. ,OjJfflggllfkgaad mjhTfs
3. jdCryd miyTfs
4. RUstiy eiwmikggd miyTfs

jiyAWmiyTs;

jd Cry miyTWk NghJ (Keijaefotiy) miytd trrhdJkhwiyvdTk miyaawwad nkhjjMwwy khwhjJvdTk vLjJf nfhsfNwhk. Mdhy czikaiy Clfjjd CuhaTkwWk fhwwd ,Oitahy fhyk mjfhfFk NghJtrRFiwfdwJ. ,jd miyTfs eiyeWjjggIhky ,UfFk kwWk rhirmiyaawwd Mwwy gbggbahfFiwfdwJ. ,ejMwwy ,ogGmiyaawwi #oeJss Clfk clfthjyhy VwgLfwJ. ,ejtifmiy ,affk jilAWmiyTfs vdmioffggLfdwJ. NtWtjkhf $wdhy miyad trRFiwfdwJkwWk miyaawwaad Mwwy Clfjjd jilfFvjuhfnraaggllNtiyahfkhwwggLfwJ. ,ttif ,affk jilAW ,affk vdmioffggLfwJkwWk ,eefotiy cuhaTtir (jilAWtir) miyaawwaad jirNtfjjwFNehjftiy ,UfFk.



jilAWrhirmiyaaww–fhyk mjfhfFk NghJtrRFiwfwJ.

vLj;Jf;fhl;Lfs;

1. jdCryd miyTfs (fhwwd jilAld) myyJvznza eugggglfydwFs jdCryd miyTfs
2. njhlbr Rwwy VwgLk kdfhejmiyTfs
3. fhytdhkllhiy VwgLk jilAWmiyT

eiyeWj;jggl;lmiyTfs;

Cryiy Mbf nfhzbUfFkNghJxUriymiyTfSfFgwFmiyTeWjjggLk. ,jwFfhuzk jilAWtirahFk. ,jidj jthffjsStiriar nrYjjmiyTfshdJeiyeWjjggLfwJ.

Gw %yjjiyUeJMwwiygadgLjjmiyaawwfFmsggjdhy miyTfsd trRkhwhky ,UfFk. ,ttifmjhTfiseiyeWjjgglmjhTfs vdfNwhk.

vLj;Jf;fhl;L:

mjhTWk ,irffyitad Mwwiykdfymlffmyyjkd %yjjyUeJngwrnrajy

jzgG mjhTfs;

vej xU miyawwh jhd ,oej Mwwiy GwrruiyT mikggdhy ngwW njhlheJ ,aqFfdwNjh mej miyawwia jzgG miyawwh myyJ ,affgglL miyawwh vd mioffdNwhk.

,ttif mjhTfsy; nghUshdJ Mukgjjy ,ayG mjhntz zy mjhTWk gddh Gw ruiyT tiraid fhuzkhf Gw ruiyT tiraid mjhntz zy mjhTWk. ,jjifa mjhTfs jzgG mjhTfs vdW mioffggLfwJ.

vLj;Jf;fhl;L:
fkgh ,irf fUtfsy ngwggLk mjhTfs

xj;jjhT:

xjjjhTjzgGmjhtd rwgGefoTMFk. ,qFGwruiyTtiraid (myyJ ,afftiraid) mjhntz Zk mjhTWk nghUsd ,ayGmjhntz Zk rkkhf ,UfFk. ,jd tistdhy mjhTWk nghUsd trRmjfhffMukgjJngUk trRefiyiag ngWk. ,ejefoitxjjjhTvdTk mjd mjhTfs xjjirTvdTk mioffggLfwJ.

vLj;Jf;fhl;L:
xyahy fz zhbcilj y

xjjirTmjhTfs ghyjjy VwgLtijjthffghyjjd kJ ,uhZttuhfs mztFjJfleJnryymDkjffgglkhllhhfs.

,uhZttuhfs ghyjijf fleJnryYkNghJ>mthfs ghyjjd kJfhybvLjJitfFk mjhntz ghyjjd ,ayGmjhntz zwFrkk vdy ,gghyk xjjirmjhTfisngwyhk. trrd kjgGkfgnghaJvdgjhy ghyk ,beJtothagGssJ.

11TH , awgpay;
njhFjp–II
myF– 11
miyfs;

mwpKfk;

Keija myfpy ehk xU Jfspd miytpidg gwwp tpthjpjNjhk. Jfsfspd njhFgigf nfhzlXh Clfjijf (medium) fUJNthk. xU Kidapy ,lhghlil (disturbance) cUthffpdhy mJ KdNdwpr nrdW kWKidia milfpwJ. mjhtJ Kjy Gsspe piwapy VwgLjjpa ,lhghlhdJ mUfpy css mLjj Gsspe piwfF mLjjLjJ gugggglfpJ. ,qF ftdpff NtzbaJ ahnjdpy› khWghL klLNk gugggglfpwJ. Gsspe piwfs myy. ,JNghdW ehk ntspggLjJk NgrrhdJ ekJ njhzilapy cssFuy tisapd mjphtpdhy NjhdWfpwJ. ,jd fhuzkhf RwWgGw fhwW %yf$Wfs mjphtileJ mjdhy Ngrrpd tpisT (jftyfs) ntspapy (space) css xU Gsspapypueh kwnwhU GsspfF Clfjjpd Jfsfis vLjJr nryyhky gugggglfpwJ.

vdNt ntspapy xU Gsspapypueh kwnwhU GsspfF Clfk khwwgglhky Mwwy kwWk cejjij vLjJr nryYk epfoT miyvdggLk.

flwfiufF mUfpy epdwhy xUth flypy ,UeJ fly eH xNu miy tbtjjpy Vww ,wffjJld flwfiuia miltijf fhz ,aYk. vdNtmJ fly miyfs vdggLk. xUuggh Ngzl Rzlgglhy mJ epiyahd miyfs vdggLk miy tbtjjpy mjphTWk. ehk kpdfhej miyahfpa xspapd %ykhf mofpa ,awifiaf fhzfpNwhk. ehk ,dpikahd nkyypirg ghlyfis xypmiyfs %ykhff NflfpNwhk. mdwhl thotpy ifgNgrp jfty njhlhG Kjy Nyrh mWitrpfprir tiu miyfspd Vuhskhd gadghLfs cssd.

epiyahf css xU ehggugpy ehk xU fyiy vhpejhy› ehpd Nkwgugpy fy Nkhjpa ,ljjpy xU khWghL cUthtijf fhzyhk. ,ej ,lhghlhdJ njhlheJ mjpfhpfFk Muqfs nfhzLss xU ika tllqfshf ntspgGwkhf tphtileJ Nkwgugpd vyiyapy NkhJtijf fhzyhk. Vnddwhy fyypd ,aff Mwwypd xU gFjp Nkwgugpy css eh %yf$WfSfF Vnddwhy fyypd ,aff Mwwypd xU gFjp Nkwgugpy css eh %yf$WfSfF khwwggLfpwJ. czikapy euhdJ (Clfk) ,lhghlLld ntspNa efuhJ. ,jid ehpd Nkwgugpy xUfhfpjj Jzbid itggjd %yk fhz ,aYk. ,lhghlhdJ (miy) ehpd Nkwgugpy nryYk NghJ mej JzL NkYk fOkhf efUk. ehpd %yf$Wfs mtwwpd rkepiyiag nghUjJ mjphtaffjij Nkwnfhstij ,J fhlLfpwJ.

,Ojpjf;fl;lggl;lnky;ypafkgpapy; miyfs; Njhdpwjy;:

xU eskhd nkyypa fkgpia vLjJfnfhzL mjd xU Kidia Rtwwpy flLNthk. jpBnud Rzbdhy fapwwpy xU khWghL cUthfpwJ. ,ej khWghL jpBnud NjhdwpaJ NkYk mJ Fiwej Neujjpwnf ebfFk. vdNt ,ej khWghL miyjJbgG vdggLk. njhlhrrpahf Rzlgglhy epiyahd miyfs cUthfpwJ. fpllhhpd (Guitar) Rzlggll fkgpapd (Plucked sting) %yk ,J Nghdw miyfs cUthffggLfpwJ.

,irf;fitapy; miyfspd; cUthf;fk;:

xU ,uggh Jzby xU ,irffitia mbjjhy ,irffitapd Gaqfs mjd ikagGsspiag nghUjJ mjphTWk. Gak xUikag Gsspiag nghWjJ mjphTWk vdgjd mhjjk ntspgGwk kwWk clGwk nryYjy MFk. GakhdJ ntspgGwkhf efUk NghJ mjd mUfpy css fhwW mLfif mJjsSfpwJ. mjhtJ ,ggFjpapy mjpfkhdfhwW %yf$Wfspd Njffk cssJ. vdNt mlhjjp kwWk mOjjKk $l kpf mjpfkhFk ,ggFjpfs ,Wffggll gFjpfs myyJ ,Wffqfs vdggLk. ,Wffggll

fhwW mLfF KdNdhff; efheJ mUf;y c s s mLjjfhwW mLf i f ,WfFk. ,Nj Kiwa;y xU ,Wffjj;d miy fhww;d to;Na KdNdw;r nryYf;wJ. GakhdJ clGwkhf efUk NghJ tygGwkhf efhjj Clfjj;d Jfsfs jwNghJ g;dGwkhf fhww;d klr;ggzGfhuzkhf ,lJGwkhfefUf;wJ. ,ejg gFj;a;y mlhjj;kwWk mOjjk ,uzLk Fiwthfc s s J. ,Jjshrr;myyJelr;vdggLk.

miy ,af;fj;j;d; gz;Gfs;:

- miyfs;d gutYfF Clfkhd J e;iykk (inertia) kwWk klr;ggz igf (elastic) nfhzbUffNtzLk.
- nfhLffggll Clfjj;y miya;d j;irNtfk khw;y;ahFk. mNj rkak Clfjj;y c s s Jfsfs nttNtW e;iyfs;y khWgllj;ir NtfqfSld ,aqFk. mtww;d eLe;iya;y ngUk j;irNtfKk t;s;kG e;iyfs;y j;irNtfk Ro;ahfTk ,UfFk.
- miyfshdJ vj;nuhs;gG› t;yfy› FWfflLt;isT› t;s;kG t;isT kwWk jst;isT Mf;atww;wF clgLk.

,aej;umiy ,af;fk; kwWk; mjd; tiffs;:

1. **,aej;umiy** – guTtjwF xU Clfk Njitggk miyfs ,aej;u miyfs vdggLk.
   vLjJffhlL: xy; miyfs› eh;d Nkwgugg;y cUthFk r;wwiyfs Kjy;ad.

2. **,aej;ut;ay; myyhj miy** – guTtjwF vtt;j ClfKk Njitgglhj miyfs ,aej;ut;ay myyhj miyfs vdggLk.

   NkYk› miyfis ,uzL tifggLjjyhk
   1. FWffiyfs
   2. nelliyfs

FWf;fiy ,af;fk; (Transverse wave motion):

FWffiy ,affjj;y› Clfjj;d Jfsfs mjd eLe;iyiag nghUjJ miyguTk j;irfF (Mwwy khwwggLk j;irfF) nrqFjJj j;ira;y miyAWk myyJ mj;htilAk. miyguTk j;irahdJ mj;hTWk jsjj;wF (Clfjj;d Jfsfs mj;hTWk jsjj;wF) nrqFjjhfmikAk.
vLjJffhlL: xs; (k;dfhejmiyfs)

mj;hTWk jsjj;wF (Clfjj;d Jfsfs mj;hTWk jsjj;wF) nrqFjjhfmikAk
vLjJffhlL: xs; (k;dfhejmiyfs)

nel;liy ,af;fk; (Longitudinal wave motion):

nelliy ,affjj;y Clfjj;d Jfsfs mjd eLe;iyiag nghUjJ miy guTk j;irfF ,izahd j;ira;y (Mwwy khwwggLk j;ira;y) miyTWk myyJ mj;htilAk
vLjJffhlL: xy;

Mr;ha;aUld; MNyhridnra;f:

- Rdhk; ([gghd;ankho;a;y # - dh - k vd crrh;ffggLf;wJ) vdgJ JiwKf miyfs vdw nghUsgLk. Rdhk; vdgJ mj;f NtfjJlDk k;fgngUk t;irAlDk njhlhrr;ahf tUk ngh;a ,uhlrr miyfshFk. 2004 Mk MzL brkgh khjk 26 Mk Njj; ,ej;aht;d njdgFj;a;y vddelejJ.
- <ugG miyfs - LIGO (Laser Interferometer Gravitational wave Observatory) MaT ,awg;aYffhdNehgy gh;R 2017

1. Nguhr;h;ah nuadh nta]

2. Nguhrhah Nghrhgh]
3. Nguhrhah fg v] jhhNd

"LIGO Matfjjy <hgGmiyfsd MaTggzaay cWjahdgqfsggwfhf" toqfggllJ.

FWf;fiyfs; kwWk; nel;liyfs; xggLjy;

t.vz	FWf;fiyfs;	nel;liyfs;
1.	Clfjjd Jfsfs mjhtilAk jir› miyfs guTk jirfF nrqFjjhfcssJ.	Clfjjd Jfsfs mjhtilAk jir› miyfs guTk jirfF ,izahf cssJ.
2.	khWghLfshdJ mfLfs kwWk KfLfs tbtiy cssd	khWghLfshdJ ,Wffqfs kwWk jshrrfs tbtiy cssd.
3.	klr Clfjjy FWffiyfs gut ,aYk	midj: Jtif Clfjjyk (jlk› jutk kwWk thA) nelliyfs gut ,aYk

FwgG:

1. Clfk ,yyhjeiy ntwwlk vdggLk. kidfhej miyfs klLNk ntwwljjd toNaguTk.
2. uhNy miyfs (Rayleigh Waves) vdgit FWffiy kwWk nelliy Mfa ,uzLk Nrhejjhff fUjggLfwJ.

miy ,afjjy; gadgLk; gjqfs; kwWk; tiuaiwfs;

,U miyfSk ird tbtkhf ,Uejhy mit ,uzbwFk ,ilNa eiwa NtWghLfs cssd. vdNt xU miyia kwnwhdwiyUeJ NtWgLjj ehk riy mbggilr nrhwfis (Terminologies) tiuaiw nraaNtzLk.

,Oj;Jf;fl;lggl;lfkgaiy; VwgLk; miyxd;iwf; fUJf.

ehk cUthFk miyfsd vzzfifaiy Mhtk nfhzlhy›Xh RlL myyJ NkwNfhsklljij (,ileiy myyJ mikjeiy) fUJNthk. ,qF ,ileiy vdgJ fhllgglLss filkll NfhlhFk. eioyll gFjaid Nkykllg GssKfLvdTk›eioyiggljhjgFjaid foklgGssmfLvdTk mioffggLfwJ. ,ejmiyahdJOtiyUeJBgFjiakzLk kzLk VwgLjJfwJ. ,ejrwagFjaid esjijxUmiyesk vdtiuaWffyhk.

xUmiyesjijf Fwggjwffnuffv OjJNyklh(lambda) λ itg gadgLjJfNwhk. FWffiyfFfhlbathW›mLjjLjj ,U KfLfSfF ,ilggllnjhiyT (m) mLjjLjj ,U mfLfSfF ,ilggllnjhiyTxUmiyeskhFk. nelliyfFmLjjLjj ,U ,Wffqfs myyJjshrrfSfF ,ilggllnjhiyTxUmiyeskhFk. miyesjjd SImyFkllh.

mjhntz› mjhT Neuk mfatwiw mweJnfhssfhlba miyiaf (3 miy esqfis cilaJ) fUJNthk. Neuk t=0y miy ,lJGwkiUeJ AGssia milfwJ.

Neuk t=1s ,y AiaflfFk miyfsd vzzfif ,uzL MFk. vdNt mjhntz vdgJ1 tidhbaiy flfFk miyfsd vzzfif" vd tiuaWffggLfwJ. mjd myFn`hl]› FwaLHz.

,ejcjhuzjjiy

$$f = 2\ \text{Hz}$$

,U miyfs AGssia fleJ nryy MFk Neuk xU tidhb (Neuk) vdiy xU miy AGssiaflff MFk Neuk miy tidhbahFk. ,JNt xU miyT Neuk (T) MFk.

$$T = \frac{1}{2} = 0.5s$$

mjhntz Zk miy esKk vjhjftpy ,UfFk vdmwpayhk.

$$T = \frac{1}{f}$$

miyTNeuk (T) vdgJ xUGsspy tpahf xU miyflff MFk Neuk MFk.

FwpgG:

1. XuyF Neujjpy Rowrpfspd (RwWffspd) vz zpfif Nfhz mjhntz vdggLk.

   Nfhz mjhntz $w = \frac{2p}{T} = 2pf$ (myFNubad /tpdhb)

2. xuyFesjjpy Rowrpfspd vz zpfifmyyJxuyFesjjpy miyfspd vz zpfifmiyvz vdggLk.

   $$miyvz\ k = \frac{2p}{l}$$ (myFNubad /kllh)

   jpirNtfk v›Nfhzmjhntz ωkwWk miyvz kMfpatwwpwF ,ilNaahdnjhlhG

   $$jpirNtfk\ v = l f = \frac{l}{2p}(2pf) = \frac{(2pf)}{2p/l} = fl$$

miyapd; trR(Amplitude of the wave):

miyfs midjJk rkmiyesk›rkmjhntz kwWk rkmiyTNeuk nfhzLrkjpirNtfjjpy nryfpdwd ,ejmiyfSffpilggllxNuNtWghLmfLmyyJKfLfspd cuaqfs. ,jypUeJehk czhtJmfLmyyJKfbd cauKk miyapd gzigephzaggjpy Kffpagq Ftffpfwj. vdNt›trRvdwxU ,awgpay mstpidmiyfSfFtiuaWffNtzbAssJ. miyapd trirFwpGmrirg nghWjJClfjjpd ngUk ,lgngahrrpvdtiuaWffyhk (cjhuzkhf ,ejNehtpy xmrR) ,qFmJAvdf Fwpffggpfwj.

ntt;NtWClfq;fspy; miyapd; jpirNtfk:

ezljzlthsjjpy Rjjpayhy mbfFk NghJ›rwWnjhiytpy jzlthsjjpy fhJitjJNflLFkNghJ ,U xypfs (xNufzjjpy myy) NflFk. jzlthsjjpd tpahf (jpzkClfk) NflFk xypKdghfTk›fhwwpd tpNaNflFk mNjxyprwWjhkjkhfTk NflFk. vdNt›nttNtWClfqfspy xypapd jpirNtfk xdwyy.

,ejgFjpapy›miyfspd jpirNtfjij ,U NtWepiyfspy tUtpUgNghk.

1. ellggllfkgpapy VwgLk FWffiyfspd jpirNtfk.
2. klrpjjdiknfhzlClfjjpy nelliyfspd jpirNtfk

ell;lggl;lfkgpapy; VwgLk; FWf;fiyapd; jpirNtfk:

fkgpxdwpy ,aqFk FWffiyapd jpirNtfjijfzffpLNthk. fkgapd ,lJKidiaNkyNehffpnrhLffpdhy›mejJbgGtyJKidNehffpvvdwjpirNtfjjpy efUk ,jwFg nghUs xaTepiyapy cssFwpgghajjpy cssghhitahsiug nghUjJefhfpwJ.

fkgapy xUmbggilg gFjpiaf fUJNthk. fkgapy A›BvdwGsspfis ,ffzjjpy fUJNthk›dl, dmvdgJfkgapd rpWgFjpesk kwWk epiwvdNghk. tiuaiwapdgbes epiwmlhjjp(µ) MdJgpdtUkhWvOjggLfpwJ.

$$\mu = \frac{dm}{dl}$$

$$dm = \mu dl$$

mbgg i lgFj ABMd J t l l j j d xUgFj Nghy O i t i k a k h f n f h z L R M u j J l d t i s e J N f h z k θ i t t i s N f h L i k a k O t y V w g L j J f w J . θ i t t i s N f h L A B d e s k d l k w W k M u k R i a g g a d g L j j g d t U k h W v O j y h k .

$$q = \frac{dl}{R}$$

fkgad ,Otirj Uk ika Nehf FKL f f k (v z kjgG)

$$a_{cp} = \frac{v^2}{R}$$

ika Nehf F tir

$$F_{cp} = \frac{(dm)v^2}{R}$$

,ejf fkgad rWgFj (elemental string) c z Uk ika Nehf F tir iag ujaL t j d %yk f z f f l y h k .

$$\frac{(dm)v^2}{R} = \frac{mv^2 dl}{R}$$

,Otir TMd J> fkgad rWgFj esk ABad njhLNfhlbd to Nanray gLf wJ . t i s N f h L ABad esk k f r r w a J . vdNt ,Otir Tay VwgLk k h W g h L G w f f z f f j j f f J .

,Otir Ti af ilkl l f $W $T\cos\left(\frac{q}{2}\right)$ kwWk nrqFj J f $W $T\sin\left(\frac{q}{2}\right)$ vd ,U $Wfshfg gF f f y h k . A, Bay f ilkl l f $Wfs rkvz kjgg y vjhj iray nray gLf dwd . vdNt> mi t x d i w x d W r k d nraf dwd . esk Abiak f r r w a j h f f U J t j h y> nrqFj J f $Wfs A, Bay nrqFj J j iray t i s t d ikak Nehf f ,Uggj h y mtwiwf $ l l N t z L k . njhFgad Mu tir F_r Md J

$$F_r = 2T\sin\left(\frac{q}{2}\right)$$

fkgad esj J ld xgg l> mi ya d t r R k f r r w a J . vdNt> r w a N f h z j j d ird kjgigj Njhuhakhf $\sin\left(\frac{q}{2}\right) \approx \frac{q}{2}$ vdf Fw f f y h k .

$$F_r = 2T \times \left(\frac{q}{2}\right) = Tq$$

Mdhy> $q = \frac{dl}{R}$ vdNt ehk ngWt J

$$F_r = T\frac{dl}{R}$$

e A l l d d ,uz l h t J t j i a fkgad r WgFj esj j wF Mu to Nanray gLj j> rke i ya y t i ra d Muj j i r $W (radial), ika Nehf F tir f F r k k h F k .

$$T\frac{dl}{R} = mv^2\frac{dl}{R}$$

$$v = \sqrt{\frac{T}{m}}$$

fhlr;rggjTfs;

fkgay VwgLk miyad jirNtfk

1. ,Otiraid ,Ukb %yjjwFNehjjftYk
2. es eiwmlhjj(Linear mass) aid ,Ukb %yjjwFvjhjjftYk
3. miytbtjijr rhuhkYk mikAk

kl;rj;jd;iknfhz;lCfjjy; nel;liyaid; jirNtfk;

ezlcUistbtf Fohay FWfFntlLggugGA›eiyahdeiwnfhz lklrjjdikCIfk (,qFfhwiwf fUJf) P mOjjjjy cssJvdf. ,ejf Fohay nelliyfisXh ,irffitiamjuitjNjh›gl]ld xdiwf nfhzLfhwiwmOjjNahVwgLjjyhk. cUisaid mrRfF ,izahfmiyKdNdWtjhff nfhsf. Mukgjjy xatiy cssCIfjjd mlhjjvdf. t = 0 Neujjy gl]ld ,lJKidaiyUeJ›*u*jirNtfjJld tyJKidNehffefhfwJ.

*v*vdgJklrmiyaid jirNtfk *u*kwWk gl]ldid jirNtfk vdf. Neu ,ilntsay gl]ld efUk J}uk $\Delta d = u\Delta t$ klrj jdiknfhz lkhWghLefhejnjhiyT $\Delta x = v\Delta t$.

ΔtNeu ,ilntsay *v*jirNtfjijmilejfhwid eiwΔ *m*vdf.

$$\Delta m = \rho A \Delta x = \rho A (v\Delta t)$$

gl]ld *u*vdwjirNtfjjy ,aqFtjhy VwgLk cejk

$$\Delta p = [\rho A (v\Delta t)]u$$

fzjjhfFvdgJ cejkhWghLvdgjhy›

eifufzjjhfF

$$I = (\Delta P A)\Delta t$$

myyJ $(\Delta PA)\Delta t = [\rho A(v\Delta t)]u$

$$\Delta p = \rho vu$$

fhwid tofahf›xyimiynryYkNghJ›rwiwagUkd cilafhwWggFjnjhlheJ ,WffqfSfFk›jshrrfSfFk clgLfwJ.

$$DP = B\frac{DV}{V}$$

,qF›*V*vdgJfhwid njhlffgUkd kwWk *K*vdgJklrCIfjjd gUkfFzfk (Bulk modulus).

Mdhy $V = \Delta x = A v \Delta t$

NkYk $\Delta V = A\Delta d = Au\Delta t$

vdNt

$$DP = B\frac{Au Dt}{Av Dt} = B\frac{u}{v}$$

xggIfiilggJ

$$r vu = K\frac{u}{v} \text{ myyJ } v^2 = \frac{K}{p}$$

Þ $v = \sqrt{\frac{K}{p}}$

nghJ thf›klr‰C lfjj‰y nelliya‰d j‰irNtfk $v = \sqrt{\frac{E}{r}}$

,qF›EC lfjj‰d klr‰fFzfk (Modulus of elasticity).

NehTfs:j‰zkjj‰wF

1. xUgh‰khzjzL(1 dimensional rod):

$$v = \sqrt{\frac{Y}{r}}$$

,qF›YvdgJjzLr nraaggllnghUs‰d aqFzfk›ρjzbd mlhjj‰. xUgh‰khzjzLaq Fzfjijkl LNkngww‰UfFk.

2. Kggh‰khzjzL(3 dimensional rod):
j‰zkk xdw‰d to‰Nanelliya‰d Ntfk

$$v = \sqrt{\frac{B + \frac{4}{3}h}{r}}$$

,qF›µt‰iwgGfFzfk›BgUkf Fzfk kwWk jzbd mlhjj‰.

Neh¡Tfs;j‰ut j¡j‰w¡F:

$$v = \sqrt{\frac{K}{r}}$$

,qFK,gUkf Fzfk kwWk ρ j‰utjj‰d mlhjj‰. gUkf Fzfk Bmyy Jkvdwv Ojjhy Fw‰gg‰lyhk.

FWffiy›nelliyfs‰d j‰irNtfk klr‰g gzGfisg nghUjjk (fkg‰a‰d ,Ot‰irT,gUkfFzfk BNghdwit) kwWk e‰iykg gzGfisAk (mlhjj‰myyJXuyFesjj‰wfhde‰iw)

ntt¡NtWClfq¡fs‰y¡ xy‰a‰d¡ Ntfk¡

t.vz¡	Clfk¡	Ntfk¡ ms^{-1}
j‰zkk		
1	,uggh	1600
2	jqfk	3240
3	g‰jjis	4700
4	jhk‰uk	5010
5	,UkG	5950
6	mYk‰d‰ak	6420
j‰utqfs (25°C ,y)		
1	kznz znza	1324
2	ghjurk	1450
3	eh	1493
4	fly eh	1533

thA(0°C , y)		
1	Mf]p[d	317
2	fhwW	331
3	` ypak	972
4	i ` lu[d	1286
thA (20°C , y)		
1	fhwW	343

xypmiyapd; gutyp:

xypmiyahdJnellyahFk.mJguTk Clfjjpy ,WffqfSk›jshrrpfSk vwgLk. foffzlghlggFjpapy fhwwpy xypapd jpirNtfjijepA+lldpd Kiwapy mstplyhk. gpddh mjd kjhdyhgy] jpUjjjijAk fhwwpy xypapd jpirNtfjijghjpfFk fhuzpfisAk tpthjpffyhk.

fhwwpy; xypapd; jpirNtfj;jpwfhdepA+l;ldpd; rkdghL:

fhwwpy xypguTk NghJVwgLk ,WffqfSk. jshrrpfSk kpfnkJthfeilngWfpwJ. vdNt ,ejepfoitntggepiykhwhepfothfepA+lld fUjpdhh. mjhtJ ,WffjjpdhY (mOjjk mjpfhpffpwJ›gUkd FiwfpwJ) VwgLk ntggk kwWk nefpotpdhy VwgLk ntgg ,ogG (mOjjk FiwAk›gUkd mjpfhpfFk) nkJthfepfotjhy ntggepiykhwhky ,Uggjhfep A+lld fUjpdhh. vdNt fhwW %yf$Wfisxueyypaygthathffujpdhy›mOjj›gUkkhWghLfs ghapy tpjpfFflLggLfpdwd. fzpjggb›

PV = khwpy

iatifggLjj›

$$PdV + VdP = 0$$

myyJ $P = -V\frac{dP}{dV} = K_I$

,qFKfhwwpd ntggepiykhwhgUkfF zfk›gupjapl›fhwwpy xypapd jpirNtfk

$$v_T = \sqrt{\frac{B_T}{r}} = \sqrt{\frac{P}{r}}$$

P vdgJfhwwpd mOjjk›NTP (,ayGntggepiykwWk mOjjk) ,y P ,d kjpgG76nr.kghjurmOjjkhFk.

vdNt›

$P = h\rho g$

$P = 0.76 \times 13.6 \times 10^3 \times 9.8)\ N\ m^{-2}$

$\rho = 1.293\ kg\ m^{-3}$

fhwwpy xypapd Ntfk (NTP)apy

$$v_T = \sqrt{\frac{(0.76' 13.6' 10^3' 9.8)}{1.293}}$$

$= 279.80\ m\ s^{-1} \approx 280\ ms^{-1}$(fzfflL kjpgG)

Mdhy›MaT %ykhf0°C apy fhwwpy xypapd jpirNtfk 332 ms^{-1}vdmsffgglLssJ. ,ejkjpgG›fzfflLkjpgigtpl16%mjpfk.

rjtjg gpio$\frac{(332 - 280)}{332}' 100\% = 15.6\%$. ,JFiwthdgpiomyy

yhgy]; jpUj;jk; (Laplace Correction):

1816 y yhgy]›NkNyFwpggplIFiwghlil›“xypXh ClfjjpY guTkNghJJfsfs kpftpiuthfmiyTWtjhy ,WffqfSk›jshrrpfSk kpfNtfkhfVwgLk” vdf fUjjpY nfhzLrhpnrajhh. ,WffjjpdhY ClfjjpwFnfhLffggLk mjpfntggKk›jshrrp %yk VwgLk FspfhrrptpisTk RwWg GwjJld rkd nraagglhJ. Vd vdpy fhwW (Clfk) Xh mhpjpwfljjpahFk. ntggepiykhwhJvdf fUjKbahjjhy› ,J xUntgggh pkhwwkpyyhepfoTMFk. ntgggh pkhwwkpyyhtpisTvdf fUJtjhy›thAghard tpjpiagpdgwWfpwJ (epA+lld fUjpaJNghy ghapy tpjpmyy). vdNt›

$$PV^{g} = khwpy$$

,qF $g = \frac{C_P}{C_v}$,

C_P–mOjjk khwhNkhyhh jd ntggVwGjjpwd

C_v–gUkd khwhNkhyhh jd ntggVwGjjpwd

tifggLjj›

$$V^{g}\,dP + P(gV^{g-1}\,dV) = 0$$

$$myyJ\ gP = -V\frac{dP}{dV} = B_A$$

,qF K_A fhwwpd ntggkhwwlwwtpistpy gUkf Fzfk. nghUjjfhwwpy xypapd jpirNtfk

$$v_A = \sqrt{\frac{B_A}{r}} = \sqrt{\frac{gP}{r}} = \sqrt{gv_T}$$

fhwwpy Kffpakhfielu[d›Mfr[d›i`lu[d kwWk gpw (,ulilmZ %yf$W thA) ,Uggjhy›$g$=1.4. vdNt›fhwwpy xypapd jpirNtfk

$vA = \left(\sqrt{1.4}\right)(280ms^{-1}) = 331.30ms^{-1}$,J MaTKbTkjpggpwFkpf ,WffkhfcssJ.

thAtpy; xypapd; jpirNtfj;ijghjpf;Fk; fhuzpfs; eyypaygGthAxd;iwf; fUJf. mjd; rkdghL

$$PV = \mu RT$$

,qFP - mOjjk›V - gUkd›T - ntggepiy›μ - Nkhyfspd vzzpfif›R– nghJthAkhwpy;nfhLffgglepiwnfhzl %yf$WfFfoffzlthWvOjyhk.

$$\frac{PV}{T} = khwpy$$

epiwm ia›khwpyahfitjjhy›thAtpd mlhjjpahdJ›gUkDfF vjphjftpy khWk

$$r\ \mu\ \frac{1}{v}V = \frac{m}{r}$$

nghUejpdhy›fpilggJ

$$\frac{P}{r} = cT$$

,qFc xUkhwpy;. nfhLffgglfhwwpy xypapd jpirNtfjijfoffhZ khWvOjyhk.

$$v = \sqrt{\frac{gP}{r}} = \sqrt{gcT}$$

Nkwfzlrkdghlbypuejehk mwtJ›

mOj;jj;jpd; tpisT:

xUepiyahdntggepiyapy›mOjjk khWgLkNgh J›mlhjjpAk Nehtpfjjjy khWfpwJ. mjhtJ $\left(\frac{P}{r}\right)$epiyahfmikfpwJ. ,jd nghUs epiyahdntggepiyapy›xypad jpirNtfk mOjjjijrhuhjJ. xUkiyapd NkYk›fOk ntggepiyrkkhf ,Uejhy›xypad jpirNtfk khwhky ,UfFk. Mdhy eilKiwapy kiyapd NkYk fOk ntggepiyrkkhf ,UffhJ. vdNt›xypad jpirNtfKk khWglbUfFk.

$$Q v \mu \sqrt{T}$$

ntggepiyapd; tpisT:

xypad jpirNtfk›ntggepiyapd (nfytpd kjpgG) ,Ukb %yjjpwFNehjftpy khWfpwJ.

v0vdgJ0°C myyJ273 K ,y xypad jpirNtfk vvdgJVNjDk xUntggepiyT ,y xypad jpirNtfk vdTk nfhzlhy›

$$\frac{v}{v_0} = \sqrt{\frac{T}{273}} = \sqrt{\frac{273+t}{273}}$$

$$v = v_0\sqrt{1+\frac{t}{273}} \approx v_0\left(1+\frac{t}{546}\right)$$

(<UWgGtpjhpitgadgLjjp)

0°C y xypad jpirNtfk v_0 = 331 ms^{-1}vdgjhy›VNjDk xUntggepiyt°Capy

$$v = (331 + 0.60t)\ ms^{-1}$$

xtnthU1°Cntggepiyc ahTffFk xypad jpirNtfk 0.61 ms^{-1}mjpfhpffpwJ.

FwpgG: ntggepiymjpfhpfFk NghJ %yf$Wfs mf Mwwy mjpfhpgghy Ntfkhfmjphtwk. vdNtjpirNtfk mjpfhpffpwJ.

mlhtjjpad; tpisT:

rkntggepiy›mOjjjjpy csxUthAffisfUJf. mtwwpd mlhjjpklLk nttNtWvdf. mejxUthAffspd topNaxypad jpirNtfqfs KiwNa›

$$v_1 = \sqrt{\frac{g_1 P}{r_1}}$$

$$v_2 = \sqrt{\frac{g_2 P}{r_2}}$$

tFfff

$$\frac{v_1}{v_2} = \frac{\sqrt{\frac{g_1 P}{r_1}}}{\sqrt{\frac{g_2 P}{r_2}}} = \sqrt{\frac{g_1 r_2}{g_2 r_1}}$$

kjpgGrkkhd thAffSfF›

$$\frac{v_1}{v_2} = \sqrt{\frac{r_2}{r_1}}$$

vdNt›thAxdwid toNaxyaid jirNtfk mlhjjaid ,Ukb %yjjwFvjhjjftiy mikfwJ.

<uggjj;jid; tisT(humidity):
<uggjk cssfhwwid mlhjjpcyhejfhwwid mlhjjpiagNghy 0.625 klqFMFk. mjhtJ<uggjk›fhwwid mlhjjpiaFiwjJtiLfwJ. vdNt><uggjk cssfhwwiy xyaid jirNtfk mjfhiffwJ.

ρ_1, v_1, kwWk ρ_2, v_2, vdgit KiwNa cyhejfhwW><uggjk cssfhwwid mlhjjpkwWk xyaid jirNtfk vdf.

$$\frac{v_1}{v_2} = \frac{\sqrt{\frac{g_1 P}{r_1}}}{\sqrt{\frac{g_2 P}{r_2}}} = \sqrt{\frac{r_2}{r_1}} \qquad (g_1 = r_2 \text{ vdiy})$$

PvdgJtsikzlymOjjkhjyhy foffzlthWvOjyhk.

$$\frac{r_2}{r_1} = \frac{P}{p_1 + 0.625 p_2}$$

,qF›p_1, p_2, KiwNa cyhejfhwWkwWk euhtaid gFjpmOjjqfs.

$$v_1 = v_2 \sqrt{\frac{P}{p_1 = 0.625 p_2}}$$

fhwwid tisT:
fhwWtRtjhYk xyaid jirNtfk khWk. fhwwid jiraiy xynryYkNghJmjd jirNtfk mjfhiffwJ. fhwwwFvjhjjiraiy xyaid jirNtfk FiwfwJ.

xymiyfsid vjpnuhyigG:

xymiyfs xUClfjjpyUeJkwnwhUClfjjwFr nryYkNghJ›foffzleifoTfs VwgLk.

1. **xyaid vjpnuhyigG:** ,uzlhtJClfk kiFejmlhjjpAilajhf (cWjpahdjhf) ,Uejhy›xyahdJKOtJkhfKjy Clfjjwfsnsna (kzLvOfwJ) vjpnuhyigGmilfwJ.

2. **xyaid tiyfy:** xypxUClfjjpyUeJkwnwhUClfjjwFnryYkNghJ (,uzlhtJClfk Kjy ClfjijtplmlhjjpmjfkhfcssNghJ) mjd Mwwy ,uzlhtJClfjjhy clftuggLtjhy›Mwwy ,ogGVwgLfwJ.

,ejg ghlggFjpaiy xyaid vjpnuhyigigklLk fUJNthk. xsiag Nghy›xyAk vjpnuhyigGtijfSfFclgLk. mtijfs
1. xyaid gLNfhzk›vjpnuhyigGNfhzjjwFr rkk
2. Xh gugghy xymiyvjpnuhyffggLkNghJgLGssiay gLmiy›vjpnuhyigGmiykwWk FjJfNfhLMfaitxNujsjjpy mikAk.

Mb xdwhy xsivjpnuhsiffggLtJNghy›xyAk Xh fbdkhd›rkjsgugg iy vjpnuhyiffggLtJgsiqF(Specular)vjpnuhyigGvdggLfwJ. ,Jxyaid miyesk›vjpnuhyigGgugigtiglugg id NkL›gssjijtilrwajhf ,UfFk NghJVwgLfwJ.

rkjsgugGfs;y; xy;a;d; vj;nuhy;gG:

xy;miyfs>rkjsRth kJNkhJkNghJ> (xs;miyfs NghyNt) mejRtww;y;UeJkznlOf;dwd(bounces off) xy;gghd xdWRtww;wFrhathfxUFw;gg;llNfhzjj;y itffgglhy> %yjj;y;UeJ (xy;gghd) tUk xy; (Gss;xy; %yk vdffUJf) iaNfhsmiyKfgghffUjyhk. vdNt>Rtuhy vj;nuhy;ffggLk miyKfgGk Nfhsfmiyffgghf;NtmikAk. mjDilatisTikajij (,J rkjsgugg;d kWGwk mikej;UfFk) xy; %yjj;d g;kgkhffUjyhk (kha myyJfwgidxy;gghd) NkYk ,J jsjj;d g;dGwk mikeJssJvdTk fUjyhk.

tisTgugGfs;y; xy;a;d; vj;nuhy;gG:

xy;a;d gzGvj;nuhy;ffggllgugigAk nghUjjJ. Fo> Ft; kwWk rkjsgugGfshy vj;nuhy;ffggllxy;miyfs;d gzGfs nttNtwhfcssd. Ft; gugghy vj;nuhy;ffggllxy;t;heJnrytjhy>mjd ty;ik (Mwwy) FiweJt;Lf;wJ.

mNjrkak Fo; gugghy vj;nuhy;ffggllmiyxUGss;a;y Ft;ffggLtjhy vs;jhfngUffkilAk (ty;ik>Mwwy mj;fh;ff;wJ). gutisavj;nuhy;gghdfs (tisTvj;nuhy;gghd) xy;miyfisFw;gg;llGss;a;y Ft;ggjwfhftbtikffggLf;dwd. ,it>mj;fj;irgzGilaEz z;axy;gghdfis(microphones) tbtikffg gadgLf;dwd.

vejxUgugGk (tOtOgghdJmyyJnrhunrhugghdJ) xy;iacl;ftUk vdehk mw;Nthk. vLjJffhllhfngh;amiwfs myyJfiyauqfqfs myyJj;iuauqFfs Mf;atww;y VwgLjjggLk xy;mjd Rthfs>Nkw$iufs> jiu kwWk ,Ufiffshy ngh;Jk clftuggLf;wJ. ,ej ,ogigjLff>tisTxy;gugGfs (Fo; gugGfs) xy;gghd Kdghfmikffgglf;dwd. ,it xy;gghd;y;UeJtUk xy;iaNflNghh $llk (audience) Nehff;vj;nuhy;ff;dwd. ,ejKiwvyyhj;irfs;Yk xy;guTtijf FiwjJ>muqfk KOtJk ruhfxy;guTtijNkkgLjJf;wJ. vdNtjhd muqfjj;y vejg gFj;a;y mkhej;UggtUfFk xy;ahdJvejt;jjilAk;dw;nrdwilf;wJ.

xy;vj;nuhy;gg;d; gad;fs;

,jaj;Jbg;Gkhd;: ,J xy;a;d gdklqfhdvj;nuhy;gg;d jjJtjj;y ,aqFf;wJ.

,J %dWgFj;fisnfhzlJ.

1. ,jajj;d kJitfFk gFj;
2. fhj;y itfFk gFj;
3. ugg;h Foha

1. **,jaj;j;d; kJitf;Fk; gFj;:** ,J r;wajlLtbt;yhdxjjj;hTr rtT. ,J xy;iak;fEz z;akhfczUk. NkYk czhejxy;iangUfFk.

2. **fhj;y; itf;Fk; gFj;:** ,J cNyhff Fohafshy MdJ. ,J ,jajj;y;UeJczhejxy;iaNflfg gadgLf;wJ.

3. **ugg;h; Foha:** ,J ,jak kJitfFk gFj;iaAk fhj;y itfFk gFj;iaAk ,izff;wJ. ,jak kJitfFk gFj;a;d rtTczhejxy;iafhj;y itfFk gFj;fFvLjJr nryf;wJ. Eiuauy;d rjjk myyJ ,jajj;d JbgGmyyJcly cs cWgGfs VwgLjJk xy;iaczheJ>mijfhj;y itfFk gFj;fFuggh Foha;y VwgLk gdklqFvj;nuhy;gG %yk vLjJr nryf;wJ.

4. **vj;nuhy;:** Rth myyJkiymyyJvejnthUxy;jjilgugg;dhYk xy;vj;nuhy;ffggllL>kzLk kzLk NflfggLk xy;vj;nuhy;vdggLk. 20°C a;y fhww;y xy;a;d Ntfk 344 ms^{-1}. 344 m njhiyt;YssRtww;idNehff;ehk

rgjk nrajhy mJ 1 tpehbapy Rtwiwmilak. Rtwwpy vjpnuhypjjgpwF›NkYk 1 tpdhbfopjJmejxypekikmilak. vdNt› ,Utpdhbfs fopjJvjpnuhypiaNflNghk.

mwptpay mwpQhfspd fzfflbd gb›ehk ,U xypmiyfis›njspthfNflff$bakpff Fiwej Neu ,ilntspy (kdpjnrtpapd njhlh NflFk jpwd) xUtpehbapd $\frac{1}{10}$gFjpmjhtJ0.1sMFk.

$$\text{jpirNtfk} = \frac{\text{flej J}\}\text{uk}}{\text{vLj J nfhzl Neuk}} = \frac{2d}{t}$$

2d = 344 0.1 = 34.4 m

d = 17.2 m

20°C-apy vjpnuhypNflf›vjpnuhyp(echo)Nflf›vjpnuhypfFk Rth (gugG) mikaNtzbaFiwejglrj njhiyT17.2 m.

Nrhdhh; (SONAR) : Sound Navigation and Ranging xypvjpnuhypgG %yk flypDs NjLjy kwWk fzLgpbjjy fUtp.
Nrhdhh fUtpxypapd vjpnuhypgigg gadgLjjpehpDs cssnghUspd epiymyyJ ,affjijczug gadgLfpwJ. ,NjKiwapy jhd lhygpdfSk›ttthyfSk ,Uspy $l jhqfs nryyNtzbatopiaNjhenjLffpdwd.

vjph; Kofpfk; (Reverberation):%bamiwxdwpDs xypnjhlheJRthfspdhy vjpnuhypffggLk NghJ›xyp%yk xypVwgLjJtijepWjjpagpwFk›xypNflfggLk. ,ttthWXh miwapy xypkjp(Reverberation) ,UfFk epfoTvjph Koffk vdggLk. xyp %yk xypVwgLjJtijepWjjpagpwFxypNflFk Neuk "vjph Koff Neuk'(Reverberation time) vdggLk. vjph Koff Neuk $ljjpy xypapd jdpapayigg ghjpfFk. vdNt›muqfqfs cfejmsTvjph KOff Neuk mikAkhWmikffggLfpwJ.

FwpgG:
xypmiyfspd tiffs:xypmiyapd mjphntz mbggilapy xypmiyfis 3 FOffshfg ghpffyhk.

1. Nfshxyp (jho mjphntz miyInfrasonic) 20 Hz tplFiwthdmjphntz cilaxypmiyfs kdpjd NflfKbahj (Nfsh) xypvdggLk. ,ejmiyfs epyeLffjjpd NghJVwgLk. ghkGfs ,ejmjphntz cilaxypfisNflff$bait.

2. nrtpAzh xyp(Audible Waves):
20 HzKjy 20 kHz (20,000 Hz)tiumjphntz cilaxypmiyfskdpjnrtpczUk miyfs vdggLk. Nkwfzlmjphntz neLffxypmiyfiskdpjdpd nrtpahy czu ,aYk.

3. **knahyp (cah; mjphntz; xypmiy**Ultrasonic)
20 kHziatplmjpfmjphntz cilaxypmiyfs knahypvdggLk. ttthyfs (Bats) ,ejxypiaVwgLjjTk›NflfTk $bait.

Nrziy Ntfk; (Supersonic speed)
Xypapd jpirNtfjijtplmjpfNtfjjpy ,aqFk nghUs Nrziy Ntfjjpy (Supersonic speed) nrytjhffUjggLk.

khf; vz;
%yjjd jpirNtfjjpwFk> xypad jpirNtfjjpwFk ,ilNaahdjfNtkhf vz vdggLk.

$$\text{khf vz} = \frac{\%yjjpd\ jpirNtfk}{xypad\ jpirNtfk}$$

KdNdWmiymy;yJ ,aq;Fk; miy:

miyxdWClfjjpy njhlheJ KdNdwpr nrdwhy mejmiyKdNdWmiymyyJ ,aqFk miyvdWngah.

KdNdWmiyapd; gz;Gfs;:

1. Clfj Jfsfs mjd rkepiygGsspiaikakhff nfhzLkhwhjtrrpy mjphTWfpdwd.
2. xtnthUJfspd fllKk 0 Kjy 2p tiukhWfpdwd.
3. vejnthUJfSk njhlheJxatpy ,Uggjpyiy. miyKdNdWk NghJxtnthUfilepiyGsspfspy klLk ,UKiwXaTepiyfFtUfpdwd.
4. KdNdWFWffiyfs KfLfs mfLfshfTk> KdNdWnelliyfs ,Wffqfs> jshrrpfshfTk guTfpdwd.
5. Jfsfs rkepiygGsspiaflfFkNghJrkmsTngUkjpirNttfjjpy nryfpdwd.
6. nλnjhiytpy (n - xU KO vz) gphffggllJfsfspd ,lgngahrrp jpirNtfk> KLffk rkkhFk.

rkjsKdNdWmiyf;fhdrkdghL

t = 0s y ,OjJf fllggllfkgpiarlnld ,OjJtpL. nfhLffggllkhWghlbdhy VwgllJbgGNehfFwpxjpirapy epiyahdNtfk v y KdNdwprnryfpwJ.

miyjJbggpd tbtjijfzpjKiwapy t = 0tpdhbapy $y = y(x,0) = f(x)$vdFwpffyhk. miyjJbggpd tbtk mjd KdNdWk ghijapy khwhJvdf fUJNthk. rpwpJ Neuk tfFgpwF> tyggffk efhjjJbgigx'vdf FwpgNghk

$$y = (x,t) = f(x') = f(x - vt)$$

,NjNghy> miyjJbgGepiyahdjpirNtfk vAld ,lggffk ,aqFtjhff fUjpdhy> $y = f(x+vt)$

,Umiyfs $y = f(x+vt)$Ak $y = f(x - vt)$Ak foffzlxUghpkhz tiffnfOrkdghlbwFnghUeJk> mJNtmiyr rkdghLvdggLfpwJ.

$$\frac{\P^2 y}{\P x^2} = \frac{1}{v^2}\frac{\P^2 y}{\P t^2}$$

,qFFwpaL¶gFjp tiff nfOitf (Partial derivative) Fwpffpwjd. Nkwfzlrkdghlbd midjJjhTfSk miyfFnghUejhJVnddpy vejxUVwff$bamiyAk epiyahdkjpgGfismidjJ$x$kwWk tfFngwNtzLk. Mdhy> xUrhhGxUmiyiaFwpjjhy> mJNkwfzltiffnfOrkdghlbwFnghUejNt zLk. xUghpkhzjjpy (xUjdpggllkhwp)> x– lg nghUjjnkhjjtiffnfOTk gFjptiffnfOTk xdNwmij xUghpkhzjjpy (xUjdpggllkhwp)> x- lg nghUjjnkhjjtiffnfOTk gFjptiffnfOTk xdNw> mij

$$\frac{d^2 y}{dx^2} = \frac{1d^2 y}{v^2 dt^2}$$

,ijxUgh;khz jj;wFNkYk (,uzL› %dW›NkYk) vOjyhk. vs;ikffhfxUgh;khz miyrrkdghlilklLk fUJNthk.

miyxdw;d; tiuglbtk;:

flo;f;fz;l ,U tbt miykhWghLfis tiuglkhffhl;LNthk;.

1. nts; (myyJ ,lQrhhej) khWghLtiuglk (space variation graph)
2. fhyk (myyJNeukrhhej) khWghLtiuglk (time variation graph)

nts;khWghLtiuglk;:

ird rhhGtiuglk y = A sin (*kx*)Neujijeiyahff nfhzL›xiag nghWjJ ,lngahrr;khWghLtiuaggLLssJ. y = A sin (*kx*) vdwird rhhGtiuNfhLfhllggLLssijfUJNthk. ,qF*k*xUkhw;y. λ miyesk vdgJxNumj;hTeiya;y css ,U mLjjLjjGss;fSff;ilNaahdj njhiyT. y = xkwWk y = x + λ vdw ,U Kidfs;Yk ,lngahrr;yMdJxNumsT. mjhtJ›

$y = A \sin(kx) = A \sin(k(x+\lambda))$

$= A \sin(kx + k\lambda)$

ird rhhGxUruhd Neu Kiwa;y khWk (,qF Neu $2p$) vdNt›

$y = A \sin(kx + 2p) = A \sin(kx)$

xgg;l›

$kx + k\lambda = kx + 2p$

,JfhlLf;wJ›

$$k = \frac{2p}{l} radm^{-1}$$

,qFkvdgJmiyvz. ,J$2p$Nubad;y vjjidmiyfs cssdvdf fhzTk myyJvttsTNtfkhfmiy›nts;a;y miyTWf;wJvdf fhzTk gadgLf;wJ. miya;d nts;rrhhejKiwahdmj;hT(Periodicity)

$$l = \frac{2p}{k} m$$

t = 0 sy y(x,0) = y (x = λ, 0)

VNjDk xU Neuk ta;y y(x, t) = y(x + λ, t)

Neu khWghLtiuglk; (Time variation graph)

e;iykhwhky cssNghJ›Neujijg nghUjJ› ,lngahrr;a;y VwgLk khWghLtiuglkhftiuaggLLssJ.y = A sin (ω*t*) vdwird rhhGtiuglj ijf fUJNthk. ,qFωNfhzmj;hntz. ,JNeujijg nghWjJvttsTt;iuthfmiymiyTWf;wJmyyJxUt;dhbfFvjjidRowr;fs VwgLf;wJvdgijf fhlLf;wJ. NeuQrhhej ,ilnts;t;iutj;hT(Periodicity)

$$T = \frac{2p}{w} \text{ Þ } w = \frac{2p}{T}$$

Nfhzmj;hntz›mj;hntz Zld foffzlthWnjhlhGgljjggLLssJ. $w = 2pf$,qF*f*mj;hntz CljfJfs xUt;ehba;y VwgLjJk miyTfs;d vzz;fifvdtiuaWffggLf;wJ. mj;hntzz;d jiyfo;miyTNeukhjyhy›

$$T = \frac{1}{f} s$$

TClfjJfs xUmiyit (mjhit) Kbggjwfhd Neuk. vdNt›miyad Ntfjij›miy 1 tehbaly flfFk njhiyTvdtiuaWffyhk.

$$v = \frac{l}{T} = l f ms^{-1}$$

Jfs; jirNtfk; kwWk; miyjirNtfk;

rkjsKdNdWmiyay (rhir) Clfjjd Jfsfs mtwwd rkeiygGssiaikakhff nfhzLjdrrhiraly miyTWfdwd. Jfs xdW ,affjjYssNghJ›vejxUfzjjYk mjd ,lgngahrrkhWk tjk jirNtfk vdtiuaWffggLfwJ. ,JNtJfsd jirNtfk

$$v_p = \frac{dy}{dt} ms^{-1}$$

Mdhy› $y(x,t) = A\sin(k x - wt)$

,NjNghy› $\frac{dy}{dt} = wA\cos(k x - wt)$

,NjNghy KdNdW (,aqFk) miyad jirNtfjij (,qFNtfk) tiuaWffyhk. xUKdNdWmiyiaf fUJNthk. ,Jtyggffk Nehff ,aqFfwJvdf. fzjtbtly xUird miyahff fhllyhk. P vdgJmjd flljjy xh Gssvdf. $y_p$vdgJrkeiyalyUeJmjd ,lgngahrrvdf. vejnthUfzjjYk (t) ,lgngahrrahdJ

$$y = y(x, t) = A \sin (k x - \omega t)$$

mLjjfzk t' = t + Δtaly P d eiyx' = x + Δxvdf. ,ejgGjafzfjjy (t) ,lgngahrr

$$y = y(x',t') = y(x + Dx, t + Dt)$$
$$= A\sin [k(x + Dx) - w(t + Dt)]$$

miyad tbtk khwhjJmjhtJmiyad fllk khwhJ (vdNty ,lgngahrrxUkhwy) vdNtrkggLjj›

fllk khwhJ (vdNty ,lgngahrrxUkhwy) vdNtrkggLjj›

$y(x', t') = y(x,t)$,

$A \sin [k(x + \Delta x) - \omega (t + \Delta t)] = A \sin (k x - \omega t)$

myyJ

$$k(x + Dx) - w(t + Dt) = k x - wt = khwy$$

jhff›

$$v = \frac{Dx}{Dt} = \frac{w}{k} = v_p$$

,qF$v_p$miyad jirNtfk (wave velocity) myyJfljirNtfk (phase velocity) Nfhzmjhntz›miyvzfismjhntz kwWk miyesk %yk vOj› ,jd %yk Nfhzmjhntz›miyvz kwWk jirNtfqfisfoffzlthWvOjyhk.

jirNtfqfisfoffzlthWvOjyhk

$$w = 2p f = \frac{2p}{T}$$

$$k = \frac{2p}{l}$$

$$v = \frac{w}{k} = l f$$

NkwnghUeJjy; jj;Jtk;

xUKidaly fllggllfkgad xUKidiarlnldWNky ,OjJtllhy›miyjJbgGVwgLk. NkYk mJfkgaly KdNdwr nryfwJ. khwhffkgad ,UKidiaAk ,Uth gbjJfnfhzL› ,UtUk xNufzjjy mkKidfisrlnldWNky

,OjJtplhy; ,uzLmiyjJbgGfs xdiwNehffpxdWefheJ;xUGsspapy; rejpjJ;mgGsspiafleJmNjtbtpy; nryYk. Mdhy;FWffpLk Gsspapy; klLk mtwwpd; gzGKOtJk khWglL;fhlbathWFWffpLk JbgGfs xNutbtk ngwWssdthmyyJvjph; tbtk ngwWssdthvdgijg nghWjJmikAk.

xNu tbtk nfhzl JbgGfs; FWffpLk NghJ njhFgad ,lngahrrp jdpggll ,lngahrrpfspd $Ljyhf miktjhy; mqF trR; jdpggll ,UJbgGfspd trRfis tpl mjpfkhf ,UfFk. mNj Neujjpy ,U JbgGfspd trRfs rkkhf ,UeJ; Mdhy tbtqfs 180 vjphfllljjpy FWffpllhy; trRfs xdiwnahdW mojJf nfhzLk; mgGsspiaf flej gpwF mNj tbtjij kzLk ngwW vjph vjpuhf KdNdWfpdwd. miyfs klLNk ,JNghdw Mrrhpaggk gzig ngwWssd. ,eepfoit ehk NkwnghUeJjy jjJtk vdfpNwhk. miyfs FWffpLkNghJ VwgLk njhFgad gzGfis NkwnghUjJjy jjJtk tpsfFfpwJ.

,ij vjjid miyfSfF NtzLkhdhYk tphpTgLjjyhk. mjhtJ ,uzL myyJ mjwF Nkwgll miyfs xNu Neujjpy Xh Clfjjpy FWffpllhy; njhFgad ,lngahrrpahdJ; jdpggll miyfspd ,lngahrrpfspd ntflh $Ljyhf mikAk. miyfs vdgJ miyrrkdghlbwF nghUejp (miyr rkdghL vdgJ ,UgbgFjptiffnfONeh rkdghL) mikeJssd. mitNeuhf ,izAk NghJ (miyfspd Neh NkwnghUeJjy vdmioffggLfpwJ) njhFgaDk mNjtiffnfOrkdghlLld nghUeJk.

fzpjKiwapy GhpeJnfhss ,U rhhGfis;miyfspd ,lngahrrpfisf fUJNthk.

vLjJffhllhf;

$$y_1 = A_1 \sin(kx - \omega t)$$

kwWk

$$y_2 = A_2 \cos(kx - \omega t)$$

y_1, y_2 ,uzLk miyrkdghlLfFxjJssjhy;mjd $Ljy;

$$y = y_1 + y_2$$

,JTk miyrrkdghlbwFnghUeJfpwJ. mjhtJ; ,lngahrrpfs $LjYfFclgLk jdikAilait. y_1, y_2it xUkhwpy; %yk ngUffpdhy mtwwpd trRmejkhwpypklqFmjpfhpfFk.

mjhtJ C_1, C_2vdwkhwpypfisf nfhzLKiwNa ,lngahrrpy y_1, y_2iangUffpdhy;njhFgad ,lngahrrp

$$y = C_1 y_1 + C_2 y_2$$

,ijvjjidmiyfSfFNtzLkhdhYk nghJthffyhk. vLjJffhllhfnmiyfisfUjpdhy;NkYk xUghpkhzjijtplmjpfghpkhzqfspy fUjpdhy;ehk ,lngahrrpiantflh tbtpy vOjNtzLk. ,jd mbggilapy njhFgad ,lngahrrp

$$\vec{y} = \sum_{i=1}^{n} C_i \vec{y}_i$$

NkwnghUeJjy jjJtk foffzltwiw tpsfFfpwJ.

1. ntsp(myyJ) ntsprhhejFWfflLtpisT (,JNtvspikahfFWfflLtpisTvdTk fUjggLfpwJ)
2. Neuk myyJNeuQrhhejFWfflLtpisT (tpkkyfs vdTk mioffggLfpwJ)
3. epiymiyfs jjJtk

NkwnghUeJjy jjJtjjpwFxjJr nryYk miyfs (trR;miyesjijtplkpffFiwthfcssmiyfs) Neh miyfs vdggLk. miyapd trRmjpfkhf ,Uejhy;mejmiyfs Neh jdikawwmiyfs vdggLk.

,ejmiyfs Neh NkwnghUeJjy jjJtjijkWk. vLjJffhlL: Nyrh› ,ejghljjpy ehk Neh miyfisklLk ghhgNghk. foffzlJizj jiygGfspy xdwdgpd xdwhftpthjpgNghk.

miyfspd; FWf;fll;Ltpist:

,Umiyfs NkwnghUjJtjhy mjd njhFgGmiyapd trrpy VwgLk mjpfhpgG›FiwTmyyJtrRkhwhky ,UfFk tpistTFWfflLtpistTvdggLk.

xNumjphntz Zk›epiyahdfllNtWghLφkwWk xNumiytbtk nfhzl ,U rhpirmiyfs (Xhpay %yqfs vdf fUjyhk) mtwwpd trRfs A_1, A_2vdpy

$$y_1 = A_1 \sin(kx - \omega t)$$

$$y_2 = A_2 \sin(kx - \omega t + \phi)$$

xNu jpira py› xNu Neujjpy ,aqfpdhy mitfspd FWfflL tpisT (mjhtJ ,U miyfSk xdWld xdW NkwnghUeJjy) VwgLk fzpjggb›

$$y = y_1 + y_2$$

nghUjjekfFfpilggJ›

$$y = A_1 \sin(kx - \omega t) + A_2 \sin(kx - \omega t + \phi)$$

jphpNfhzkjpggb

$$\sin(a + b) = (\sin a \cos b + \cos a \sin b)$$

vdNt

$y = A_1 \sin(kx - \omega t) + A_2 [\sin(kx - \omega t) \cos\varphi + \cos(kx - \omega t) \sin\varphi]$

$$y = \sin(kx - \omega t)(A_1 + A_2 \cos\phi) + A_2 \sin\phi \cos(kx - \omega t)$$

$$A\cos\theta = (A_1 + A_2 \cos\phi)$$

kwWk $A\sin\theta = A_2 \sin\phi$

vdf nfhzlhy rkdghL khwwpvOjyhk

$$y = A\sin(kx - \omega t)\cos\theta + A\cos(kx - \omega t)\sin\theta$$

$$y = A(\sin(kx - \omega t)\cos\theta + \sin\theta\cos(kx - \omega t)$$

$$y = A\sin(kx - \omega t + \theta)$$

kwWk it ,Ukbahffp $ll›

$$A^2 = A_1^2 + A_2^2 + 2A_1A_2\cos\phi$$

nrwpTvdgJtrrpd ,Ukbvdgjhy ($I = A^2$) njhFgad nrwpTmgGsspay fllNtWghlilnghUjJmikAk.

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Mf;ff; FWf;fll;Ltpistpw;F:

xUmiyapd KfL›kwnwhUmiyapd KfLld NkwnghUeJkNgh J›mtwwpd trRfs $llggll›Mfff FWfflLtpistTVwgll›mjd trRjdpgglmiyfspd trRfistplmjpfkhf ,UfFk.

MffFWfflLtpistTxUGsspay Vwgllhy mgGsspay nrwpTngUkkhf ,UfFK. mjhtJ

$$\cos\phi = +1 \Rightarrow \phi = 0, 2\pi, 4\pi, ... = 2n\pi,$$

,qFn = 0, 1, 2, …..

,ejfllNtWghlby› ,U miyfs NkwnghUejpdhy›Mfff FWfflLtpistTVwgLk.

$$I_{maximum} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = (A_1 + A_2)^2$$

vdNt› njhFgad tr‹R›

$$A = A_1 + A_2$$

mo‰TFWf;fl‰Lt‰isT:

xUmiya‰d mfL›kwnwhUmiya‰d KfLcld Nrhejhy (NkwnghUej‰dhy) mqFmo‰TFWfflLt‰isTVwgLk. mo‰TFWfflLt‰isTVwgLk Gss‰ay nrw‰Tr‰Wkkhf ,UfFk. mjhtJ $\cos j = -1 \Rightarrow j = p, 3p, 5p, ... = (2n-1)p$, ,qFn = 0, 1, 2, ..., ejf fllNtWghlLld ,U miyfs NkwnghUeJkNghJmo‰TFWfflLt‰isTVwgLk.
vdNt›

$$I_{r‰Wkk} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = (A_1 - A_2)^2$$

njhFgad; tlr‰R:

$$A = |A_1 - A_2|$$

mo‰TFWfflLt‰isTfFxUvs‰afhlr‰t‰sffk nraJfhllyhk.
Svdwxy‰gghd‰y‰UeJ(Speaker) xy‰miyfs P vdwFoha %yk mDggggLf‰wJ. P MdJTtbt‰yhdxUrej‰ahfcssJ. vdNtxy‰miya‰d ghj‰Mwwy xUj‰ira‰Yk kWghj‰Mwwy vj‰h j‰ira‰Yk nryf‰wJ. ,NjNghy xy‰Mwwy NehfFeiuAk ,Ughijfs‰d to‰Nanrdwilf‰wJ. xy‰miyahdJxy‰gghd‰y‰UeJ›NehfFeiuVNjDk xUghijto‰Nanrdwilak ghijesk rvdf. glj‰j‰y‰UeJfo ghijesk r‰1e‰iyahdJNkyghijesk MdJ›NkNycssefUk Foha %yk khwwf$baJ. ,ej ,U ghijesqfSffhdNtWghLghijNtWghL∆rvdggLf‰wJ.

ghijNtWghLλ, Ro‰ahfNthmyyJmiyesqfs‰d (λ) KO vz klqFfshfNth ,UfFk›vd‰y

$$\Delta r = n\lambda$$

,qF›n = 0, 1, 2, 3....

r_1 $r_2$ghijfs‰y tUk ,tt‰Umiyfs vejnthUffzj‰Yk NehfFeiuxNuflljj‰y (fllNtWghL0° myyJ $2p$) rej‰fFk NghJMfffFWfflLt‰isitVwgLjJk. ,eje‰foTfs‰y (NehfFeuhy) xy‰a‰d nrw‰TngUkkhfczuggLk.

ghijNtWghLmiyesjj‰d (λ) miuvz kj‰gGfshfmikejhy›fz‰jggb›

$$Dr = n\frac{l}{2} \qquad ,qF›n = 1, 3$$

(nxwiwvz)

,eje‰iya‰y fhlbathW›r_1 $r_2$ghijfs‰d to‰NaNehfFeiuvejxUfzj‰Yk milAk xy‰miyfs vj‰h flljj‰y (fllNtWghL p myyJ 180°) mikAk NghJmo‰TFWfflLt‰isTVwgLk.

,ee‰foTfs‰y›NehfFeuhy r‰Wknrw‰T (myyJRo‰nrw‰Tmjht Jxy‰Na ,UffhJ) czuggLk. ghijNtWghL›fllNtWghLfSff‰ilNaahdnjhlhG

$$fllNtWghL = \frac{2p}{l} \text{ (ghijNtWghL)}$$

$$Dj = \frac{2p}{l} Dr \text{ myyJ } Dr = \frac{l}{2p} Dj$$

DB = 10 m kwWk $OC = \frac{1}{2}(5) = 2.5$

CD = OC - 1 = 2.5 m + 1 m = 1.5 m

$x_1 = \sqrt{(10)^2 + (1.5)^2} = \sqrt{100 + 2.25}$

$= \sqrt{102.25} = 10.1m$

nrqNfhz KfNfhzk EFBy

DB = 10 m kwWk OE = $\frac{1}{2}$ (5) = 2.5 m = FA

FB = FA + AB = 2.5 m + 1 m = 3.5 m

$x_2 = \sqrt{(10)^2 + (3.5)^2} = \sqrt{100 + 12.25}$

$= \sqrt{112.25} = 10.6m$

ghij NtWghL $Dx = x_2 - x_1 = 10.6m - 10.1m = 0.5$ m. ,ej ghij NtWghL $\frac{l}{2}$ tpwF rkkhf Ntzlk.

$Dx = \frac{l}{2} = 0.5 \Rightarrow l = 1.0m$

xyp %yjjpd mjpHntz fhz›

$v = l f \Rightarrow f = \frac{v}{l} = \frac{343}{1} = 343Hz$

= 0.3 kHz

Xypggh dfs› %yjjpypUeJvjpHflljjpypUejhy ghijNtWghL $\frac{l}{2}$ NkYk $\frac{l}{2}$ ghijNtWghL cUthFkNghJ›nkhjjghijNtWghLλ MFk. vdNtmiyfs xNuflljjpy miktjhy›B– y xypapd nrwpTngUkkhf ,UfFk.

tpkkyfs; Njhdpwk; tljk;

rwNwNtWgllmjpHntz nfhzl ,uzLmyyJmjwFNkwgllmiyfs NkwnghUeJtjhy›xUGssparly Neujijg nghUjJtrRkhWgLfpdwxypNflFk ,ejtpisNttpkkyfs vdggLk. xUtpdhbapy VwgLk trRngUkqfspd vzzpfifNatpkky mjpHntz vdggLk. ,uzLxyp %yqfs klLNk ,Uejhy›mtwwpd mjpHntz NtWghNltpkky mjpHntz vdggLk. xUtpdhbapy tpkkyfspd vzzpfif $n = |f_1 - f_2|$

epiyahdmiyfs; (Stationary Waves)

epiymiyfSf;fhdtpsf;fk;

miyxdWfbdkhdxdwpd kJNkhJkNghJ›mJkznlOeJteJmNjClfjjpy vjpHjjpiraply›gioamiyAld (Nkhjpamiy) NkwnghUeJtjhy fpilfFk miytbtNkepiymiyfs myyJepiyahdmiyfs vdggLk.

xNutrR›xNujpirNtfk nfhzl ,U rhpirKdNdWmiyfs (fkgpxdwpy czlhd) vjph vjph jpiraply ,aqFfpdwdvdf.

Kjy miyapd (gLmiy) ,lngahrrp›

$y_1 = A \sin(kx - \omega t)$

(tyJgffk eUk miy)

,uzlhtJmiyapd (vjpnuhypgGmiy) ,lngahrrp

$y_2 = A \sin(kx + t)$

(,lJgffk efUk miy)

NkwnghUeJ j i y j j J t g g b › , U m i y f S k F W f f L m i l e J › n j h F g a d , l g n g a h r r ›

$y = y_1 + y_2$

rkdghLnghUj j ›

$$y = A\sin(kx - \omega t) + A\sin(kx + \omega t)$$

j h N f h z k j t j f i s g a d g L j j i a k h w w v O j

$y(x,t) = 2A\cos(\omega t)\sin(kx)$

, J N t › e i y m y y J e i y a h d m i y f s v d g g L k . , J K d N d h f f N a h m y y J g d N d h f f N a h e f u h J . M d h y K d N d W m i y m y y J , a q F m i y K d N d h f f N a h m y y J g d N e h f f N a h e f U k .

$$y(x,t) = A'\cos(\omega t)$$

, q F › $A' = 2A\sin(kx)$ › , J m j h T W f f k g a d F w g g l l g F j A ' t r R l d j d r r h i r , a f f j j Y s s i j F w f f w J . $\sin(kx)$ n g U k k h f c s s e i y a y › A ' n g U k k j g g y , U f F k .

$$\sin(kx) = 1 \Rightarrow kx = \frac{p}{2}, \frac{3p}{2}, \frac{5p}{2}, ... = mp$$

, q F m v d g J m i u K O v z m y y J m i u v z k j g G f s . t r r d n g U k k j g G c s s e i y i a v j h f f Z v d f N w h k .

m i y v z i z m i y e s j i j g a d g L j j F w f F k N g h J m M d J v j h f Z t d e i y i a f o f f z l t h W F w f f y h k .

$$x_m = \left(\frac{2m+1}{2}\right)\frac{l}{2}, \text{ , q F } m = 0, 1, 2,$$

m = 0 v d y n g U k j j d e i y

$$x_0 = \frac{l}{4}$$

m = 1 v d y › n g U k j j d e i y

$$x_1 = \frac{3l}{4}$$

m = 2 v d y n g U k j j d e i y

$$x_2 = \frac{5l}{4}$$

v d w t h W m i k A k

m L j j L j j v j h f Z f f S f f i l N a a h d J } u j i j f o f f z l t h W f z f f l y h k .

$$x_m - x_{m-1} = \left(\frac{2m+1}{2}\right)\frac{l}{2} - \left(\frac{(2m+1)+1}{2}\right)\frac{l}{2} = \frac{l}{2}$$

A ' d n g U k k j g G n t s a d r y G s s f s Y k r W k k j g G n t s a d N t W r y G s s f s Y k m i k A k .

$$\sin(kx) = 0 \Rightarrow kx = 0, p, 2p, 3p, ... = np$$

, q F *n* x U K O v z m y y J K O v z k j g G f s . v e j g G s s f s y m j h T , y i y N a h (, a f f k , y i y N a h) m g G s s f s f Z v d g g L k .

n M t J f Z t d e i y

$$x_n = n\frac{l}{2} \text{ , q F › } n = 0, 1, 2$$

n = 0 v d y r W k k V w g L k e i y

$$x_0 = 0$$

n = 1 v d y r W k k V w g L k e i y

n = 1vdy rWkk vwgLk eiy

$$x_1 = \frac{l}{2}$$

n = 2 vdy rWkk VwgLk eiy

$$x_2 = l$$

vdwthWmiAk;.

mLjjLjjf Z ffS ffilNaahdnjhiyitf foffzlthWfzffiyhk.

$$x_n - x_{n-1} = n\frac{l}{2} - (n-1)\frac{l}{2} = \frac{l}{2}$$

eiymiyfsd; gz;Gfs;

1. ,Ujlkhdvyiyf Sffil Nafl Lggljjggllmiy. vdNt ,JClfjjy KdNehffNahgdNdhffNahefuhJ. mjhtJmjDila ,ljjy eiyahf ,UfFk. vdNt› ,Jeiymyy Jeiyahdmiyfs vdggLfwJ.

KdNdWmiyfS f;Fk›eiymiyfS f;Fk ilNaahdxggL:

t.vz;	KdNdWmiyfs;	eiymiyfs;
1.	KdNdWFWffiyay KfLk›mfLk VwgLk. KdNdWnelliyfsy ,WffKk›jshrrfSk VwgLk. ,ejmiyfs Xh Clfjjy KdNehffNahmyyJgdNdhffNahefheJnfhz bUfFk. mjhtJxUFwggllj irNtfjJld Clfk xdwy KdNdwf nfhzbUfFk.	eiyFWffiyfsy KfLk›mfLk VwgLk eiynelliyfsy ,WffKk›jshrrfFk VwgLk. ,ejmiyfs Clfjjy KdNdhffNahgdNdhffNahe fuhJ. ,itClfjjy KdNdwhjmiyfs.
2.	miynryYk jiray cssmidjJJfsfSk rktrRld mjhTWk	fZty cssJfsfs jtukwwmidjJJfsfSk ntNtWtrRfSld mjhTWk. trRfZty Romyy JrWkk. vjhfZty ngUkk.
3	Mwwiyjhqfr nryYk	Mwwiyf fljJtjyiy

2. ngUktrReiyaYssGssfs vjhff Z vdTk›RotrReiyaYssGssfs fZvdTk mioffggLfwJ.
3. mLjjLjj ,U fZmyyJvjhff Z ffS ffilNaahdnjhiyT $\frac{l}{2}$
4. xUfZ›mjwFmLjjvjhff Z twF ,ilNaahdnjhiyT $\frac{l}{4}$
5. eiyahdmiyfsd toNafljjggLk Mwwy RoahFk.

Rukhdiay; VwgLk; eiymiyfs;

Ruk vdgJ xyAld njhlhGilaJ. mjdhy Rukhdvdgj xynjhlhghdtwiw msffggadgLk fUt. fkgfsy VwgLk eiyahdFWffiyfsd mjhntz›fkgad ,Otir›mjh esk›XuyFfkgad eiwMfatwiwfhlrtsffk nraJmsffgadgLjJk fUtahFk.

vdNt› ,ffUtiagadgLjjfoffzlmsTfismsffyhk.

1. ,irffitmyyJkhWjirkdNdhlljjd mjhntz
2. fkgad ,Otir

3. njhqft;lggllnghUs;d e;iw

mikgG:

Rukhd;vdgJxUkllh esKssxUkugnglbmjd kJruhd cNyhfffkg;nghUjjgglbUfFk. fkg;a;d xU Kid xUnfhff;AlDk›kWKid XU cUisfgg;to;NaXh e;iwjjhqf;AlDk ,izffgglLssJ. fkg;a;d ,Ot;iriamj;fh;ffkWKida;y e;iwfs Nrhffgg;Lf;wJ. ,uzLefhjjf $ba $h Kidfs fkg;iafNonjhllthWRukhd;a;d gyifkJitffgglLssd. mtww;wf;ilNaahdj njhiyitkhww;mj;hTWk fkg;a;d esjijkhwwyhk.

nrayghL:
e;iyahdFWffiyfs fkg;a;y VwgLjjggLf;wJ. vdNt $hKidP, Q, t;y fZffSk cUthf;fdwd. mj;hTWk fkg;a;d esk /vdf.

$$l=\frac{l}{2} \Rightarrow l=2l$$

mj;hTWk fkg;a;d mj;hntz fvdf. Tfkg;a;d ,Ot;ir›µ vdgJ xuyF fkg;a;d e;iw vd;y›

$$f=\frac{v}{l}=\frac{1}{2l}\sqrt{\frac{T}{m}}\,n`hl]$$

ρvdgJfkg;g nghUs;d mlhjj;›dfkg;a;d t;llk vd;y XuyFfkg;a;d e;iw›

$$\mu=gugG\times mlhjj;=pr^2r=\frac{prd^2}{4}$$

mj;hntz $f=\frac{v}{l}=\frac{1}{2l}\sqrt{\frac{T}{\frac{pd^2r}{4}}}$

/ $f=\frac{1}{ld}\sqrt{\frac{T}{pr}}$

mbggil mj;hntz; kwWk; Nkw;Ruq;fs;:
j;lkhd vyiyfis x=0 kwWk x=L Mf fUJNthk. fkg;ia ikajj;y ,UeJ Mlb (f;jhh fkg;) e;iy miyfs VwgLjJf. mej e;iy miyfs Fwgg;ll miyesjij ngww;Uf;wJ. vyiyfs;y trR FiweJ kiwtjh›y ,lngahrr;fs foffzl e;gejidfF clgl Ntz;Lk.

$$y(x=0,t)=0 \text{ kwWk } y(x=L,t)=0$$

xtnthU fZTk $\frac{l_n}{2}$, iljnjhiyt;y miktjhy ekfFn $\frac{l_n}{2}=L$,qFn xU KO vz›L vdgJ vyiyfs;d ,iljnjhiyT› vdgJ vyiyfFlgll e;gejidfis G+hjj; nraAk Fwgg;ll miy eskhFk.

$$l_n=\frac{2L}{n}$$

vdNt›Fwgg;llvyiyfFmidjJmiyesqfSk VwglhJ›Fwgg;llmiyesk klLNkVwgLk.

n=1,Kjy e;iymj;hTfF› $l_1=2L$

n = 2, 2 k e|iymj|hTfF›

$$l_2 = \left(\frac{2L}{2}\right) = L$$

n = 3, 3 k e|iymj|hTfF›

$$l_3 = \left(\frac{2L}{3}\right)$$

,tthwhfkwwnkj|gGfSfFk mikAk. xtnthUe|iymj|hTfFkhd›mj|hntz ,aye|iymj|ntz (Natural Frequency) vdggLk. mijfoffzlthWfzff|lyhk.

$$f_n = \frac{v}{l_n} = n\left(\frac{v}{2L}\right)$$

,ej ,ay mj|hntz z|d›k|ff Fiwejkj|gGmbgg ilmj|hntz (Fundamental Frequency) vdggLk.

$$f_1 = \frac{v}{l_1} = \left(\frac{v}{2L}\right)$$

,uzlhtJ ,ay mj|hntz Kjy NkwRuk vdggLk.

$$f_2 = 2\left(\frac{v}{2L}\right) = \frac{1}{L}\sqrt{\frac{T}{m}}$$

%dwhtJ ,ay mj|hntz 2tJ NkwRuk vdggLk.

$$f_3 = 3\left(\frac{v}{2L}\right) = 3\left(\frac{1}{2L}\sqrt{\frac{T}{m}}\right)$$

NkYk ,JNghdWmikAk vdNt›*n*tJ ,ay mj|hntz.

$f_n = nf_1$, qF*n*xU KO vz

,ay mj|hntzfs›mbgg ilmj|hntz z|d KO vz klqFfshfmikAk NghJ›mejmj|hntzfs rh|irfs vdggLk. vdNt›Kjy rh|irvdgJ f_1 - f_1 (mbgg ilmj|hntz Kjy rh|irvdggLk)›

2tJ rh|ir$f_2 = 2f_1$, 3tJ rh|ir$f_3 = 3f_1$kwWk g|w.

,Oj;Jf; fl;lggl;lfkg|ay; VwgLk; FWf;fiyf;fhdt|j|fs;
%dWt|j|fs

1. esj|jwfhdt|j|:
nfhLffgglfkg|ad› ,Ot|irT (e|iyahdJ) kwWk XuyFesj|jwfhde|iwμ (e|iyahdJ) vd|y›mj|hntz mj|hTWk fkg|a|d esj|jwFvj|hjjft|y mikAk.

,Oj;Jf; fl;lggl;lfkg|ay; VwgLk; FWf;fiyf;fhdt|j|fs;
%dWt|j|fs

esj;jwfhdt|j|:
nfhLffgglfkg|a|d› ,Ot|irT (e|iyahdJ) kwWk xuyFesj|jwfhde|iw (e|iyahdJ) vd|y›mj|hntz mj|hTWk fkg|a|d esj|jwFvj|hjjft|y mikAk.

$$f \mu \frac{1}{l} \Rightarrow f = \frac{C}{l}$$

$\Rightarrow l' f = C$, ,qFCkhw|y|

,Ot|irf;fhdt|j|:

nfhLffgglmjhTWk fkgad esk l(eiyahdJ) kwWk XuyFesjjwfhde;iwm(eiyahdJ) vdy mjhntz ,Otirt ,d ,Ukb %yjjwFNehjftiy mikAk.

$$f \mu \sqrt{T}$$

$$\Rightarrow f = A\sqrt{T}$$, ,qFAxUkhwiy

eiwf;fhdtijj;

nfhLffgglmjhTWk fkgad esk l(eiyahdJ) kwWk ,Otirt (eiyahdJ) vdy mjhntz›XuyFesjjwfhde;iwμ ,d ,Ukb %yjjwFvjhjjftiy mikAk.

$$f \mu \frac{1}{\sqrt{m}}$$

$$\Rightarrow f = \frac{B}{\sqrt{m}}$$,qFBxUkhwiy

nrwT(Intensity) **kwWk; cugG**(Loudness):

Xh xy; %yk kwWk ,U Nflgtiu (xy;iaNflgth) fUJf. xy; %yk xy;iackofwJNkYk MwwiyvLjJr nryffwJ. ahh msejhYk xyad Mwwy›midtUfFk xNumsthfNt ,UfFk. vdNt›xy;Mwwy mggFjay cssNflgtiur rhhejyy. Mdhy ,U NflgthfisfUjdhy mthfs czUk xy;khWgllJ. ,Jfhjd czhjwd Nghdwr;yfhuz;fisr rhhejJ. ,twiwmst;lnrwT›cugGvdw ,U msTfistiuaWff;Nwhk.

xyad; nrwT:

xy;%yk xdwiyUeJxy;miyfs guTkNghJ›MwwyhdJRww;Assmidj J› (,ayf$ba) to;fs;Yk vLjJrnryyggLk.

xuyFNeujjy myyJxUtdhbay ck;oggLk myyJCLUTk ruhrhxy;MwwNy›xyad jwd vdggLk.

vdNt›xy;KdNdWk j;irfFnrqFjjhfxuyFgugg;d to;NaCLUt;r nryYk xy;jjwNd›xyad nrwT(Intensity) vdtiuaWffggLfwJ.

xUFwgg;llxy; %yjjwF (eiyahd %yk)›mjd xy;rnrwthdJxy;%yjjy;UeJnjhiytd ,UkbfFvjhjjftiy mikAk

$$I = \frac{xy;\ \%yjj;d\ jwd}{4pr^2} \Rightarrow I \mu \frac{1}{r^2}$$

,JNt›xy;rnrwt;d vjht;fij ,Ukbt;jahFk.

xyad; cugG:

xNunrwTnfhzl ,U xy; %yqfs xNuxy;cugGngww;Uffj Njitayiy. vLjJffhllhfgY}d xdWmikj;ahd %lggllmiway ntbfFk NghJmjd cugGmj;fkhfTk›mNjgY}d Rjjkhdreij;ay ntbfFk NghJcugGk;ffFiwthfTk ,UfFk. ,qFnrwTrkkhf ,UggDk cugGmtthwhf ,yiy. xy;rnrwTmj;fh;fFk NghJcugGk mj;fh;fFk. xyad nrwitf fhlbYk ,qF $Ljyhfcw;WNehfFgthd Elgk kwWk mDgtk mf;afhuz;fs vttsTmj;fcugGcssxy;vdgijmwtjiy gqFtf;ff;wJ. ,JNtxyad cugGvdggLfwJ. Nflgthd czhjwDk ,qFgqFtf;ff;wJ. vdNt›xy;cugG›xyad nrwTkwWk fhjd czhjwd (,J njs;thfNflgtiug nghWjjmsT. NkYk ,JxUtUfFxUth khWgLk) Mf;atwiwg nghUjjJ. Mdhy xy;rnrwTNflgtiug nghWjjJmyy.

vdNt›xyp cugGvdgJ“xyp iafhJ c zUk jpwdpd epiymyyJNflgthpd xyp c zUk jpwd" vdt iuaWffggLfpwJ.

xypapd; nrwpTkwpWk; cugG:

ekJfhJ c zuf$baxyapd nrwpT ,ilntspl$10^{-2}$ Wm^{-2}ypUeJ20 W m^{-2}ntgh - ngfdh tpjpggb“cugGkdpjhfshydwpfUtpxdwpd %yk msffggllnrwptpd (I)klfifkjpgGfFNehjjftpy ,UfFk.

$$L \mu In I$$

$$L = k\ In\ I$$

,qFkxUkhwpy. ,JmsfFk myifr rhhejJ. ,uzLcugGfs L_1kwWk L_0,jwF ,ilNaahdNtWghL›Jyypakhfmspffggll ,UnrwpTfSffpilNaahdrhhGcugGMFk. fzpjggbxypr nrwpTkllqfs

$$DL = L_1 - L_0 = k\ In I_1 - k\ In\ I_0 = k\ In \frac{\acute{e}I_1 \grave{u}}{\hat{e}I_0 \acute{u}}$$

k = 1vdpy›xypnrwpTkllk ngy (bel)vdwmyfhy msffggLfpwJ. (mnyf]hzlh fpufhk ngy epidthf)

k = 1vdpy ngy

k = 10vdpy nlrpngy

$$DL = In \frac{\acute{e}I_1 \grave{u}}{\hat{e}I_0 \acute{u}} ngy$$

,JeilKiwapy nghpamyF. vdNtnlrpgy (decibel)vdwrpwpamyifgadgLjJfpNwhk.

$$1\ nlrpngy = \frac{1}{10} ngy$$

vdNt› Nkwfzl rkdghlil 10 My ngUffp 10 My tFffff fpilggJ.

$$DL = 10 \frac{æ \acute{e}I_1 \grave{u}ö 1}{ç In \hat{e} \acute{u} ÷ 10} ngy$$

$$DL = 10 In \frac{\acute{e}I_1 \grave{u}}{\hat{e}I_0 \acute{u}} nlrpngy \quad (k = 10)$$

eilKiwg gadghlbwfhf› ,awifklfiffFgjpyhf 10 mbkhdklfifiagadgLjJfpNwhk.

$$DL = 10 \log_{10} \left| \frac{I_1}{I_0} \right| nlrpngy$$

fhwpWjkpgj;jpd; mjpfhT:

ehj]tuk›kwWk gpw ,irffUtpfs fhwWf fUtpfs vdggLk. ,itfhwWj jkgmjpfhTfs jjJtjjpy ,aqFfpwJ. fhwWfUtpapd vspatbtk Mhfd organ - fUtp ,irgNgio) Foha MFk. vLjJffhllhf›GyyhqFoy›fpshbndl›ehj]tuk.
Mhfd Foha ,U tifggLk.

%baMhfd; Foha;:

ehj]tuk›kwWk gpw ,irffUtpfs fhwWf fUtpfs vdggLk. ,itfhwWj jkgmjpfhTfsfUtpapd vspatbtk Mhfd fUtp ,irgNgio) Foha MFk. vLjJffhllhf›GyyhqFoy›fpshhpndl›ehj]tuk.
Mhfd Foha ,U tifggLk.

%baMhfd; Foha;

f;shh;ndl gljijghUqfs. ,JxUgffk %bakwnwhUgffk j;wejFoha. j;wej Kid to;ahftUk xy; %bagFj;a;y vj;nuhy;fFk xy;csNstUk xy;Ald 180°vj;hfllj;jy ,UfFk. vdNt› %bagFj;a;y Jfsfs;d ,lngahrr;vgnghOJk Ro;. ,lngahrr;Ro;ahtjhy %bagFj;a;y fZTk. j;wejgFj;a;y vj;hffZTk VwgLf;dwd. mj;hTWk mj;hTxy;a;d vs;amj;hTe;iyiambggilmj;hTe;iyvdNghk. %baKida;y Jfsfs;d ,affk ,yyhjjhy fZTk mbggilmj;hTe;iya;y j;wejKida;y vj;hffZTk cUthFk. LFoha;d esk›VwgLk

miyfs;d miyesk $l_1$vd;y›

$$L = \frac{l_1}{4} or\ l_1 = 4L$$

xy;a;d mj;hntz

$$f_1 = \frac{v}{l_1} = \frac{v}{4L}$$

j;wejKida;y fhwiwtYthfCJtjhy›mbggilmj;hntz z;d KO vz klqFfshy Md mj;hTfisVwgLjjyhk. mejmiyfs NkwRuqfs vdggLf;dwd.

,uzlhtJe;iymj;hTfis (Kjy NkwRuk) fhlLf;wJ. ,j;y ,U fZffSk ,U vj;hfZffSk cssJ

$$4L = 3\lambda_2$$

$$L = \frac{3l_2}{4} myyJ\ l_2 = \frac{4L}{3}$$

mj;hntz

$$f_2 = \frac{v}{l_2} = \frac{3v}{4L} = 3f_1$$

,JKjy NkwRuk MFk. ,ejmj;hntz mbggilmj;hntz z;d %dWklqFvdgjhy ,J %dwhtJrh;irvdggLk.
%dWfZffSk› %dWvj;h fZffSk cila %dwhtJe;iymj;hT

$$4L = 5\lambda_3$$

$$L = \frac{5l_3}{4} myyJ\ l_3 = \frac{5L}{5}$$

mj;hntz

$$f_3 = \frac{v}{l_3} = \frac{5v}{4L} = 5f_1$$

,J ,uzlhtJNkwRuk MFk. ,ejmj;hntz mbggilmj;hntz izg Nghy leJklqfhfcssjhy› 5tJ rh;irvdTk miof fggLf;wJ.

vdNt %baMhfd Foha;y VwgLk mj;hTfs xwiwggilth;irrh;irfisf nfhzLssJ. rh;ira;d mj;hntz $f_n = (2n+1) f_1$NkwRuqfs;d mj;hntz fs;d jfT.

$$f_1 : f_2 : f_3 : f_4 : .... = 1 : 3 : 5 : 7 ....$$

gljjy fhllggllGyyhqFoiyfhzf. ,J ,UGwKk j;wejFoha ,U j;wejKidfs;Yk vj;hffZffs cUthf;dwd. ,qFVwgLk k;fvs;amj;hTe;iyiafhzNghk. ,ee;iyNambggilmj;hTe;iyvdggLf;wJ. j;wejKidfs;y vj;hffZffs VwgLtjhy›Foha;d csNsikajjy xNunahUfZcUthf;wJ. y;UeJ›LvdgJFoha;d esk vdfVwgLk miya;d miyesk fhz›

$$L = \frac{l_1}{2} \text{ or } l_1 = 2L$$

VwgLk mjhtd›mjhnt z

$$f_1 = \frac{v}{l_1} = \frac{v}{2L}$$

,JNt›mbggilmjhnt z
mbggilmjhnt z izt lcah mjhnt z fisVwgLjjjwejKidaly fhwiwNtfkhfCjNtzLk. ,jjifamjhnt z fs NkwRuqfs vdggLk

jwejMhfd Fohaly VwgLk ,uzlhk eiymjhitf fhlLfwJ. ,J ,U fZitAk %dWvjhff Zitak cilaJ.

$$L = l_2 \text{ or } l_2 = L$$

mjhnt z

$$f_2 = \frac{v}{l_2} = \frac{v}{L} = 2' \frac{v}{2L} = 2f_1$$

,JKjy NkwRuk vdggLfwJ. n = 2vdgjhy ,J ,uzlhtJrhirvdTk mioffggLfwJ.
%dwhk eiymjhT ,jy 3 fZTk› 4 vjhffZTk cssJ.

$$L = \frac{3}{2} l_3 \text{ myyJ } l_3 = \frac{2L}{3}$$

mjhnt z

$$f_3 = \frac{v}{l_3} = \frac{3v}{2L} = 3f_1$$

,J3tJ NkwRuk. n=3vdgjhy ,J 3tJrhirvdTk mioffggLfwJ.

vdNtjwejMhfd Foha midjJrhirfisAk cilaJ. nMdJrhiraid mjhnt z $f_n = nf_1$. vdggLfwJ. vdNtNkwRuqfs mjhnt zfsid jfT

xjjjhTfhwWj jkgf fUtp:

xjjjhTfhwWjkgf fUtpxUkllh esk cilafzzhbmyyJcNyhff Fohahy MdJ. fhwWjkgjjy VwgLk xjjjhitf fzffplLmjd %yk rhjhuzntggeiyaly fhwwy xyaid jirNtfk fhzgadgLfwJ. NkYk fhwWj jkgesjijkhwWtjd %yk xjjjhTmjhnt z khWgLtijmsffTk gadgLfwJ. xUKidiaj jwejjhfTk kWKidia %bajhf ,fFohAld uggh Foha %yk ,izffgglleh Nrkffyk R fhzgpjjthWVwgLjjggllssJ. ,ej KO mikgGk msTNfhy nghUjjggllnrqFjJjhqfpaly nghUjjgglLssJ. uggh Fohaly ghjpasTeh epuggggllssJ. eh klljijNrkffyjjid (R) caujijkhwWtjd %yk›NjitfFVwgkhwwf nfhssyhk. ehid Nky gugG %bagFjpahfTk kWKidjwejKidahfTk nraygLk. vdNt› ,J %baMhfd Fohahfnraygl fwJ.

miyaid fZehid Nkwgugg Yk vjhfZjwejKidaYk VwgLk. jwejKidaly ,irffitxdiwmjh itjJgpbjjhy nelliyfs cUthfpfhlbagbfoNehffpefUk. ehid gugigmilejTld ,ejmiyvjpuhspffggLk miyAld NkwnghUeJtjhy epiyahdmiyfsVwgLk. mjd esjijkhwwpfhwWj jkgjjid mjhnt z› ,irffitaid mjhnt z Zld (,irffitaid ,ay mjhnt z) xjjjhtilar nraAkNghJ›mjpfcugGcssxypVwgLk. ,jd nghUs fhwWjjkgjjid mjhnt z› ,irffyitaid mjhnt z ZfFr rkkhfpxjjjhTffhdepgejidiag ngWk. ,ejepiyahdJfhwWj jkgjjid esk›xypmiyaid miyesjjid

æ1 öth
ç÷ klqfhfmikAk NghJVwgLk. Kjy xjjjhthdJL$_1$esjjy
è4 ø
VwgLtjhffUJNthk.

$$\frac{1}{4}l = L_1$$

Mdhy›vjhff Z Jyyakhfjwe jKiday VwgLtjyiy. vdNt›ehk xUjUjjjinraaNtzLk. ,JNt Kid jUjjk vdggLfwJ. vjhf Z thdJjwejKiday xUrwa J}ujjy VwgLfwJvdf. vdNt›Kjy mjhTeiy›Kidjj Ujjj Jld

$$\frac{1}{4}l = L_1 + e$$

,gnghOJfhwWjjkgjjd esjijkhww ,uzlhtJxjjjhTesk L_2twF Kid jUjjjJld

$$\frac{1}{4}l = L_1$$

xUrwaJ}ujjy VwgLfwJvdf. vdNt›Kjy mjhTeiy›Kidjj Ujjj Jld

$$\frac{1}{4}l = L_1 + e$$

,gnghOJfhwWjjkgjjd esjijkhww ,uzlhtJxjjjhTesk L_2twF Kid jUjjjJld

$$\frac{3}{4}l = L_2 + e$$

Kidjj UjjjijGwffzff›rkdghLNtWghlilfzlhy›

$$\frac{3}{4}l - \frac{1}{4}l = (L_2 + e) - (L_1 + e)$$

$$\therefore \frac{1}{2}l = L_2 - L_1 = \Delta L$$

$$\therefore l = 2\Delta L$$

miwntggeiyay xyad jirNtfjijfoffzlthWfzfflyhk.

$$v = fl = 2f\Delta L$$

Kidjj Ujjjijrkdghlgadgljjfhz

$$e = \frac{L_2 - 3L_1}{2}$$

lhgsh tisT:

,uay eiyaeilNkilay edWfnfhzL›ekikf fleJnryYk njhlhtzbad Cnjhyiaf Nflgjhff fwgidnraNthk. tzbekikneUqFkNghJxyad RUj(Pitch)myyJmjhntz (Frequency) $Ltijak tzbekiktilLtyfr nryifay›RUjFiwtijAk ekkhy NflfKbAk. ,Jlhgsh tistwFXh vLjJffhllhFk.

xy%yjjwFk mtnthyiaf NflgtUfFk ,ilNacssrhhG ,affjjdhy ,ttisTVwgLfwJ. ,affjjdhy VwgLk ,jjifamjhntz khwwjij M]jhaehlilr NrhejfzjtayhsUk ,awgayhsUkhdNahfhz fw]bad lhgsh (1803 – 1853) vdgth Kjyy Muhaejh.

xy; %yjj;wFk NflgtUfFk ,ilNaxUrhhG ,affk cssNghJxy; %yjj;y ,UeJtUk xy;a;d mj;hntz Zk mijf Nflgtuhy czuggLk xy;a;d mj;hntz Zk khWglL ,UfFk. ,JNtlhgsh t;isTvdggLk.

lhgsh t;isTxUmiye;fothFk. MfNt›xy;miyfSfFklLk;dw;xs;miyfSfFk g;wk;dfhejmiyfSfFk lhgsh t;isTVwgLf;wJ. xy;miyfs;d lhgsh t;ist;y cssgyNtWNehTfs kwWk Nflgtuhy czuggLk mj;hntz z;wfhdNfhitiajUt;jjy gww; ,ggFj;a;y ehk tthj;ffyhk.

NflLzh; mj;hntz: e;iyahd %yk; kwWk; ,af;fj;j;y; cs;sNflgth;

Clfjijg (fhwW) nghUeJXat;y cssGss;xy; %yk (S)xdiwf fUJNthk. xy; %yk itffgglLsCl fkhdJ›ruhfTk xat;y cssJvdTk nfhsNthk. xy; %yk nts;t;Lk xy;miyfs;d mj;hntz *f*kwWk miyesk λMFk.

xy; %yj;y;UeJMuto;Nantsrnry Yk Nfhsfxy;miyfs *v*vdwrkj;irNtfj;y midjJj;irfs;Yk guTf;dwd. xy;miyfs;d ,Wffqfs (myyJmiyKfgGfs) xU - ikatllqfs fhllgglLssd. mLjjLjj ,U ,WffqfSfF ,ilNaahdnjhiyTmjd miyesk λMFk. NkYk.miya;d mj;hntz Nflgth e;iyahf cssNghJ› %yjj;wFk (s)NflgtUfFk (L) ,ilNarhhg;affk ,UffhJ. *u*kwWk λ Mfaitkhwhky ,Uggjhy›Nflgtuhy czuggLk xy;a;d mj;hntz Zk xy; %y mj;hntz Zk rkkhf ,UfFk.

e;iyahd %yjijNehff;Nflgth Neuhfefhtjhff nfhsNthk. Nflgth;d Ntfk $v_L$vd;y›Nflgtiug nghUjJxy;a;d rhhGNtfk $v' = v + v_L$MFk.miyesk khwhky cssjhy (%yk e;iyahf ,Uggjhy)›Nflgth czUk xy;a;d mj;hntz khWf;wJ. NflLzh mj;hntz *f'* MdJg;dtUk rkdghlhy ngwggLf;wJ.

$$f' = \left(\frac{v + (-v_L)}{v}\right) f$$

$$f' = \left(\frac{v - v_L}{v}\right) f$$

(%yjijt;lLNflgth t;yf;r nryYkNgh)

MfNt›e;iyahd %yjijt;lLNflgth t;yf;r nryf;whh vd;y› %y mj;hntz iz t;lNflLzh mj;hntz Fiwthf ,UfFk.

NflLzh mj;hntz: efUk %yk kwWk e;iyahdNflgth xy; %yKk (S)NflgtUk (L)xaTe;iya;y ,Uggjhff fUJNthk.

mLjjLjj ,U ,Wffqfs gljj;y fhllgglL› ,uzLxUikatllqfshy Fw;ffgglLssd. ,uzlhtJ ,Wffk rkgjj;y nts;a;lggL› %yjj;wFmUf;y cssJ. ,ttU ,WffqfSfF ,ilggllnjhiyTxy;a;d miyesk λ MFk. %yjj;d mj;hntz *f*Mifahy› ,ttU ,Wffqfs nts;a;lggLk fhy ,ilnts;

$$T = \frac{1}{f} = \frac{l}{v}$$

,gNghJ e;iyahd Nflgtiu Nehff; xy; %yk Neuhf efhf;wJ xy; %yj;d Ntfk $v_s$vdfkwWk ,ejNtfk xy;a;d Ntfjij *v* t;lf FiwT MFk.

T fhy ,ilntspay> Kjy ,affk nryYk $vT = l$ njhiyT kwWk xypdk efUk njhiyT $v_s T$ MFk. ,jd tpisthf> ,U ,WffqfSfF ,ilggll njhiyT λ - ypUeJ $l' = l - v_s T$ vdW Fiwfpwj. vdNt> Nflgth czUk miy esk

$$l' = l - v_s T = l - \left(\frac{v_s}{f}\right)$$

NflLzh mjpht z MdJ>

$$= \frac{v}{\left(\frac{v}{f}\right) - \left(\frac{v_s}{f}\right)}$$

MfNt epiyahd Nflgtiu Nehffp xypdk efUkNghJ> %y mjphntz iz tpl NflLzh mjphntz mjpfkhf ,UfFk.

epiyahd Nflgtiu tplL xypdk tpyfpr nryfpwJ vdpy>v_s– fF vjphfFwp ,Ltjd %yk NflLzh mjphntz izg ngwyhk.

$$f' = \left(\frac{v}{v + v_s}\right) f$$

MfNt> epiyahd Nflgtiu tplL xypdk tpyfpr nryfpwJvdpy> %y mjphntz iz tplNflLzh mjphntz Fiwthf ,UfFk.

NflLzh mjphntz : xypdk kwWk Nflgth ,UtUNk ,affjjpy cssNghJ

xypdk kwWk Nflgth ,UtUNk ,affjjpy cssNghJ> NflLzh mjphntz zpwfhd thagghL ,ttpU rkdghLfisAk xdwpizggjd %yk ngwyhk.

$$f' = \left(\frac{v + v_L}{v - v_s}\right) f$$

,qF ehk gadgLjjpAss Fwpalk kugpy> xypdk myyJ Nflgth xdiw Nehffp kwnwhdW efUk NghJ v_s kwWk v_L Mfpait NehfFwp kjpgGfisg ngWfpdwd. mtthNw> xypdk myyJ Nflgth xdiw tplL kwnwhdW tpyfpr nryYk NghJ mit vjphfFwp kjpgGfisg ngWfpdwd.

xypdk %yjjpwFk NflgtUfFkpilNa rhhgpaffk fhzggLk gyNtW #oepiyfspy NflLzh mjphntz zpwfhd thagghLfs njhFjJ mspffgglLssd.

Xypapd Ntfjjpy VwgLk khWghL (xypdk xatpYk Nflgth efUk NghJ) myyJxypapd miyesjjpy VwgLk khWghL (Nflgth xatpYk xypdk efUk NghJ) fhuzkhfNtmjphntz khWghL VwgLfpwJ vdgij ftdpggJ Kffpakhfk.

Xypdk kwWk Nflgth vd ,uzLk efUk NghJ>xypapd NtfkhWghL kwWk xypapd miyes khWghL Mfpa ,uzbd fhuzkhf mjphntz khWghL VwgLfpwJ.

Xypia tplNtfkhf xypdk efUk NghJ (mjhtJ #gghrhdpf Ntfjjpy %yk efUk NghJ)> NflLzh mjphntz izf fzffplcjTk rkdghLfs Mfpaitgadglhj. NkYk xypdk %yjjpd KdGwk css epiyahd Nflgtuhy xypia NflfKbahJ. xypdk miyfshdJ %yjjpwF gpdGwk miktNj fhuzkhFk.

,jjifa Ntfqfspy> Gjpjhf cUthFk miyfSk Kd fzjjpy cUthd miyfSk Mfff FWffllL tpistpdhy kpfgnghpa trRld $ba xypia cUthffpdwd. ,ij 'xypKoffk'(sonic boom) myyJ mjphrrpdk miy'(Shock wave) vdfpNwhk.

gyNtW #oepiyfspy NflLzh mjphntz

t.vz;	#oepiy	Nfl;Lzh; mjhntz;
1	epiyahdS– I LefUk NghJ	$f' = \left(\frac{v + v_L}{v}\right) f$
2	epiyahdS– I tplLLtpyfpr nryYk NghJ	$f' = \left(\frac{v - v_L}{v}\right) f$
3	epiyahdL– I NehffpSefUk NghJ	$f' = \left(\frac{v}{v - v_s}\right) f$
4	epiyahdL– I tplLStpyfpr nryYk NghJ	$f' = \left(\frac{v}{v + v_s}\right) f$
5	SkwWk Lxd iwnahdWneUqFk NghJ	$f' = \left(\frac{v + v_L}{v - v_s}\right) f$
6	SkwWk Lxd iwnahdWtpyfprnryYk NghJ	$f' = \left(\frac{v - v_L}{v + v_s}\right) f$
7	L– I SJujJk NghJ	$f' = \left(\frac{v - v_L}{v - v_s}\right) f$
8	S– I LJujJk NghJ	$f' = \left(\frac{v + v_L}{v + v_s}\right) f$
9	SkwWk Lxd iwnahdWneUqFfpdwd›NkYk xypapd jpirapy V_mNtfj Jld Clfk ,aqFk NghJ	$f' = \left(\frac{(v + v_m) + v_L}{(v + v_m) - v_s}\right) f$

Xypapy VwgLk lhgsh tpisTrkrrh jdikawwJ. mNj Ntis› xspapy VwgLk lhgsh tpisT rkrrh jdik nfhzlJ. epiyahd Nflgtiu Nehffp xyp %yk efUk NghJ VwgLk NflLzh mjhntz kwWk epiyahd xyp %yjij Nehffp mNj Ntfjjpy Nflgth efUk NghJVwgLk NflLzh mjhntz Mfpaitrkkhf ,Uggjpyiy. ,ttpUepfoTfspy rhhGNtfk xdwhf ,UejNghjpYk› NflLzh mjhntz nttNtwhf cssJ. MfNt xspapy VwgLk lhgsh tpisTrkrrh jdikawwJ vdfpNwhk. xyp gutYfF Clfk Njit vdgJ Clfjijg nghUjJmjd Ntfk mikfpwJ vdgNjfhuzk MFk.

Xspkwwk gpwkpdfhejf fjhtrRfisg nghUjjtiu ,ttpU NehTfspy NflLzh (myyJfzLzh) mjhntz xdwhfNt ,UfFk. MfNtxspkwWk gpwkpdfhejf fjhtprRfspy VwgLk lhgsh tpisT rkrrh jdiknfhzLssJ. Vnddpy xspapd gutY Clfjijg nghUjJ miktjpyiy.