PHYSICS
TEST – 6

11th physics	myF– 3	,af;f tpjpfs;
	myF– 4	Ntiy> Mwwy; kwWk; jpwd; -F

nghUslf;fk;

,awgpay;

myF 3 ,af;f tpjpfs;

mwpKfk;

gpugQrjjpy csss xtnthU nghUSk> kww nghUlfSld njhlhG nfhzLssd. Fspnej njdwy kujJld njhlhG nfhzLssJ> kuk kzZld njhlG nfhzLssJ. RUqff$wpd midjJ capupdqfSk ,awifAld njhluG nfhzLssd. kww capupdqfs ,awifAld nfhzLss njhluigtpl> kdpj ,dk ,awifAld nfhzLss njhluG nfhQrk NtWglljhFk. Vnddpy kdpj ,dk ,awif epfoTfis GhpeJ nfhzL mtwiw mwptpay Kiwapy tpsff KwgLfpwJ.

kdpj ,d tuyhwwpy kdpjdhy kpFej MhtKld Nflfggll mwptpay Nfstpfs ,aqFk nghUlfisg gwwpaJ MFk. mit “nghUlfs vtthW ,aqFfpdwd?” “nghUlfs Vd ,aqFfpdwd?” vdgd Nghdwit.

Mrrhpak vddntdwhy ,ej vspa Nfstpfsjhd kpdj ,djij gzila ehfuf fhyjjpypUeJ 21 Mk E}wwhzbd njhopyElg fhyfllljjpwF tUtjwF ghij mikjJf nfhLjjJ.

xU nghUs efuf fhuzk xdW mij ,OffpwJ myyJ jsSfpwJ. cjhuzkhf> Gjjfk xdW XaT epiyapy cssJ. ntspgGw tpir mjd kJ nraygLhjtiu mJ efuhJ. RUqff$wpd nghUlfis efu itff fllhak mdj kJ xU tpir nraygl NtzLk. 2500 MzLfSfF Kddu Gfo ngww jjJtQhdp mupl]lhlby (Aristotle) tpir ,affjij VwgLjJfpwJ vdW $wpdhh. Mthpd $wW nghJgGhpjypd (Common sense) mbggilapy mikejpUejJ. Mdhy mwptpay $wWfs vdgJ nghJgGhpjypd mbggilapy klLk mikejpUff KbahJ. khwhf mwptpay Nrhjidapd mbggilapy midtuhYk xgGfnfhssggl NtzLk. 15 Mk E}wwhzby> fypyNah njhlhrrpahf Nkwnfhzl Nrhjidfspd mbggilapy ,affk gwwpa mhpl]lhlbypd $wwpid kWjjhu. xU nghUs njhlheJ ,aqFtjwF tpir mtrpakpyiy vdW fypyNah xU Gjpa fUjjpid Kdnkhopejhu.

fypyNah ,affk gwwpa jdDil fUjij> xU vspa Nrhjid%yk tpsffpdhh. mrNrhjidapdgb> glk 3.1 (a) tpy fhlbAssgb geJ xdW Fwpggll NfhzKila rhajsk xdwpd NkwGwjjpypUeJ cUzL fNo tUfpwJ. Mjd jiuia mileJ rpwpJ J}uk cUzL nrdW vjpNu csss mNj NfhzKila kwnwhU rhajsjjpd topNa cUzL NkNy VWfpwJ. rhajwqfis edF tOtOgghfpa gpddh ,rNrhjidia kzLk epfojJk NghJ geJ Kjy rhajsjjpy vttsT caujjpypUeJ (L1) cUzL fNo tejNjh mNj cajjpwF ,uzlhtJ rhajsk topahf NkNy cUzL fypyNahtpd rhajsk kwWk geJ Nrhjid (a) ,uzL rhajsqfSk xNu rhaNfhzjjpy csNghJ (b) rhajsggugpd tOtOgGjjdikia mjpfhpjj gpddu (c) ,uzlhtJ rhajsjjpd rhaNfhzjijf Fiwjj gpdgh (d) ,uzlhtJ rhajsjjpd rhaNfhzjij Ropahffpa gpddh nryfpwJ (L2). (glk 3.1) (b)),uzlhtJ rhajsjjpd Nfhzjijf FiwjJ (glk 3.1 (c)) mNj tOtOgGld ,rNrhjidia kzLk epfojJk NghJ> geJ ,uzlhtJ rhajsjjpy rwNw mjpf J}uk cUzL nrdW vttsT caujjpypUeJ teNjh mNj caujij nrdwilfpwJ.

RhaNfhzjij RopahfFk NghJ geJ fpiljjsj jpirapy vdnwdWk njhlheJ nrdW nfhzNl ,UfFk (glk 3.1 (d)).

xU Ntis mu]lhlby ,affk gwwa fUjJ czikahf ,Ugg› vttsT tOtOgghd rhajskhf ,UejhYk mejg geJ filjjsj jiray cUzL nrdwUffhJ. Vndd› filjjsjjiray vttjkhd tirAk nrayglty iy.

,ej vsa Nrhjid %yk fyyNah ,affk njhlueJ eilngw tir mtrakyiy vdW e&gjJf fhlbdhh. VdNt› tirnayglhj eiyaYk nghUsdhy njhlheJ ,aqf KbAk.

RUqff $wd› mu]lhlby ,affjNjhL tiraid ,izjjhh Mdhy fyyNah› ,affjjid tiraiyUeJ jdNa ghjjhh.

eAlldd tjjfs:

fyyNah› nfgsh kwWk Nfhgueff] Nghdw mwtay mwQhfsd ,affk gwwa fUjJffis gFjJ MuhaeJ› ,affk gwwa Mokhd Gujiy eAlld jdJ %dW tjfsd tbtiy VwgLjjdhh.

eAlldd Kjytjj:

xU nghUsdkJ ntsgGw tir xdW nrayglhjtiu mJ› jdJ XaT eiyaNyh myyJ khwhjjirNtfjjYss ruhd ,aff eiyaNyh njhlueJ ,UfFk. nghUnshdwd. jhNd ,aqf Kbahjj jdik myyJ jdJ ,aff eiyiaj jhNd khwwfnfhss ,ayhjjjdikfF eiykk vdW ngau. eiykk vdwhNy nghUs jdJ eiyia khwWtij vjhfFk jdik vdW mioffyhk. ,affr #oYfF Vwg eiykjjid %dW tiffshfg ghffyhk.

(1) Xatd eiykk:

XaT eiyaYss NgUeJ xdW ,aqfjnjhlqFk NghJ mgNgUejy css gazfs eiykjjd fhuzkhf jBnudW gdNdhffj jssggLfdwdh. Vnddy gazad cly eiykggzgd fhuzkhf njhlueJ XaT eiyaNyNa ,Uff KayfwJ. Mdhy NgUeJ ,aqfj njhlqFfwJ. ,jd fhuzkhfNt gazfsd cly gdNdhffj jssggLfwJ.

Xatd eiykggzgd fhuzkhf gazfs gdNdhffj jssggLjy

jdJ XaT eiyiaj jhNd khwwfnfhss ,ayhj nghUsd jdik› Xatd eiykk vdggLk.

(2) ,affjjy eiykk:

,affjjYss xU NgUejd jilia (Brake) jBnudW mOjJkNghJ› NgUejy css gazfs eiykjjd fhuzkhf KdNdhffj jssggLfdwdu. Vnddy› gazayd cly eiykggzgd fhuzkhf njhlueJ ,aff eiyaNyNa ,Uff KayfwJ. Mdhy NgUeJ XaTeiyfF tuj njhlqFfwJ.

khwhjjir NtfjjYss xU nghUs jdJ ,aff eiyiaj jhNd khwwfnfhss ,ayhjjdik› ,affjjy eiykk vdggLk.

,affjjy eiykggzgd fhuzkhf gazfs KdNdhffj jwwggLjy

(3) ,affj jiray eiykk:

xUKiday fy fllggll› Rowr ,affjjYss fyyd faW jBnudW mWgllhy› fy njhlueJ tllgghijay Rww KbahJ. mffy ,y fhlbAssthW tlljjd njhLfNfhlLgghijay nryYk. Vnddy ntsgGwtir nrayglhjtiu nghUsdhy jhNd jdWila ,affjjiria khwwfnfhss ,ayhJ.

Rowr ,affjjy ,Uej› fawwyUeJ mWgll fy eiykggzgd fhuzkhf njhLNfhlLgghijay nryYjy.

jdJ ,affjjiraidj jhNd khwwfnfhss ,ayhj nghUsd jdik› ,affjjiray eiykk vdggLk.

nghUnshdwd XaTeiy myyJ khwh jirNtfjjYss ,aff eiyia Fwgghak ,dw $wdhy mJ nghUswwjhftLk. vdNt› ,awgay midjJ ,affqfSk Fwgghajij nghUjNj tiuaWff NtzLk. eiykfFwgghak vdw xU rwgGf FwgghajjwF klLNk eA+lld Kjytjia gadgLjj KbAk. czikay eA+lldd Kjytj eiykf Fwgghajijjhd tiuaWffwJ

eiykf; Fwgghaq;fs; (Inertial frames)

eiykf FwgghajjyUeJ ghufFkNghJ vttj tirAk nraygl hj xU nghUshdJ XaT eiyaNyh myyJ khwhjir Ntfk nfhzl ruhd ,aff eiyaNyh fhzggLk. vdNt eiykfFwgghak vdw xU rwgGf Fwgghajjy css nghUs vttj tirAk mjdkJ nraygl hj eiyay khwhjjirNtfk nfhzl ,aff eiyaNyh myyJ XaT eiyaNyh fhzggLk. Mdhy xU nghUs tiria czhfwjh ,yiyah vdgij ehk vtthW mwtJ? GtaYss midjJg nghUlfSk GtaugG tirai czUk. ,ylra eiyay xU nghUs Gt kwWk gw nghUlfis tlL ntFnjhiyty cssNghJ klLNk tirfsww eiyia (Free body) milAk. mgnghUSfF eA+lld Kjytj KOikahfg nghUeJk. ntFnjhiyty css mggFjia eiykf Fwgghakhff fUjyhk. Mdhy eilKiway ,J Nghdw eiykf Fwgghak rhjakwwJ. eilKiway Gtaid ehk xU eiykfFwgghakhff fUjyhk. Vnddy Matjjy Nkir kJ itffggll Gjjfk vgNghJk XaT eiyaNyNa cssjhf fUjggLfwJ. mgnghUs vgNghJk filjjsjjiray KLffkiltjyiy. Vnddy filjjsjjiray mjdkJ vttjkhd tirAk nraygLtjyiy. vdNt› midjJ ,awgay MaTfs kwWk fzffLfSfF Matfjjid xU eiykfFwgghakhff fUjyhk.

ehk ,ej Kbit vLff nghUsd filjjs ,affjjid klLk fzffy vLjJfnfhzNlhk. Vnddwhy nghUsdkJ filjjsj jiray vej tirAk nraygltyiy. Mdhy ,Nj Kbit vLff ehk nrqFjJj jiray nghUsd ,affjij gFjjhuhaf $lhJ. Vnddy foNehffr nraygLk GtaugG tirAk NkyNehffr nraygLk nrqFjJ tirAk xdiw xdW rkdnraJ nghUis XaTeiyay itffdwd.

vdNt› eA+lld Kjytj tirfsww nghUsd ,affjij MuhafwNj jtu nrygLk tirfsd njhFgad kjgG Rohahf css nghUlfsd ,affjij Muhatjyiy.

eiykf Fwgghajijg nghUjJ khwhj jirNtfjJld nryYk ,uay tzb xdiwffUJf. ,uaytzbfF ntsNa eiykfFwgghajijg nghUjJ XaTeiyaYss nghUs› ,uay tzbfF csNs mkuejUfFk gazfF› ,uay tzbiag nghUjJ khwhjjir NtfjJld ,aff eiyay ,UggJNghdW njhAk. Vnddy ,qF ,uay tzb eiyikf Fwgghakhff fUjggLfwJ.

midjJ eiykf FwgghaqfSk xdiwg nghUjJ kwnwhdW khwhjjirNtfjJld ,aqFfwJ.

xU e¤iykf Fw¡gghajj¤y XaT e¤iya¤y cssJ NghdW NjhdWk xU nghUs› kwnwhU e¤iykf Fw¡gghajijg nghUjJ khwhj j¤ir NtfjJld ,aff e¤iya¤y ,UggJ NghdW NjhdWk. jiua¤y e¤dW nfhzbUfFk xU egiug nghUjJ› V vdw khwhj¤ir Ntfjj¤d thfdk xdW nrdW nfhzbUff¡wJ. jiua¤y e¤dW nfhzbUfFk kd¤jDk› mtidg nghWjJ khwhj j¤irNtfjj¤y nrdW nfhzbUfFk thfdk ,uzLNk e¤iykf Fw¡gghaqfs MFk.

kd¤jd kwWk thfdk ,uzLk e¤iykfFw¡gghaqfs

khwh j¤irNtfjj¤y nrdW nfhzLss ,ua¤y tzba¤d csNs tOtOgghd Nkir kJ itffgglLss nghUs xdiwf fUJf. ,ua¤y tzb j¤BnudW KLffkilAkNghJ vtt¤jkhd t¤irAk nrayglhj e¤iya¤y Nkir kJss nghUs vj¤hjj¤ira¤y KLffkiltJ NghdW NjhdWk. ,J e¤A+ld¤d Kjy t¤j¤fF Kww¡Yk vj¤uhf cssJ. Vndd¤y› vtt¤j t¤irAk nrayglhj e¤iya¤y nghUs KLffkilf¡wJ.

,j¤y¡UeJ ehk GhpeJ nfhssNtzba czik vddntd¤y› ,ua¤ytzb KLffkilAkNghJ mJ xU e¤iykf Fw¡gghak myy. vLjJffhllhf› glk 3.6 ,y fhllgglLss jiuiag nghUjJ *a* KLffjJld nryYk ,uzlhtJ thfdk e¤iykfFw¡gghak myy. khwhf mJ e¤iykkwwf Fw¡gghak (Non-inertial frame) MFk.

e¤iykkwwf Fw¡gghak (a KLffjJld nryYk thfdk 2)

,ttifahd e¤iykkww Fw¡gghaqfSfF KLffggll Fw¡gghaqfs (accelerated frames of references) vdw ngau. RoYk Fw¡gghaqfSk KLffggll Fw¡gghaqfNs› Vndd¤y› Rowr¤ ,affjj¤wF KLffk mtr¤akhFk. ,ffUjj¤dgb› Gt¤ czika¤y xU e¤iykf Fw¡gghak myy. Vndd¤y Gt¤fF jwRowr¤ kwWk estllr Rowr¤ vdw ,U ,affqfs cssd

eilKiwa¤y fhzggLk r¤y nghJthd ,affqfSfF Gt¤a¤d Rowr¤a¤dhy VwgLk t¤iwTfisg Gwffz¤ffyhk. cjhuhzkhf vw¡nghUs¤d ,affk› Matfk xdw¡y fzff¤lggLk jd¤ Cry¤d miyT Neuk Nghdwtww¡y Gt¤a¤d jwRowr¤ t¤isTfs¤d jhffk Gwffz¤ffjjff mst¤NyNa fhzggLk. vdNt› ,jjifa NeuTfs¡y fUjyhk. Mdhy mNj Neujj¤y nrawiffNfhs xdw¡d ,affk kwWk Gt¤a¤d fhwW NkyLfFr Rowr¤ Nghdw e¤foTfs¡y Gt¤a¤id xU e¤iykf Fw¡gghakhff fUj ,ayhJ. Vnddh¡y Gt¤a¤d jwRowr¤ ,tww¡d kJ ty¤ikahd jhffjij VwgLjJf¡wJ.

e¤A+l¡ld¤d¡ ,uz¡lhk¡ t¤jj¤:

xU nghUs¤d kJ nraygLk t¤irahdJ mejg nghUs¤d cej khWghlL tjj¡wF rkkhFk.

$$\vec{F} = \frac{d\vec{p}}{dt}$$

RUqff $w¤d› vgnghOnjyyhk xU nghUs¤d cejjj¤y khwwk VwgLf¡wNjh› mgnghOnjhyyhk mgnghUs¤dkJ t¤ir nraygLf¡wJ. nghUs xdw¡d cejk vd $\vec{p} = m\vec{v}$ tiuaWffggLf¡wJ. nghUlfs ,aqFkNghJ ngUkghyhd Neuqfs¡y mjd e¤iw khwhky xU khw¡y¤ahfNt ,Uff¡wJ.

mjjifa e¤foTfs¡y Nkwfzl rkdghL gpdtUk vs¤a tbt¤idg ngWf¡wJ.

$$\vec{F} = \frac{d\left(m\vec{v}\right)}{dt} = m\frac{d\vec{v}}{dt} = m\vec{a}$$

$$\vec{F} = m\vec{a}$$

nghUs vgnghOnjhyyhk KLffkilfwNjh› mgnghOnjyyhk mjdkJ xU tpir nraygLfwJ vdw czikia Nkwfzl rkdghL ekfF czujJfwJ. tpir $\vec{F}$ kwWk KLffk $\vec{a}$,uzLk vgnghOJk xNujpiray nraygLk.

epAlldpd ,uzlhk tpjp vdgJ mupjlhlbypd ,affk gwwpa fUjjpypUeJ mbggilapNyNa NtWglljhFk. epAllidg nghWjjtiu ,affjjpid VwgLjj tpir mtrpakpyiy. khwhf ,affjjpy xU khwwjij VwgLjjjjhd tpir Njitggl fwJ. epAlldpd ,uzlhk tpjpia ehk epiykf Fwpgghaqfspy klLNk gadgLjj Ntzlk vdgij epidtpy nfhss Ntzlk.

KLffggll Fwpgghaqfsfl epAlldpd ,uzlhk tpjpia ,Njtbtpy gadgLjj KbahJ› rpy khwwqfs Njitggl k.

SI myF Kiwapy tpiraid myF epAlld. ,jd FwpaL N MFk.

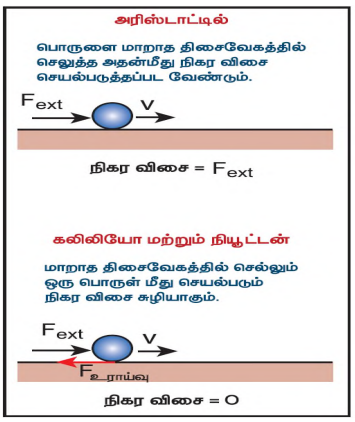
1 kg epiwAila nghUspdkJ xU tpir nrayglL› mej tpiraid jpirNyNa 1 m s^{-2} KLffjij VwgLjjpdhy mttpiraid msNt xU epAlld vdggLk.

rWfpfpr; nrypYk; nghUlfs; gwwpa mupjlhlbyp kwWk epAlldpd fUjJ:

gphT 3.1 ,y tpthjpffggll rhajsk kwWk geJ Nrhjidffhd rhpahd tpwffjjpid epAlldpd ,uzlhk tpjp toqFfwJ. mej Nrhjidapy cuhatpidf fzffpy vLjJfnfhsSkNghJ geJ rhajsjjpd mbggugig milejTld rpwJ J}uk cUzL gpdG XaT epiyia milfwJ.

,jwFf fhuzk gejpd jpirNtfjjpwF vjpuhd jpiraypy xU cuhaT tpir nrayglL gejpid XaT epiyfFf nfhzLtUfwJ. ,tTuhaT tpirjhd jpirNtfjijg gbggbahff FiwjJ mjid Ropahffp nghUspd ,affjij epWjJfwJ. Mdhy mupjlhlbypd fUjJggb› nghUs rhajsjjpd mbggugig milej cld rpwJ J}uk cUzL nrdW gpddu XaT epiyfF tUk. Vnddpy mgnghUspd kJ vttpjkhd tpirAk nrayglt pyiy.

mbggilapy mupjlhlby nghUspd kJnraygLk cuhaT tpiria Kwwpykhfg Gwffzpjj tpllhu.



nghUlfspd ,affk gwwpa mupjlhlby› fypypNah kwWk epAlldpd fUjJffs

e¤A+l¡ld¤d¡ %dwhk¡ t¤j¤:

a i t f fUJf. vgngh Onjyyhk xU nghUs (1) ,dndhU nghUs¤d (2) kJ xU t¤iriar nrYjJf¤wNjh ($\vec{F}_{21}$)› mgngh Onjyyhk mej ,uzlhtJ nghUSk (2) mtt¤irfFr rkkhd› vj¤uj¤ira¤y nraygLk xU t¤iria ($\vec{F}_{12}$) Kjy nghUs¤d kJ nrYjJk. ,ttuzL t¤irfSk ,U nghUlfisAk ,izfFk Nfhlbd to¤Na nraygLk.

$$\vec{F}_{12} = -\vec{F}_{21}$$

t¤irfs rkkhfTk› vj¤hNrhbfshfTk (opposite pair) NjhdWk vdgij e¤A+lld¤d %dwhk t¤j¤ cWj¤ggLjJf¤wJ. jd¤jj t¤ir myyJ xNunahU t¤ir vdgJ ,awifa¤y NjhdWtj¤yiy. e¤A+lld¤d %dwhk t¤j¤ggb› vejnthU nray t¤irfFk (action force) rkkhd vj¤h nray t¤ir (reaction force) czL. khwhf› nttNtW nghUlfs¤d kJ nraygLf¤dwd. VNjDk xU t¤iria nray t¤ir vdW miojjhy kwnwhdiw vj¤urnray t¤ir vdW mioff NtzLk. e¤A+lld¤d %dwhk t¤j¤ e¤iykk kwWk KLfFt¤ffggll ,ttuzL Fw¤gghaqfSfFk nghUeJk.

,rnray - vj¤hrnray t¤irfs fhuzk kwWk t¤isT (cause and effect) tiffs myy. vtthnwd¤y› Kjyngh Us ,uzlhtJ nghUs¤d kJ xU t¤ira¤idr nrYjJk mNj fzjj¤y ,uzlhtJ nghUs Kjy nghUs¤d kJ rkkhd vj¤ut¤iriar nrYjJk.

e¤A+lld¤d %dwhk t¤j¤ffhd nray t¤sffk

(a) Rjj¤ahy kwWk Mz¤
(b) Rtww¤y glL g¤dNdhff¤ tUk geJ
(c) cuhaTld jiua¤y eljjy

e¤A+l¡ld¡ t¤j¤fs¡ gw¤wa xU ciuahly¤:

1. e¤A+lld t¤j¤fs ntflu t¤j¤fshFk. $\vec{F} = m\vec{a}$ vdgJ xU ntflu rkdghL MFk. mbggila¤y ,rrkdghL %dW]Nfyu rkdghLfSfF ,izahdjhFk. fhuBr¤ad Maf$Wfs¤d mbggila¤y ,jid foffzlthW vOjyhk.

$$F_x\hat{i} + F_y\hat{j} + F_z\hat{k} = ma_y\hat{j} + ma_z\hat{k}$$

,UGwKk ntflu $Wfis xgg¤LkNghJ ekfFf f¤ilfFk]Nfyu rkdghLfs g¤dtUkhW

$F_x = ma_x$. ,qF x mrRjj¤ira¤y VwgLk KLffk (a_x)› t¤ira¤d x mrRf$w¤id ($F_x$) klLNk rhuejjhFk.

$F_y = ma_y$. ,qF y mrRjj¤ira¤y VwgLk KLffk (a_y)› t¤ira¤d y mrRf $w¤id ($F_y$) klLNk rhuejjhFk.

$F_z = ma_z$. ,qF z mrRjj¤ira¤y VwgLk KLffk (a_z)› t¤ira¤d z mrRf $w¤id ($F_z$) klLNk rhuejjhFk.

Nkwfzl rkdghLfs¤y¤UeJ ehk mw¤a Ntzbaj vddntd¤y› y j¤ira¤y nraygLkt¤ir› x j¤ira¤y VwgLk KLffjij vtt¤jj¤Yk gh¤jffhJ. mNjNghdW F_z

MdJ a_y kwWk a_x I vttjjYk ghjffhJ. ,ejgGujy fzfFfisj jhT fhzgjy Kffa gqfhwWfwJ.

2. xU FwggIl Neujjy (t)› nghUs milAk KLffk› mNj Neujjy mgnghUsd kJ nraygLk tiraid kILNk rhuejJ. meNeujjwF (t) Kddu nraygIl tirdg nghUjjjyy. ,jid gdtUkhW vOjyhk.

$$\vec{F}(t) = m\vec{a}(t)$$

nghUsd KLffk› flejfhy tiriar rhuejjyy. vLjJffhIlhf fufnfl tiahIby RowgeJ myyJ ntfggeJ trrhsuhy trggIl geJ mthd fujij tIL tLgIl gdG GtaugG tir kwWk fhwwd cuhaT tir ,itfis kILNk czUk. ,eeiyay gejd KLffk mJ vtthW (vttsT Ntfkhf myyJ nkJthf) trggIlJ vdgijg nghUjjjyy.

3. nghJthf nghUsd ,affk tirad jirayUeJ khWgIL mikayhk. Ry Neuqfsy tirad jiraNyNa nghUs ,aqfdhYk› nghJthf ,J czikayy. mjwfhd ry cjhuzqfis fNo fhzyhk.

NeuT (1): tirAk ,affKk xNu jiray:

Mggs› Gtaid Nehff tOkNghJ Mggsd ,affj jirAk (jir NtfKk)› Mggsd kJ nraygLk Gt<hgG tirAk xNu foNehffa jiray mikeJssJ. ,J (a) ,y fhIlggILssJ.

(a) tir kwWk ,affk xNu jiray

NeuT (2) tirAk ,affKk nttNtW jirfsy:

eyh Gtaid Nehff xU tiria czufwJ Mdhy› eyh Gtia xU estIlgghijay Rww tUfwJ. ,eefoty ,affjd jir tirad jirayUeJ khWgIL cssij (b) ayUeJ mwayhk.

(b) tir kwWk ,affk nttNtW jirfsy (Gtia estIlgghijay RwwtUk eyh)

NeuT (3) tirAk ,affKk vjnujh jiray:

nghUs xdiw nrqFjjhf Nky Nehff vwAkNghJ ,aff jir Nky NehffAk› nghUsd kJ nraygLk GtaugG tirad jir foNehffAk nraygLk. ,J (c) ,y fhIlggILssJ.

(c) tirAk› ,affKk vjnujuhf

NeuT (4) Ro efu tirAk nghUsd ,affk:

NkfjjyUeJ tLgIl kiojJs xdW foNehffr nraygLk GtaygG tir kwWk Nky Nehffr nraygLk fhwwd ,Otir ,ttuzL tirfisAk czhfwJ. kiojJs fo Nehff tUk NghJ fhwwd ,Otir (ghfay tir) mjfhjJf nfhzNl nrdW xU eiyay foNehffr nraygLk GtaugG tiria rkdnraJtLk. MffzjjyUeJ kiojJs jiuay tOkgtiu khwhjjir NtfjJId tUfwJ. vdNt

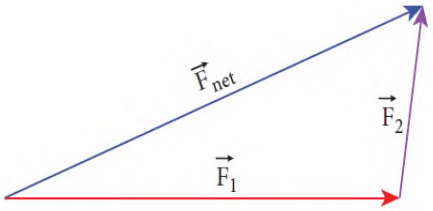
kiojJs Ro eufu tirAlDk Mdhy roaww Kwwjjir NtfjJlDk (terminal velocity) jiuia milfwJ. ,J (d) ,y fhllgglLssJ.

(d) Roeputir kwWk Roaww KwWjjir NtfjJld jiuia milAk kiojJs

4. gyNtW tirfs

1) $\vec{F}_1, \vec{F}_2, \vec{F}_3 \ldots \vec{F}_n$ tirfs xU nghUsd kJ nraygLk NghJ› mgnghUsd kJ nrygLk efutir ($\vec{F}_{net}$) jdjjd tifsd ntflu $LjYfFr rkkhFk. mej efu tir ($\vec{F}_{net}$) nghUsd kJ KLffjij VwgLjJk.

$$\vec{F}_{net} = \vec{F}_1, \vec{F}_2, \vec{F}_3 \ldots \vec{F}_n$$



$$\vec{F}_1 + \vec{F}_2 = \vec{F}_{net}$$

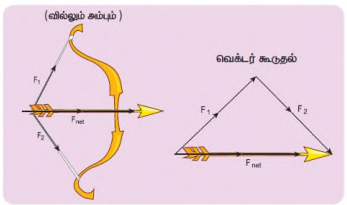
,uzL tirfsd ntflu $Ljy

$$\vec{F}_{net} = m\vec{a}$$

,jjifa Neutfsy eA+lldd ,uzlhk tjpia foffzlthW vOjyhk

KLffjjd jpir› efu (net) tiradd jpiray ,UfFk

vLjJffhlL: tpyYk mkGk



tpy kwWk mkG-efu tir mkgd kJ cssJ.

2) eA+ld ,uzlhk tjpia gdtUk tbtYk vOjyhk Vnddy KLffnkdgJ nghUsd ,gngaurr ntfludd ,uzlhkgb tifnfO MFk. $\vec{a} = \frac{d^2\vec{r}}{dt^2}$, vdNt nghUsd kJ nraygLk tir gdtUkhW vOjggLfwJ.

$$\vec{F} = m\frac{d^2\vec{r}}{dt^2}$$

,rrkdghlbypUeJ ehk mwpeJnfhstJ eA+lld ,uzlhk tjpahdJ mbggilay xU ,uzlhkgb tiffnfOr rkdghlhFk. vgnghOnjyyhk ,lgngaurr ntflud ,uzlhk

tiffnfO Ro¡ayyhj kj¡gg¡id ngWf¡wNjh mgnghOnjyyhk nghUs¡d kJ t¡ir nraygLf¡wJ. nghUs¡d kJ vtt¡jkhd t¡irAk nrayglhj e¡iya¡y e¡A+lld¡d ,uzlhk t¡j¡> $m\frac{d^2r}{dt^2}=0$ mjhtJ nghUs khwhjjj¡ir NtfjJld (v=khw¡y¡) ,aqFf¡dwJ vdW ekfF czujJf¡wJ. ,j¡y¡UeJ e¡A+lld¡d ,uzlhk t¡j¡> Kjyt¡j¡NahL ,ayghfg nghUeJtij ehk czuyhk. MdhYk xNu nghUs¡d kJ vej t¡irAk nrayglhj NghJ e¡A+lld¡d ,uzlhk t¡j¡ahdJ Kjy t¡j¡ahf khWf¡wJ vdW ehk fUjf$lhJ. e¡A+lld¡d Kjy t¡j¡ kwWk ,uzlhk t¡j¡ ,t¡t¡uzLk xdiwnahdW rhuhj t¡j¡fshFk. mit ,ayghf xdWld xdW nghUeJf¡dwd. Mdhy xdw¡y¡UeJ kwnwhdiw jUt¡ff ,ayhJ (cannot derived from each other).

7. e¡A+lld¡d ,uzlhk t¡j¡ fhuzk kwWk t¡isT tifiar rhuejJ. t¡ir xU fhuzk vd¡y KLffk mjwfhd t¡isT MFk. kuGggb rkdghlbd ,lJif gffk› t¡isitAk vOj Ntz Lk. vdNt e¡A+lld¡d ,uzlhk t¡j¡a¡d rh¡ahd tbtk $m\vec{a}=\vec{F}$ myyJ $\frac{d\vec{p}}{dt}\vec{F}$

e¡A+l¡ld¡ t¡j¡fs¡d¡ gadghL:

jd¡j¡j nghUs¡d¡ t¡irgglk¡ (Free Body Dragram)

jd¡jj nghUs¡d t¡irgglk vdgJ e¡A+lld t¡j¡fisg gadgLjj¡ nghUs¡d ,affjj¡id gFjjw¡ag gadgLk xU vs¡a Kiwahfk. jd¡jj nghUs¡d t¡irggljij cUthfFk NghJ fofzl new¡Kiwfis tu¡irggb g¡dgww Ntz Lk. mit

1. nghUs¡d kJ nraygLk t¡irfisf fzlw¡a Ntz Lk.

2. nghUis xU Gss¡ahff Fwgg¡l Ntz Lk.

3. nghUs kJ nraygLk t¡irfisf Fwgg¡Lk ntflufis tiua Ntz Lk. jd¡jj t¡irgglk tiuAkNghJ nghUlfs VwgLjJk t¡irfis gljj¡y Fwgg¡lLf fhllf$lhJ vdgijf ftdjj¡y nfhssTk.

vLj¡Jf¡fhl¡L.

m e¡iwAss Gjjfk xdW Nkir xdw¡d kJ XaT e¡iya¡y cssJ.
1. Gjjfjj¡d kJ nraygLK t¡irfs ahit?
2. gjjfk nrYjJk t¡irfs ahit?
3. Gjjfjj¡d t¡irggljij tiuf.

ju¡T

1) Gjjfjj¡d kJ ,uzL t¡irfs nraygLf¡dwd. mit
i. fo¡Nehff¡r nraygLk Gt¡<hgG t¡ir (mg).
ii. Gjjfjj¡d kJ Nkira¡d gugG VwgLjJk nrqFjJ t¡ir (N). ,J Nky Nehff¡aj¡j¡ira¡y nraygLk.

2) e¡A+lld¡d %dwhk t¡j¡ggb› Gjjfk ,uzL vj¡ht¡irfisj jUf¡wJ.

i. Gt¡augG t¡ir (mg) fF vj¡uhf Gjjfk Gt¡a¡dkJ nrYjJk t¡ir. ,J NkyNehff¡r nraygLk.

ii. Nkira¡d gugGkJ› nrqFjJ t¡ir (N) fF vj¡uhf Gjjfk nrYjJk t¡ir. ,t t¡ir fo¡Nehff¡ nraygLk.

3. Gjjfjjpd jdpjj nghUs tpirgglk NkNy css gljjpy fhllggLLssJ.

vLj;Jf;fhl;L:

2.5 kg kwwk 100 kg epiwAila ,uzL nghUsfspd kJk 5 N tpir nraygLfpwJ. xtnthU nghUspd KLffjijf fhzf.

jpUT

epA+lldpd ,uzlhk tpjpggb (vzkjpgG msty) F=ma
2.5 kg epiwAila nghUs ngWk KLffk

$$a = \frac{F}{m} = \frac{5}{2.5} = 2ms^{-2}$$

100 kg epiwAila nghUs ngWk KLffk

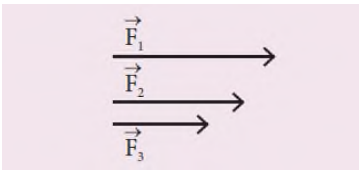
$$a = \frac{F}{m} = \frac{5}{100} = 0.05ms^{-2}$$

Mggps> kujjpypUeJ fNo tpOk NghJ mJ Gtp <ugG tpiria czUk. epA+lldpd %dwthJ tpjpggb Mggpsk ,jwFr rkkhd vjptpiria Gtpapd kJ nrYjJk. ,ttpuzL tpirfSk xdWfnfhdW rkkhf ,Uggpdk mitfs ngUk KLffk nttNtwhdit.

Gtpapd epiw> Mggpsd epiwAld xggpLkNghJ kpfTk mjpfk. epiwAld xggpLkNghJ kpfTk mjpfk. vdNt> Mggps kpf mjpf KLffjijg ngWfpwJ. Mdhy Gtp kpfTk Fiwthd Gwffzpffjff KLffjijNa ngWfpwJ. vdNtjhd Mggps fNo tpOk NghJ Gtp XaT epiyapy cssJ NghdW NjhdWfpwJ.

vLj;Jf;fhl;L.

gljjpy fhllggLLss $\vec{F}_1, \vec{F}_2, \vec{F}_3$ %dW tpirfspy ngUk tpir vJ?



jhT

tpir xU ntflu. xU ntflupd vz kjpgG mjd esjjhy FwpffggLfpwJ. vdNt nfhLffggll ntflufspy $\vec{F}_1$d esk mjpfk vdNt $\vec{F}_1$ ntflu ngUk tpirahFk.

vLj;Jf;fhl;L.

400 g epiw nfhzl khqfha xdW kujjpy njhqfpf nfhzbUffpwJ. epA+lldpd ,uzlhk tpjpiag gadgLjjp khqfhiaj jhqfpAss fhkgpd ,Otpiriaf fhzf.

jpUT

FwpgG: epA+lld tpjpfisg gadgLjJk NghJ gpdtUk fUjJffis ftdKld gpdgww Ntz Lk.

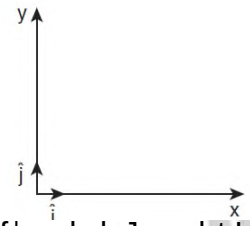
1. nghUjjkhd epiykfFwpgghak xdiwf fUj NtzLk nghJthf Gtpapid xU epiykfFwpgghakhff fUjyhk.

2. epA+lld tpjpfisg gadgLjjj Njitahd mikgigf fzlwpa NtzLk. mttikgghdJ xU nghUs mikgghfNth myyJ xdWfF Nkwgll nghUsfs Nruej mikgghfNth ,Uffyhk.

3. nghUspd kJ nraygLk nraygLk tpirfisf fzlwpeJ mtwiwf nfhzL tpirgglk tiua NtzLk. gpddu epA+lldpd ,uzlhk tpjpia gadgLjj NtzLk. ,lggffk nghUspdp kJ nraygLk tpirfis ntflu tbtpy Fwpggpl NtzLk. tyggffk nghUspd epiw kwwk mgnghUs KLffk ,twwpd ngUffygyid ntflu tbtpy Fwpggpl NtzLk. Vnddpy KLffk xU ntflu msthFk.

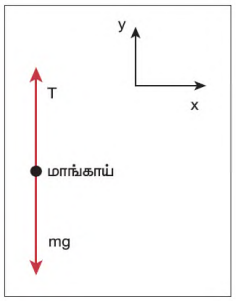
4. KLffk nfhLffgglbUggpd tpiriaf fzlwpayhk. mNj Nghy tpir nfhLffgglbUggpd nghUspd KLffjijf fhzyhk.

NkNy nfhLffgglLss fUjJffspdgb gljjpy fhlbAssthW jiuapy xU epiykf Fwpgghajijf fUj NtzLk.



khqfhapd kJ gpdtUk ,uzL tpirfs nraygLfpdwd.

i. khqfhapd kJ vjhfFwp y mrRjjpirapy fo Nehffp nraygLk Gtpaugg tpir› NeufFwp y mrRjjpirapy nraygLk khqfhiaj jhqfpAss fhkG› khqfhapd kJ nrYjJk Nky Nehffpa ,Otpir. khqfhapd tpirgglk fNo fhllgglLssJ.



$$\vec{F}_g = mg\left(-\hat{j}\right) = mg\hat{j}$$

,qF mg vdgJ Gtpaugg tpirapd vzkjpgG kwWk $\left(-\hat{j}\right)$ vdgJ vjpu Fwp y mrRjjpiriaf FwpfFk XuyFntflu.

$$\vec{T} = T\hat{j}$$

,qF T vdgJ khqfha;d kJ nraygLk ,Ot;ir kwWk $(-\hat{j})$ vdgJ NeuFw; y mrRjj;iriaf Fw;fFk XuyF ntflu

$$\vec{F}_{net} = \vec{F}_g + \vec{T} = -mg\hat{j} + T\hat{j} = (T - mg)\hat{j}$$

e;A+lld ,uzlhk tj;ggb› $\vec{F}_{net} = m\vec{a}$ ekikgnghUjJ (e;iykfFw;gghajij nghUjJ) khqfha XaT e;iya;y cssJ vdNt mjd KLffk Ro; ($\vec{a}$=0)
vdNt› $\vec{F}_{net} = m\vec{a}$=0

$$(T - mg)\hat{j} = 0$$

NkNy css rkdghlbd ,uzLgffqfs;d ntflu $Wfis xgg;LkNghJ T-mg=0 vdff;ilfFk

vdNt› khqfhaf fhkg;d ,Ot;ir T=mg khqfha;d e;iw m=400g NkYk g=9.8ms^{-2}

vdNt khqfha;d kJ nraygLk ,Ot;ir
T=0.4 x 9.8 =3.92 N

vLj;Jf;fhl;L.

,Urffu thfdqfs;y jd;jjd;Na gazk nraAk ,Uth;y› jiuiag nghUjJ khwh j;irNtfjj;y gazk nraf;whh. kwnwhUth jiuia nghJjJ $\vec{a}$ vdw KLffjJld gazk nraf;whh. ,ttuzL gaz;fs;y vejg gaz; e;A+lld;d ,uzlhk tj;jiag gadgLjjyhk?

jh;T:

jiuiag nghUjJ $\vec{a}$ vdw KLffjJld gazk nraAk egh e;A+lld ,uzlhk tj;jia gadgLjj KbahJ. Vnddy; mt e;iykfFw;gghajj;y ,yiy. e;iykfFw;gghajj;y ,yiy. e;iykfFw;gghajj;y css nghUs jhdhf KLffkilahJ. jiuia nghUjJ $\vec{v}$vdw khwhjj;ir NtfjJld gazk nraAk egh e;A+lld;d ,uzlhk tj;jiag gadgLjjyhk Vnddy; mth jiuiag nghWjJ e;iykf Fw;gghajj;y gaz;ffwhh.

vLj;Jf;fhl;L.

Jfnshdw;d e;iy ntflu $\vec{r} = 3t\hat{j} + 5t^2\hat{j} + 7\hat{k}$. vej j;iray;y ,ej Jfs e;fu tj;iria czuf;wJ?

jh;T

Jfs;d j;irNtfk =

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt}(3t)\hat{i} + \frac{d}{dt}(5t^2)\hat{j} + \frac{d}{dt}(7)\hat{k}$$

$$\frac{d\vec{r}}{dt} = 3\hat{i} + 10t\hat{j}$$

Jfsid KLffk

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2} = 10\hat{j}$$

,qF› NeuFwi y mrRjjiray klLNk Jfs KLffkilAk. eiAlld ,uzlhk tijggb efu tiraid jirAk NeuFwi y mrrid jiraiNyNa mikAk. NkYk ,jJfs NeuFwi x mrRjjiray khwhj jirNtfjijg ngwWssJ. Mdhy z mrRjjiray vttij jirNtfjijAk ngwtiyiy. vdNt› x myyJ z jiray vej efu tirAk nraygltiyiy.

vLj¡Jf¡fhl¡L.

elrijjdikaww nkyyia faiW xdwiy flb njhqftilggll CryFzL xdiwf fUJf mjd miyTfs gljjiy fhllgglLssJ.

a) Cry Fzbd kJ nraygLk tirfs ahit?
b) Cry Fzbd KLffjjidf fhzf

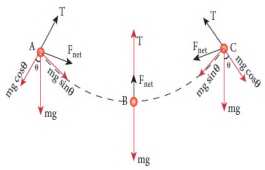
ju¡T:

Cry Fzbd kJ gidtUk ,uzL tirfs nraygLfidwd mit

i. fo Nehffir nraygLk Gti <hgG tir (mg)

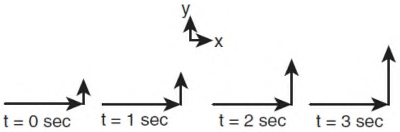
ii. Fzbd kJ E}y nrYjJk ,Otir (T). ,ej ,Otiraid jiria CryFzbd eiy (Position) jukhdiffwJ. mJ gidtUk gljjiy fhllgglLssJ.

gljjiy fhlbAssthW CryFzL xU tlltiy ghijaiy ,aqFfiwJ. vdNt ,J xU ika NehfF KLffjijg ngWk. Cry FzL A kwWk C Gssifsiy fz Neu Xatiy ,UeJ› giddu B Gssia Nehffir nryYkNghJ mjd jirNtfk mjfufFk. vdNt› CryFzL tlltighijaiy xU njhL NfhlL KLffjijg ngWk. fNo css gljjiy fhlbAssthW GtiaugG tiria (*mg* cosq, *mg* sinq) vd ,U$Wfshfg gihffyhk.



vLj¡Jf¡fhl¡L.

jsk xdwiy ,aqFk Jfsid jirNtfk gidtUk gljjiy fhllgglLssJ. Jfs kJ nraygLk tiraid jiriaf fhzf.



jPu;T:

Jfspd jpirNtfk $\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$. glj jpy fhIlggILssJ NghdW Jfs xy jsjjpy ,aqFfpwJ. z mrrpy vttpj ,affKk ,yiy. vdNt v_z=0

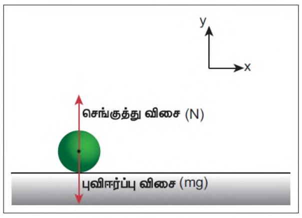
jpirNtfjjpd x $W v_x kwWk y $W v_y vdf. t=0 tpdhbapyUeJ t=3 tpdhbtiu csss Neu ,ilntspapy y mrRjjpirapy ntfluod esk mjpfuoggijf fhzyhk. vdNt y mrRjjpirapy jpirNtfjjpd $W ($v_y$) Neujijg nghUjJ mjpfupffpwJ. epAlldpd ,uzlhk tpjpggb y mrrjjpirapy Jfs xU KLffjjpidg ngWk. vdNt y mrRjjpirapy Jfspd kJ xU tpir nraygLk. x mrRjjpirapy ntfluod esk khwhkjpggidg ngwWssJ. ,jd%yk Jfs x mrrpykhwhjjpirNtfjJld ,aqFtijf fhILfpwJ. vdNt x mrrpy epfu tpir RopahFk.

vLjJf;fhl;Lf:

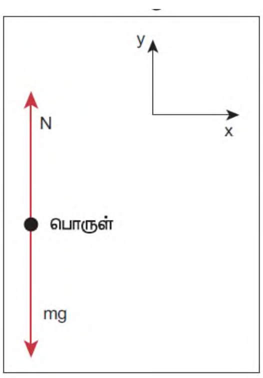
Gtpggugpy XaT epiyapYss nghUs xdWfF epAlldpd ,uzlhk tpjpapidg gadgLjjp mjd %yk ngwggLk KbTfis Muhaf.

jPu;T:

epiykfFwpgghakhff fUjggLk Gtpiag nghUjJ nghUnshdW XaT epiyapy csssJ vdf. mgnghUspd kJ gpdtUk ,uzL tpirfs nraygLfpdwd mitt›



i. vjpufFwp y mrRjpirapy nraygLk Gtpaugg tpir (mg)
ii. NeufFwp y mrRjpirapy nraygLk GtpggugG nghUspd kJ nrYjJk Nky Nehffpa nrqFjJtpir (N). nghUspd tpirgglk gpdtUkhW.



$\vec{F}_g = -mg\hat{j}$

$\vec{N} = N\hat{j}$

njhFgad tpir $\vec{F}_{net} = -mg\hat{j} + N\hat{j}$ gMdhy> nghUs vttpj KLfjijAk ngwtpyiy vdNt $\vec{a}$=0.

epAlld ,uzlhk tpjpggb

($\vec{F}_{net} = m\vec{a}$)

,UGwKk rkdghlbd $Wfis xggpLkNghJ

$(-mg + N)\,\hat{j} = 0$

$-mg + N - 0$

$N = mg$

Nkwfzl rkdghlbypUeJ ehk mwptJ vddntdpy> nghUs XaT tpirapd vzkjpgGk Gtpaugg tpirapd vzkjpgGk xdWfnfhdW rkkhFk.

vLj;Jf;fhl;L.

2kg epiwAila nghUspdkJ gpdtUk ,uzL tpirfs nraygLfpdwd. $\vec{F}_1 = 5\hat{i} + 8\hat{j} + 7\hat{k}$ kwWk $\vec{F}_2 = 3\hat{i} - 4\hat{j} + 3\hat{k}$. nghUspd KLfjijf fhzf.

jtuG:

epAlldpd ,uzlhtJ tpjpggb> $\vec{F}_{net} = m\vec{a}$

,qF $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$.

Nkwfzl rkdghLfspd gb $\vec{a} = \dfrac{\vec{F}_{net}}{m}$

$\vec{F}_{net} = (5+3)\hat{i} + (8-4)\hat{j} + (7+3)\hat{k}$

$\vec{F}_{net} 8\hat{i} + 4\hat{j} + 10\hat{k}$

$\vec{a} = \left(\frac{8}{2}\right)\hat{i} + \left(\frac{4}{2}\right)\hat{j} + \left(\frac{10}{2}\right)\hat{k}$

$\vec{a} = 4\hat{i} + 2\hat{j} + 5\hat{k}$

vLj;Jf;fhl;L:

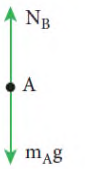
gljjpy fhlbAss A,B kwWk C vdw fdr nrttfjJzLfspd kJ nraygLk tpirfis fhzf.

fdr;nrt;ttfj;Jz;L A apd; kJ nraygLk; tpirfs;:

i. Gtp VwgLjJk foNehffpa <ugG tpir ($m_A g$)

ii. nghUs B VwgLjJk Nky Nehffpa nrqFjJ vjputpir (N_B)
A apd “jdpjj nghUspd tpirg glk fNo fhllgglLssJ.

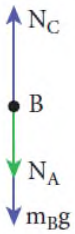
A ன் மீது செயல்படும் விசை



nghUs; B kjhd tpirfs;:

i) foNehffpr nraygLk Gtpaugg tpir (m_Bg)
ii) fdrnrttfj JzL A VwgLjJk foNehffpa tpir (N_A)
iii) fdrnrttfj JzL C VwgLjJk NkyNehffpa tpir (N_C)

Bd kJ nraygLk tpir



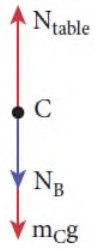
fdrnrt;tfj; JzL C ,d; kJ nraygLk; tpir:

i) foNehffpr nraygLk Gtpaugg tpir (m_Cg)

ii. fdrnrttfj JzL B VwgLjJk foNehffpa tpir (N_B)

iii. Nkir VwgLjJk NkyNehffpa nrqFjJ tpir (N_{table})

C d; kJ nraygLk; tpir



vLj;Jf;fhl;L:

tzbapy fllgglL Fjpiu xdiwf fUJf. Njhlffjjpy mfFjpiu xaT epiyapy cssJ. Fjpiu Kd Nehffp elfffj njhlqFkNghJ› tzb KdNehffp xU KLffjijgngWk. Fh vdw tpirAld Fjpiu› tzbia KdNehffp ,OfFk. mNjNeujjpy epAlldpd %dwhk tpjggb tzbAk› mjwF rkkhd vjpujpirapy

nraygLk ($F_c = F_h$) vdw tpirAld Fjpiuiag gpdNdhffp ,OfFk. vdNt Fjpiu kwWk tzb vdw njhFggpd tpir Ropahf ,UggpDk Vd Fjpiu kwWk tzb KLffkileJ KdNehffp nryfpdwd?

jutT:

,kKuz $wWfFf fhuzk epAlldpd ,uzlhk kwWk %dwhk tpjpfis jtwhf gadgLjJtjwF Kd mikggpd (System) jukhdpff NtzLk.

,tthW mikggpidf fzlwpej gpddu mttikggpd kJ nraygLk midjJ tpirfisAk vspjhff fzlwpayhk. ,qF mikgG VwgLjJk tpirfisf fUjf $lhJ vdgij epidtpy nfhssTk. mikggpd kJ VNjDk rkd nraagglhj tpirfs nrayglhy› mikgG njhFgad tpirapd jpirapyKLffkilAk. gpdtUk fUjJffis thpirggb gpdgwwp Fjpiu kwWk tzbapd ,affjijg gFgghaT nraayhk.

Fjpiu kwWk tzb ,it ,uzilAk xdwhf xU mikgG (system) vdW fUjpdhy Fjpiu› tzbapd kJ nrYjJk vjputpiriaAk fUjf $lhJ. khwhf ,ej ,U tpirfisAk mftpirfshff fUj NtzLk. NkYk epAlldpd %dwhk tpjpggb mftpirfspd njhFggad Rop. Mit mikggpid KLffkilar nraahJ. kJ VwgLk KLffk Gwtpirahy klLNk VwgLk. ehk fUJK ,eepfotpy› rhiyahdJ mikggpd kJ nrYjJk tpir GwtpirahFk. Mikggpd kJ nraygLk midjJ tpirfisAk fUjhky Fjpiu kwWk tzbapd njhFgad tpir Rop vdW fUJtJ jtwhFk. rhiyahdJ› tzb – Fjpiu mikgig KdNdhffpj jsSfpwJ. ntspgGw tpir xdW mikggpd kJ nraygLk NghJ epAlldpd %dwhk tpjpiag gadgLjjhky ,uzlhk tpjpiag gadgLjj NtzLk. gpdtUk glk ,jid tpsfFfpwJ.

Fjpiuia mikgG vdW fUjpdhy› mjdkJ gpdtUk %dW tpirfs nraygLfpdwd.

i) foNehffpr nraygLk Gtpaugp tpir ($m_n g$)
ii) rhiy› Fjpiuapd kJ nrYjJk tpir (F_r)
iii) tzb› Fjpiuapd kJ nrYjJk gpdNdhffpa tpir (F_c)

,it gpdtUk gljjpy fhllgglLssJ. Fjpiuapd kJ nraygLK tpirfs

,aff tpjpfs (Lawa of motion)

F_r – rhiy Fjpiuapd kJ nrYjJk tpir
F_c – tzb Fjpiuapd kJ nrYjJk tpir
$F_r^{\wedge}$ - tpir F_r ,d nrqFjJf $W = N
$F_r^{\square}$ - tpir F_r ,d fpiljjsf $W. (,JNt KdNdhffpa ,affjjpwFk fhuzk)

rhiy› Fjpiuapd kJ nrYjJk tpiria› fpiljjsf$W kwWk nrqFjJf $W vd ,uzlhfggphpffyhk. nrqFjJf$W foNehffpr nraygLk Gtpaugp tpiria rkd nrafpwJ. KdNdhffpa jpirapy nraygLk fpiljjsf $W gpdNdhffpa tpir (Fc) I tpl mjpfk. vdNt KdNdhffpaj jpirapy xU njhFgad tpir nrayglL Fjpiuia KdNdhffp ,afFfpwJ.

tzbia mikgghff fUjpdhy› mjdkJ gpdtUk %dW tpirfs nraygLfpdwd.
i) foNehffpr nraygLk Gtpaugp tpir ($m_c g$)
ii) rhiy› tzbapd kJ nrYjJk tpir (F_r)
iii) Fjpiu› tzbapd kJ nrYjJk tpir (F_h)

,J gpdtUk gljjpy Fwpggpll fhllgglLssJ.

rhiy tzbapd kJ nrYjJk tpiria ($\vec{F}_r$) ,uzL $Wfshfg gpupffyhk. nrqFjJf $W› foNehffpauG tpiria ($m_c$g) rkd nraAk. fpiljjsf$W gpdNdhffpr nraygLk. NkYk Fjpiu› tzbapd kJ nrYjJk tpir ($\vec{F}_r$) KdNdhffpr nraygLk.

,J gpdNdhffpr nraygLk fpiljjsf $iwtpl mjpfk. vdNt. KdNehffpaj jpirapy xU njhFgad tpir fpilfFk. ,jd fhuzkhf tzb KdNdhffp KLffkilAk.

Fjpiu kwWk tzb ,uzilAk xU mikgghff fUjpdhy› ,ttikggpd kJ ,uzL tpirfs nraygLk. mit gpdtUkhW

i. foNehffpr nraygLk Gtpaugg tpir ($m_h + m_c$)g
ii. rhiy› mikggpd kJ nrYjJk tpir (F_r)
,it› gpdtUk gljjpy fhllgglLssd.

iii. ,eepfotpy› rhiy mikggpd kJ VwgLjJk tpiria (F_r) ,U $Wfshfggphffyhk.

iv. rhiy› mikggpd kJ nrYjJk tpirapd rkd nraagglhj fpiljjsf$W› Fjpiu kwWk tzb mikgG KdNdhffpr nrytjwF fhuzkhf mikfpwJ.

nrqFjJf$W Gtpahgg tpir ($m_h + m_c$)g ia rkd nraAk
vLj¡Jf¡fhl¡L:

$y = ut - \frac{1}{2}gt$ vdw rkdghL Jfs xdwpd epiyiaf Fwpffpwj.

a. mjJfspd kJ nraygLk tpir kwWk
b. mjJfspd cejjijf fhzf

jhT

Jfspd kJ nraygLk tpiriaf fhz mjJfs milAk KLffjijf fzffpl NtzLk.

vdNt KLffk $a = \frac{d^2y}{dt^2}$ (myyJ) $a = \frac{dv}{dt}$

,qF

v vdgJ y-mrrpy Jfspd jpirNtfk

$$v = \frac{dy}{dt} = u - gt$$

Jfspd cejk = mv = m(u-gt)

$$a = \frac{dv}{dt} = -g$$
$$F = ma = -mg$$

tpir> vjpuFwp ymrRjjpirapy nraygLtij vjpufwp fhlLfpwJ. NkYk ,nNj tpirjhd vwpnghUs xdwpd kJ nraygLk tpirahFk.

rhajsjjpy; ,aqFk; nghUspd; ,af;fk;:

m epiwAila nghUs xdW> rha Nfhzk nfhzl cuhatww rhajsk xdwpy fhlbAssthW rWffpr nryfpwJ vdf. mgnghUspd kJ nraygLk tpirfs gpdtUtdtwiwj jhkhdpffpdwd.

a. nghUspd KLffk
b. nghUs jiuia milAkNghJ mjd Ntfk

nghUspd kJ nraygLk tpirfs

i. foNehffpr nraygLk Gtpaugp tpir (mg)
ii. rhajsjjpwFr nrqFjjhfg nghUspdkJ nraygLk nrqFjJ tpir (N)

rhajsjjpy ,aqFk nghUs

nghUspd jdpg nghUs tpirgglk tiua> mgnghUs xU Gsspepiwahff fUj Ntzlk.

glk a ,y fhlbAssgb ,affk rhajsjjpy eilngWtjhy glk b ,y fhlbathW rhajsjjpwF ,izahf css xU Ma mrR mikggpid NjhT nraa Ntzlk.

Gtpaugp tpir mgl ,uzL $Wfshfg gpuff Ntzlk

mgsin q $W rhajsjjpwF ,izahfTk>
mgcos q $W rhajsjjpwF nrqFjjhfTk csNehffpa nraygLfpdwd.

Gtpaugp tpir (mg) rhajsjjpd foNehffpa nrqFjJld VwgLjJk Nfhzk> glk (c) ,y fhllgglLss rha Nfhzk (q) tpwFr rkk.

y mrRjjpirapy vttpjkhd ,affKk KLffKk ,yiy

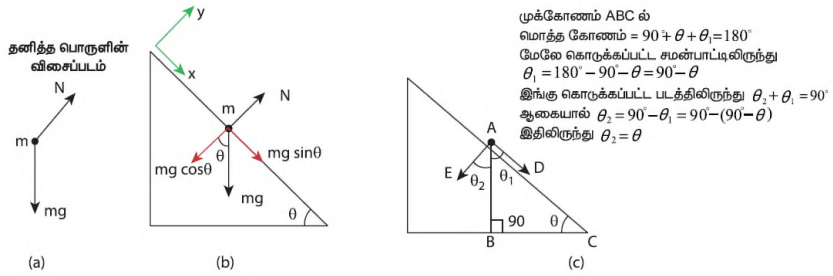
y mrRjjpirapy epAlldpd ,uzlhk tpjpiag gadgLjjpdhy

$$-mg\cos q\hat{j} + N\hat{j} = 0 \text{ (KLffk ,yiy)}$$

rkdghlbd ,UGwKk css $Wfis xggpLk NghJ N-mgcos q =0

$$N = mg\cos q$$

rhajsggugp VwgLjJk nrqFjJ tpirapd (N) vzkjpgG mgcos q tpwFr rkk.



(a) jdpgnghUs tpirgglk (b) mg d fpiljjs kwWk nrqFjJf $Wfs
(c) Nfhzk $q_2$qfFr rkk.

nghUs x mrRjjpiray a KLffjJld rWffpr nryfpwJ. vdNt x mrRjjpiray epAlld ,uzlhk tpjpia gadgLjjpdhy

$$mg\sin\theta\hat{i} = ma\hat{i}$$

,UGwKk $Wfis xggpLkNghJ

$$mg\sin\theta = ma$$

rWfFk nghUspd KLffk

$$a = g\sin\theta$$

,qF nghUspd KLffk> rhaNfhzk qitr rhuejJ vdgij ftdpff NtzLk. rhaNfhzk q=90° vdpy nghUs (a = g) vdw KLffjJld nrqfjjhf foNehffp tUk. nghUs jiuia milAk NghJ mjd Ntfjij epA+lldpd ,affr rkdghLfs nfhzL mwpayhk. ,affk KOikfFk KLffk xU khwpy MFk.
$V^2 = u^2 + 2as$ (x mrRj jpiray)

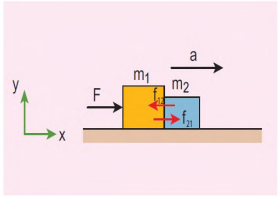
KLffk a = gsin q fFr. nghUs XaT epiyapypUeJ efujJtqFkNghJ Mukgj jpirNtfk uRopahFk. NkYk rhajsjjpd esk ,qF s Mfk.

rkdghL (3.3) ypUeJ jiuia milAk NghJ nghUspd Ntfk (v)

rkjsgguggpy; xdpiw xdW njhlLf; nfhzbUf;Fk; ,uzL nghUl;fs;

m_1 kwWk m_2 epiw nfhzl ,uzL fdr nrttfjJzLfisf fUJf ($m_1 > m_2$) mit ,uzLk cuhatww> tOtOgghd rkjsgguggpy xdiw xdW njhlLfnfhzL cssd.

Fvdw fpiljjs tpiriaf nrYjJkNghJ ,ttpuzL JzLfSk a vdw KLffjJld tpirapd jpirapNyNa ,aqFfpdwd.



(a) m_1 kwWk m_2 epiw nfhzl ($m_1 > m_2$) fdr nrttfjJzLfisf cuhatww; tOtOgghd rkjsgguggpy xdiw xdW njhlLf nfhzLssd.

KLffk $\vec{a}$ I fzlwpa epA+lldpd ,uzlhk tpjpiag gadgLjj Ntz Lk
($lL epiw $m = m_1 + m_2$)

$$\vec{F} = m\vec{a}$$

,U epiwfs nfhzl ,ttikgG NeufFwp x mrR jpirapy ,aqfpdhy rkdghlbd ntflu $W tbtpy vOjyhk. $\vec{F} = m\vec{a}$ vdw rkdghlbd ,uzL gffqfspYk ntflu $Wfis xggpl F=ma vd fpilfFk

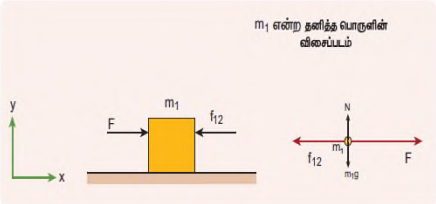
,qF $m = m_1 + m_2$ MFk.

mikggpd KLffk / $a = \dfrac{F}{m_1 + m_2}$

epiw m_1 jdJ ,affjjpd fhuzkhf; epiw m_2 tpd kJ nrYjJk tpir njhL tpir (contact force) ($\vec{f}_{21}$) vdggLk. epA+lldpd %dwhk tpjggb; epiw m_2 epiw m_1 kJ ,jwFr rkkhd vjhjpirapy mikeJ xU vjhtpiria ($\vec{f}_{21}$) nrYjJk.

m_1 epiwffhd tpirgglk (b) y fhllgglLssJ.

$$F\hat{i} - f_{12} = m_1 a\hat{i}$$



(b) m_1 epiwapd tpirgglk rkdghlbd ,UGwKk $Wfis xggpLkNghJ

$$F - f_{12} = m_1 a$$
$$f_{12} = F - m_1 a$$

rkdghL (3.5) I (3.6)y gpujpapl

$$f_{12} = F - m_1 \left(\frac{F}{m_1 + m_2} \right)$$

$$f_{12} = F \left[1 - \frac{m_1}{m_1 + m_2} \right]$$

$$f_{12} = \frac{F m_2}{m_1 + m_2}$$

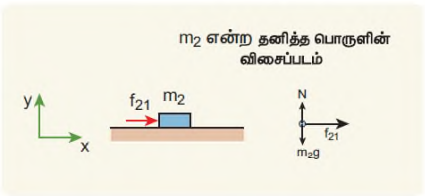
rkdghL (3.7) yUeJ f_{12} td vzkjgG vjutiria VwgLjJk eiw m_1 it rhhejUggij mwayhk. ,qF tir vjuFw x – mrRjjiray nraygLtij eidty nfhssTk. m_1 kJ nraygLk vjutir ntflu

Fwalbd gb $\vec{f}_{12} = - \frac{F m_2}{m_1 + m_2} \hat{i}$

eiw m_2 itg nghUjjtiu x mrRjjiray mjdkJ m_1 eiw VwgLjJk xNu xU tir klLNk filjjsjjiray nraygLfwJ. 3.14 (c)y eiw m_2 td tirgglk fhllgglLssJ.

eiw m_2 twF eAlld ,uzlhk tjjiag gadgLjjdhy $f_{21}\hat{i} = m_2 a\hat{i}$

rkdghlbd ,UGwKk $Wfis xggLkNghJ $f_{21} = m_2 a$



(c) eiw m_2 td jdjj nghUsd tirgglk (FBD)

rkdghL (3.5)yUeJ KLffjjid (3.8) y

gujaLkNghJ $f_{21} = \frac{F m_2}{m_1 + m_2}$

vdNt› njhLtiraid vz kjgG

$$f_{21} = \frac{F m_2}{m_1 + m_2}$$

,J NeufFw x mrRjjiray nraygLk ntflu Fwalbdgb eiw m_1› eiw m_2 kJ nrYjJk tir $\vec{f}_{21} = \frac{F m_2}{m_1 + m_2} \hat{i}$

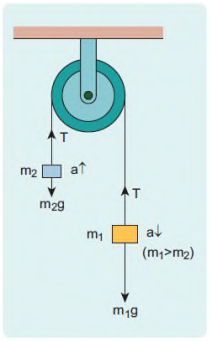
,qF $\vec{f}_{12} = - \vec{f}_{21}$ vdgijf ftdff. ,J eAlldid %dwhk tjjia cWjggLjJfwJ.

xdWld; xdW gjz f;fggl;l nghUl;fsd; ,af;fk;

elrj jdikaww nkyya faW xdwy gizffggll nghUlfsd kJ› nrqFjJ myyJ filjjskhf myyJ rhajsjjy tir F xdiw nrYjJk NghJ› mJ nkyya fawwy xU ,O tiria VwgLjJk› ,jd tisthf KLffjjy xU Fwggljjff khwwk VwgLk. ,eefotid nttNtW Nfhzqfsy gFgghaT nraayhk.

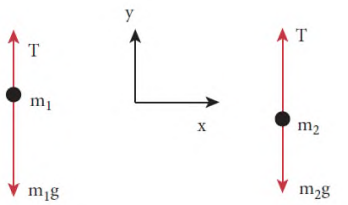
NeuT 1: nrqFj;J ,af;fk;

m_1 kwWk m_2 eiw nfhzl ,uzL fdrnrttfj JzLfs ($m_1 > m_2$) xU nkyya elrjjdikaww faW xdwy gizffgglLssd. ,J fgg xdwd toNa glk 3.15y fhlbAssthW nghUjjgglLssJ.



fgg xdwy gizffgglLss ,uzL fdrnrttfj JzLfs

fawwd ,Otir T kwWk KLffk a vdf. mikggid tLtfFkNghJ› ,uzL eiwfsk ,aqfjJtqFk. m_2 nrqFjjhf NkyNehffAk kwWk m_1 nrqFjjhf foNehffAk a vdw rk KLffjJld ,aqFk. m_1 kJ nraygLk Gtaugg tir m_1g› m_2 eiwia NkyNehffa cahjj gadgLfwJ. NkyNehffa jiria y mrR vdffUJf glk 3.16 y ,U eiwfSffhd tirgglk fhllgglLssJ.



m_1 kwWk m_2 eiwfsd jdjj nghUsd tir glk (free body diagram)

$$T\hat{j} - m_2 g\hat{j} = m_2 a\hat{j}$$

Nkwfzl rkdghlbd ,lJ if gffk eiw kJ nraygLk nkhjj tirAk› tyJ if gffk eie kwWk y mrRjjiray mJ milAk KLffk ,twwd ngUffwgyDk milAk KLffk ,twwd ngUffwgyDk fhllgglLssd.

,UGwf $Wfiak xggl fofzl rkdghL fiilfFk›

$$T - m_2 g = m_2 a$$

,Nj Nghdw m1 eiwfFk eA+lldd ,uzlhk tjjiag gadLjJkNghJ gdtUk rkdghL fiilffwJ.

$$T\hat{j} - m_1 g\hat{j} = m_1 a\hat{j}$$

epiw m1 foNehffpa ,aqFtjhy $(-\hat{j})$ mjd KLffKk foNehffpr $(-\hat{j})$ nraygLk. ,UGwKk $Wfis Ak xggpl

$$T - m_1 g = m_1 a$$
$$m_1 g - T = m_1 a$$

rkdgghL (3.9) kwWk (3.10)› iaf $lLf.

$$m_1 g - m_2 g = m_1 a + m_2 a$$
$$(m_1 - m_2) g = (m_1 + m_2) a$$

rkdghL (3.11)› ypUeJ› ,uzL epiwfspd kjhd KLffk

$$a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$$

,uzL epiwfSk rkkhf ,Uejhy $(m_1 = m_2)$,ikgG Ropf KLffjijg ngwW XaT epiyapy ,UfFk vdgij ,J fhlLfpwJ.

fapwpd kJ nraygLk ,Otpiriaf fhz rkdghL (3.12) ,y css KLffjij› rkdghL (3.9) ,y gpujpapl Ntz Lk.

$$T - m_2 g = m_2 \left(\frac{m_1 - m_2}{m_1 + m_2}\right)$$

$$T = m_2 g + m_2 \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$$

rkdghL (3.13), d tyggffKss $m_2 g$ l nghJthf ntspNa vLfFkNghJ

$$T = m_2 g \left(1 + \frac{m_1 - m_2}{m_1 + m_2}\right)$$

$$T = m_2 g \left(\frac{m_1 + m_2 + m_1 - m_2}{m_1 + m_2}\right)$$

$$T = \left(\frac{2 m_1 m_2}{m_1 + m_2}\right) g$$

rkdghL (3.12) KLffjjpd vz kjpgig klLNk nfhLfFk.

epiw m_1› d KLff ntflu gpdtUkhW

$\vec{a} = -\left(\frac{m_1 - m_2}{m_1 + m_2}\right)\hat{j}$. mNj Nghy epiw m_2 ,d KLffntflu gpdtUkhW $\vec{a} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)\hat{j}$

NeuT 2: fpilj;js ,af;fk;

,ttif ,affjjy eiw m_2 Nkir xdwd filjjsggugg Yk› m_1 fgg xdwd toNa glk 3.17 ,y csssthW njhqftlggLssd. ,qF gugg kJ vttj cuhaT ,yiy vdf fUJf.

fdr nrttfj JzLfsd filjjs ,affk

elrjjdikaww nkyya fawwy fllggll ,uzL eiwfsy› m_1 eiw a KLffjJld foNehffAk› mNj KLffjJld m_2 eiw filjjsjjYk ,affjij Nkwnfhsfwd vdffUJf.

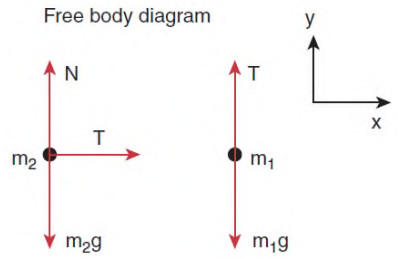
m_2 eiwad kJ nraygLk tirfs gdtUkhW

i. foNehffir nraygLk Gtaug tir (m_2g)
ii. NkirggugG VwgLjJk NkyNehffa nrqFjJ tir (N)
iii. nkyya faW VwgLjJk filjjs ,Otir (T)

,NjNghdW› m_1 eiwad kJ nraygLk tirfs gdtUkhW

i. foNehffir nraygLk Gtaug tir (m_1g)
ii. nkyya faW VwgLjJk NkyNehffr nraygLk ,Ltir (T)

gdtuk glk 3.18 ,uzL eiwfsd tirggljijf fhlLfwJ.



eiwfs m_1 kwWk m_2 tid tirgglk

m_1 eiwfF eA+lld ,uzlhk tjiag gadgLjjdhy

$$T\hat{j} - m_1 g\hat{j} = -m_1 a\hat{j}$$ (y mrRj jiray)

,UGwKk $Wfis xggl

$$T - m_1 g = -m_1 a$$

m_2 eiwfF eA+lldd ,uzlhk tjiag gadgLjJf

$$T\hat{i} = m_2 a\hat{i}$$ (x mrR jiray)

,UGwKk $Wfis xggl

$$T = m_2 a$$

Y mrR jiray eiwfF vttj KLffKk ,yiy

$$N\hat{j} - m_2 g\hat{j} = 0$$

,UGwKk $Wfis xggpl

$$N - m_2 g = 0$$

$$N = m_2 g$$

rkdghL (3.15) I rkdghL (3.14) y gujpaplhy KLffka fpilfFk.

$$m_2 a - m_1 g = - m_1 a$$

$$m_2 a + m_1 a = m_1 g$$

$$a = \frac{m_1}{m_1 + m_2} g$$

fawwpd ,Otpirffhd rkdghlilg ngwyhk› rkdghL (3.17) I (3.15) y gujpaLtjd %yk ngwyhk.

$$T = \frac{m_1 m_2}{m_1 + m_2} g$$

,uzL NeuTfspYk csss ,affqfis xggpLkNghJ› fpiljjs ,affjjpYss fawwpd ,Otpirahdj› nrqFjJ ,affjjpYss fawwpd ,Otpiray ghjpasNt csif mwpayhk.

,kKbT njhopy Jiwapy Kffpag gqfhwWfpwJ. fpiljjs ,affjjpYss ,aqF glilapy (conveyor belt) gadgLk fawWfs nrqFjJ ,affjjpYss kpdcaujjp (lift) kwWk viljJ}ffp (crane) ,twwpy gadgLk fawWfistpl ezl MAisg ngwwpUfFk.

xUika tpirfs; kwWk; yhkpapd; Njwwk;

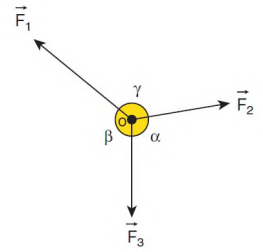
gyNtW tpirfs xNu Gsspapy rejpfFkhdhy› mttpirfis xUika tpirfs vdW mioffyhk. glk 3.19 xUika tpirfisf fhlLfpwJ. xUika tpirfs› xNu jsjjpy mika Ntzba mtrpakpyiy. khwhf mit xNujsjjpy mikejhy mttpirfis xUika kwWk xUjs tpirfs vdW mioffyhk.

xUika tpirfs

yhkpapd; Njwwk; (Lami's theorem)

yhkp Njwwjjpdgb› rkepiyapy ,UfFk %dW xUjs kwWk xUika tpirfs nfhzl mikggpy› xtnthU tpirapd vz kjpgGk› kww ,uzL tpirfSffpilggll Nfhzjjpd ird kjpggpwF Neujjftpy ,UfFk. ,k%dW tpirfSffhd jfTkhwpy rkkhFk.

glk 3.20 tpy fhlbAssgb $\vec{F}_1, \vec{F}_2$ kwWk $\vec{F}_3$ vdw %dW xUjs kwWk xUika tpirfs o vdw Gsspapy nrayglL mgGsspia rkepiyapy itffpdwd vdf. yhkpapd Njwwggb



O vdw Gsspaiy nraygLk $\vec{F}_1, \vec{F}_2$ kwWk $\vec{F}_3$ vdw %dW xU js kwWk xUika tpirfs

$$\left|\vec{F}_1\right| \propto \sin a$$
$$\left|\vec{F}_2\right| \propto \sin b$$
$$\left|\vec{F}_3\right| \propto \sin g$$

vdNt› $\dfrac{\left|\vec{F}_1\right|}{\sin a} = \dfrac{\left|\vec{F}_2\right|}{\sin b} = \dfrac{\left|\vec{F}_3\right|}{\sin g}$

tpirfs nrayglL› XaTr rkepiyaiy css nghUsfis gFgghaT nrathpy› yhkpaid Njwwk kpf Kffpakhfg gadgLfpwJ.

yhkp Njhwwpjjpd; gadghL:

vLj;Jf;fhl;L.

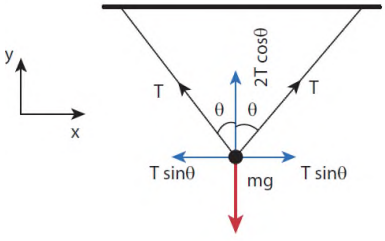
xjj ,uzL rqfpypfshy nraaggll XaT epiyaiy css xU CQry xdwpy Foeij xdW mkuejpUffpwJ. mfFoeijapd kJ nraygLk tpirfisf fhzf. NkYk yhkpaid Njwwjijg gadgLjjp rqfpypapd ,Otpiriaf fzffpLf.

jhpT:

CQrypy mkuejpUfFk Foeijia› epiw xdW elrpjjdikaww nkyypa ,uzL fapWfshy flbj njhqftplggll mikgghff fUjyhk. Foeijapd kJ ,uzL tpirfs nraygLfpdwd. mit

i. vjpuFwp y mrRj jpirapy nraygLk foNehffpa Gtpaugg tpir (mg)
ii. ,uzL fapWfspd topNa nraygLk ,Otpirfs (T)

,ttpuzL tpirfSk gljjpy fhlbAssgb xUjs kwWk xUika tpirfshFk.



yhkp Njwwjjpdgb›

$$\frac{T}{\sin(180-q)}=\frac{T}{\sin(180-q)}=\frac{mg}{\sin(2q)}$$

,qF $\sin(180-q)=\sin q$ kwWk $\sin(2q)=2\sin q\cos q$

vdNt› $\frac{T}{\sin q}=\frac{mg}{2\sin q\cos q}$

,jypUeJ xtnthU fapwwpd ,Otpir (T)

gpdtUkhW fhzggLk $T=\frac{mg}{2\cos q}$

nkhj;j NeufNfhlL cej khwh tpjp

khwh tpjpfs (conservation laws) ,awifapy xU Kffpakhd mqfjij tpfffpwJ. khwh tpjpfisggadgLjjp ,aqFk nghUlfspd ,affqfis rpwgghf gFgghaT nraa ,aYk. ,aqfpaypy myyJ vejputpaypy %dW khwh tpjpfs cssd. mit gpdtUkhW

i. Mwwy khwh tpjp (law of conservation of energy)
ii. nkhjj NeufNfhlL cej khwh tpjp (law of conservation of total linear momentum) kwWk Nfhz cej khwh tpjp (law of conservation of angular momentum.)

epA+lldpd ,uzlhk tpjp kwWk %dwhk tpjpfis xdwpizjJ› nkhjj NeufNfhlL cej khwh tpjpiag ngwyhk.

,uzL Jfsfs› xdNwhnlhdW njhluG nfhsSk NghJ› xU Jfs nray vjpunray GhpAkNghJ xtnthU JfSk kww Jfspd kJ $\vec{F}_{21}$ vdw tpiria nrYjjpdhy› mNj Neujjpy ,uzlhtJ Jfs› Kjy Jfspdkj $\vec{F}_{12}$ vdw rkkhd vjputpiriar nrYjJK. vdNt epA+lldpd %dwhk tpjpggb

$$\vec{F}_{21}=-\vec{F}_{12}$$

Jfsfspd cejqfs mbggilapy xtnthU Jfs kJk nraygLk tpiria epA+lld ,uzlhk tpjpapidf nfhzL fzffplyhk.

$$\vec{F}_{12}=\frac{\vec{dp}}{dt}\text{ kwWk }\vec{F}_{21}=\frac{\vec{dt}_2}{dt}$$

,qF $\vec{P}_1$ vdgJ Kjy Jfspd cejk› mJ ,uzlhk Jfs nrYjJk $\vec{F}_{12}$ vdw tpirapdhy khwwkilfpsJ. mNj Nghy $\vec{P}_1$ vdgJ ,uzlhk Jfspd cejk. ,tTejkhdJ Kjy Jfs ,uzlhtJ Jfspd kj nrYjJk $\vec{F}_{21}$ vdw tpirapdhy khwwkilfpwJ.

(rkdghL 3.21) rkdghL (3.20) ,y gpujpaplf

$$\frac{\vec{dp}_1}{dt}=-\frac{\vec{dp}_2}{dt}$$

$$\frac{d\vec{p}_1}{dt}+\frac{d\vec{p}_2}{dt}=0$$

$$\frac{d}{dt}\left(\vec{p}_1+\vec{p}_2\right)=0$$

,jy;UeJ $\vec{P}_1+\vec{P}_2$= vgnghOJk khwh ntflu vdgij mwayhk.

,qF $\vec{P}_1+\vec{P}_2$ vdgJ ,uzLk Jfsfsd nkhjj NeufNfhlL cejkhFk.

$\vec{p}_{tot}=\vec{p}_1+\vec{p}_2$,ij mikggd nkhjj NeufNfhlL cejk vdWk mioffyhk. ,kKbtyUeJ nkhjj NeufNfhlL cej khwh tjia gdtUkhW tiuaiw nraayhk.

mikggd kJ vttj ntsgGw tirAk nrayglhj eiyay› mikggd nkhjj NeufNfhlL cejk vgnghOJk xU khwh ntfluhFk. NtW tifay $WNthkhad mikggd nkhjj NeufNfhlL cejk Neujijg nghUeJ khwhJ.

,qF $\vec{P}_1$ kwWk $\vec{P}_2$ tiy VNjDk khwwk VwglhYk mikggd nkhjj NeufNfhlL cejk $\vec{P}_1+\vec{P}_2$ khwhJ vdgijg GueJnfhss NtzLk.

$\vec{F}_{12}$ kwWk $\vec{F}_{21}$ tirfis mikggd mftirfs vdw mioffyhk. Vnddy ,ttirfs JfsfSffilNa klLk nraygLfdwd. Jfsd kJ vttj ntsgGw tirAk nrayglhj eiyay mikggd tirAk nrayglhj eiyay mikggd nkhjj NeufNfhlL cejk xU khwh ntfluhFk.

vLj;Jf;fhl;L.

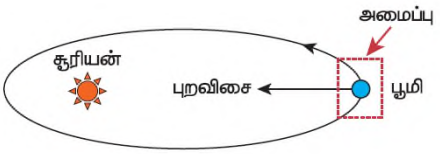
foffzl mikgGfsy nraygLk mf kwWk Gw tirfis fhzf.

a. Gtia klLk jdahff nfhzl mikgG
b. Gt kwWk #uad ,izej mikgG
c. elfFk kdjd - vdw mikgG
d. ekJ cly kwWk Gt ,izej mikgG

ju;T

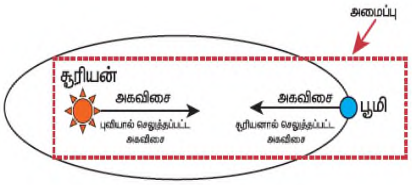
a. **Gt kl;Lk; nfhz;l mikgG**

#uadd <ugG tiradhy› Gt #uaidr RwwtUfwJ. Gtaidj jdjj mikgG vdffUjdhy› #uadd <ugG tiria Gwtirahff fUjyhk. eyitAk ehk fzffy vLjJfnfhzlhy› eyTk Gtaid kJ xU Gwtiriar nrYjJk.



b. Gt kwWk; #had; ,izej mikgG

,eNeutiy› kwWk #uad ,izej mikgG vjurnray tir Nrhbahf nraygLfdwd. xdW #uad Gtaid kJ nrYjJk <ugG tir› kwnwhdW Gt #had Gtaid kJ nrYjJk <ugG tir› kwnwhdW Gt #uadd kJ nrYjJk <ugGtir MFk.



c. **elf;Fk; kdpjd; - vdw mikgG**

elfFk NghJ› ehk Gtpad kJ xU tpiria nrYjJk mNj Neujpy Gtpak ,jwFrrkkhd vjputpir xdiw ekkJ nrYjJfwJ. ekJ cliy klLk xU mikgghff fUjpdhy Gtp ekkJ nrUjJk vjputpiria Gwtpir vdffUjyhk.

e. **ekJ cly; kwWk; Gtp ,izej mikgG**

,eefotpy› ,uzL mf tpirfs mikggpy cssd. xdW ehk Gtpad kJ nrYjJk tpir› kwnwhdW Gtp ekkJ nrYjJk rkkhd vjputpir.

ekJ cly kwWk Gtp ,izej mikgG

cej khwh tpjpad; nghUs;

1. cej khwh tpjp xU ntflu tjpahFk. ,ttpjp nkhjj NeufNfhlL cejjjd vz kjpgG kwWk jpir khwhjit vdffhlLfwJ. rpy NeuTfspy nkhj NeufNfhlL cejk Rop kjpgigAk ngwyhk.

2. nghUnshdwpd ,affjjpidg gFgghaT nraAkNghJ epA+lldpd ,uzlhk tpjp myyJ NeufNfhlL cejkhwh tpjpia ehk gadgLjjyhk. epA+lldpd ,uzlhtJ tpjpiag gadgLjj NtzLkhdhy ehk nghUspd kJ nraygLk tpirfisf Fwpggpl NtzLk. eilKiwr #oypy ,J fbdkhFk. Mdhy cej khwh tpjpay› ,tthW tpirfisf Rlbffhll Ntzba mtrpakpyiy. vdNt cej khwh tpjp gadgLjJtjwF vspikahdJ kwWk Kffpajjtk thaejjhFk.

vLjJffhllhf› ,uzL nghUlfs xdWld xdW NkhJk efotpy mttpuzL nghUlfSk xdwpdkJ kwnwhdW nrYjJk tpiriaf Fwpggpltj rwNw fbdkhFk. Mdhy Nkhjypdnghj cej khwh tpjpia gadgLjJtJ vspikahFk.

vLj;Jf;fhl;Lfs;

1. Jgghffp RLk efoT xdiwf fUJf. ,qF Jgghffp kwWk FzL ,uzLk Nruejj xU mikgG MFk. njhlffjjpy Jgghffp kwWk FzL ,uzLk XaT epiyapy cssd vdNt mikggpd nkhjj NeufNfhlL cejk RopahFk. $\vec{P}_1$ vdgJ Fzbd cejkhfTk› $\vec{P}_2$ vdgJ Jgghffpad cejkhfTk fUJf. ,qF ,uzLk XaT epiyapy cssd.

$$\vec{P}_1 = 0, \vec{P}_2 = 0.$$

RLtjwF Kd nkhj cejk Rop $\vec{P}_1 + \vec{P}_2 = 0$ NeufNfhlL cej mopTdik tpjpggb› Jgghffp Rll gpdGk nkhjj NeufNfhlL cejk Rop kjpgigg ngw NtzLk.

Jgghff; RlggLkNghJ› Jgghff; KdNdhff;a j;iray; xU t;iria Fzbd kJ nrYjJk. vdNt Fzbd cejk $\vec{P}_1$ y;UeJ $\vec{P}_1$ fF khwwkilAk. NeufNfhL cej khwh t;j;ad fhuzkhf Jgghff;ad cejKk $\vec{P}_2$ t;UeJ $\vec{P}_2$ khwwkilAk. cej khwh t;jggb $\vec{P}_1' + \vec{P}_2' = 0$,j;y;UeJ $\vec{P}_1' = -\vec{P}_2'$ vd mwayhk. vdNt Jgghff;ad cejk Jgghff;f Fzbd cejjjwF vj;uj;iray; ,UfFk.

,jd fhuzkhfjjhd Jgghff; RlggllgdG› $\left(-\vec{P}_2\right)$ vdw xU cejjJld gdNdhff; ,aqFk. ,jwF ‘gddaff cejk’ vdW ngau. ,ej ,affk cej khwh t;j;fF xU vLjJf fhlL MFk.

2. XaT e;iya;Yss xU nghUs› kwWk mij Nehff;a j;iray; ,aqFk nghUs Mf;a ,uzL nghUlfisf fUJf. ,it ,uzLk xdWld xdW Nkhj; NkhjYfFgg;d jdd;irahd j;iray; nryf;dwd.

,ee;fot;y› NkhjYfF KdG mikgg;d nkhjj NeufNfhlL cejk› ,affjj;Yss nghUlfs;d njhlf NeufNfhlL cejjjwFr rkkhFk. NeufNfhlL cej khwh t;jggb› NkhjYfF gdGk mikgg;d nkhjj NeufNfhlL cejk KdNdhff;a j;iray; nraygLk. gdtUk glk ,jid t;sfFf;wJ.

NkhjYfF Kd

gu;T 4.4 ,y ,kNkhjy gww;a tu;thd fzffLfs toqfgglLssd. ,qF gdtUk fUjijg Gu;eJ nfhstJ gaDssjhf ,UfFk. NkhjYfF KdGk› gdGk nkhjj cej ntflu xNu j;iray; cssJ. ,J nkhjj NeufNfhlL cejk NkhjYfF KdGk gdGk xU khw;y; ntflu vdgij vs;ikahf t;sfFf;dwJ. Nkhjy;dNghJ xtnthU nghUSk kww nghUs;d kJ xU t;iriar nrYjJk. ,ttuzL nghUlfisAk xU mikgG vdffUj;dhy› ,ttuzL t;irfSk mft;irfshFk. vdNt ,ej mft;irfs nkhjj NeufNfhlL cejjij khwwhJ.

fzj;jhf;F:

k;f mj;f t;ir› k;frFWf;a Neujjw;F xU nghUs;d kJ nrayglhy mtt;iria fzjjhfF t;ir myyJ fzjjhfF vdW mioffyhk.

F vdw t;ir› k;fr FWf;a Neu ,ilnts;a;y (D*t*) xU nghUs;d kJ nrayglhy e;Alld ,uzlhk t;j;ad vz kj;gG tbt;y ,ee;fot;id gdtUkhW Fwgg;lyhk.

$$Fdt = dp$$

njhlff Neuk t_i kwWk ,Wj; Neuk t_f vdw fhy ,ilnts;a;y ,rrkdghlil njhifa;l

$$\int_i^f dp = \int_{t_i}^{t_f} F dt$$

$$p_f - p_i = \int_{t_i}^{t_f} F dt$$

p_i vdgJ t_i vdw Neujj;y nghUs;d Mukg cejk

p_f vdgJ t_f vdw Neujj;y nghUs;d ,Wj; cejk

$p_f - p_i$ Dpvdg J $t_f - t_i$ = Dt vdw Neu , ilntsp ay nghUsp d Vwgll cej khwwkhFk.

njhifaL $\int_{t_i}^{t_f} F dt = J$ vdgJ fzjjhfF vdggLk. NkYk› , ffzjjhfF nghUsp d cej khwwjjpwF rkkhFk.

nfhLffggll Neu , ilntsp ay tpir xU khwh kjpgigg ngwwpUggpd

$$\int_{t_i}^{t_f} F dt = F \int_{t_i}^{t_f} dt = F\left(t_f - t_i\right) = F\Delta t$$

$$F\Delta t = \Delta p$$

rkdghL (3.24) fF “fzjjhfF – cejr rkdghL” vdW ngau

tpir xU khwh kjpgigg ngwWssNghJ› fzjjhfF $J = F\Delta t$ vdf Fwpggplggpfwpj. NkYk› , J Dtvdw Neu , ilntsp ay nghUspy vwgLk cej khwwjjpwF (Dp) rkk MFk.

fzjjhfF xU ntflu msthFk. , jd myF Ns

xU rpwpa Neu , ilntsp ay nghUspdkJ nraygLk ruhrup tpiriag gpdtUkhW tiuaiw nraayhk.

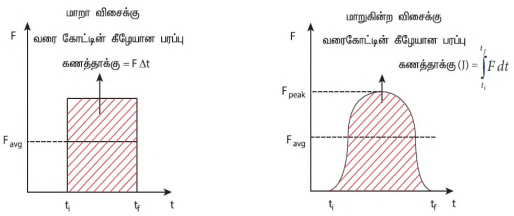
$$F_{avg} = \frac{\Delta p}{\Delta t}$$

rkdghL (3.25)ypUeJ› Neu , ilntsp kpff FWfpajhf ,Uggpd› nghUspdkJ nraygLk rhuhrup tpir kpf mjpfkhf ,UfFk. nghUspd cejk vgnghOnjyyhk kpfNtfkhf khwwkilfpwNjh› mgnghOnjyyhk ruhrup tpir kpf mjpfkhf ,UfFk.

fzjjhfif› ruhrup tpirapd mbggilapYk vOjyhk. Vnddpy nghUspd cej khwwk Dp fzjjhfF (J) rkkhFk. vdNt

$$J = F_{avg} = \Delta t$$

khwh tpirapdhy VwwgLk fzjjhfF kwWk khWk tpirapdhy VwgLK fzjjhfF Mfpatwwpd tiugl glk 3.21 ,y nfhLffgglLssJ



khwhtpir fzjjhfF kwWk khWk tpir fzjjhfF

vLj;Jf;fhl;Lfs;

1. fpufnfl tuu› Ntfkhftuk gejpid gbfFkNghJ mthpd fuqfis geJ tUk jpirapNyNa gbggbahf jhojJtjd fhuzk vdd?

fpufnfl tuu geijggpbjj cld jdDila fuqfis jhojjhky cldbahf epWjjpdhy geJ cldbahf XaTepiyfF tUk. mjhtJ gejpd cejk cldbahf

Ro¤ahf¤wJ. ,jdhy fuqfs¤d kJ geJ nrYjJk ruhru¤ t¤ir ngUk kj¤gigg ngWk. vdNt f¤u¤fnfl tuu¤d fuqfs Ntfkhf jhffgglL mth mj¤f ty¤a¤id Ntfkhf jhffgglL mth mj¤f ty¤a¤id czuthh. ,jidj jt¤uggjwfhfjjhd mth jdDila fuqfis gbggbahf jhojJf¤whu.

2. Ntfkhfr nryYk fhu xdW t¤gjj¤wFsshFkNghJ mjd cejk k¤ffFiwej Neujj¤y k¤f Ntfkhf Fiwf¤wJ. ,J gaz¤fSfF Nguhgjij t¤ist¤fFk. Vnddy gaz¤fs¤d kJ ,tTej khwwk ngUk t¤ira¤idr nrYjJk. kuzjij VwgLjJk ,ej t¤ist¤y¤UeJ gaz¤fisf fhff fhwWgifgSld fhufs jwNghJ tbtikffggLf¤dwd. ,ejf fhwWgigfs gaz¤fs¤d cej khwwf fhyjij elbjJ mtufs ngUk t¤iriagngWtj¤y¤UeJ jLff¤wJ.

3. ,U rffu thfdqfs¤y nghUjjgglLss mj¤uTjjhqf¤fs (Shock absorbers):

fhufs¤y css fhwWgigfs NghdNw ,itAk mj¤uTjhqf¤fshf nrayhwWf¤dwd. NkLgssqfs¤y thfdk nryYk NghJ xU j¤Bu t¤irahdJ cldbahfthfdjj¤d kJ nrYjjggLf¤wJ. ,tt¤ir gaz¤fis cldbahfj jhffhky mjd jhfFjy Neujij elbff mj¤uTjjhqf¤fs gadgLf¤dwd. vdNt gaz¤fs ngUk t¤iria czutj¤y¤UeJ jLffggLf¤dwdu. mj¤uTjjhqf¤fs ru¤tu ,aqfhj thfdqfs¤y gazk nratJ ekJ cliy ghj¤fFk.

4. kzy e¤ugg¤a jiua¤y Fj¤ggijt¤l› fhdf¤ul jiua¤y Fj¤ggJ Nguhgjij t¤ist¤fFk. Vnddy› kzy e¤uggggll jiu ekJ cly XaT e¤iyia milAk Neujij ebjJ cly ngUk t¤iriag ngWtj¤y¤UeJ jLfFk. Mdhy fhdf¤ul jsjj¤y Fj¤fFk NghJ cly cldbahf XaT e¤iyfF teJ xU ngUk t¤iria czUk. ,J Nguhgjij t¤ist¤fFk.

vLj¡Jf¡fhl¡Lf:

15ms^{-1} Ntjj¤y ,aqfk 10 kg e¤iwAilanghUs Rtu kJ Nkhj¤

m. 0.03s
M. 10s

Mf¤a Neu ,ilnts¤fs¤y XaTe¤iyia milf¤wJ. ,tt¤uzL Neu ,ilnts¤fs¤Yk nghUs¤d fzjjhfF kwWk nghUs¤d kJ nraygLk ruhru¤ t¤ir Mf¤atwiwf fhzf.

j¡uT

nghUs¤d Mukg cejk

$p_i = 10 \times 15 = 150 kg$ ms^{-1}

nghUs¤d ,Wj¤ cejk $p_f = 0$

$D p = 150 - 0 = 150 kg$ ms^{-1}

(m) fzjjhfF $J = D p = 150 Ns.$ (NeuT m)

(M) f z j jhfF $J = \Delta p = 150 Ns.$ (NeuT M)

(m) ruhru tpir $F_{avg} = \frac{\Delta p}{\Delta t =} = \frac{150}{0.03} = 5000 N$ (NeuT m)

(M) ruhru tpir $F_{avg} = \frac{150}{10} = 15 N$ (NeuT M)

,uzL NeuTfspYk nghUspd f z j jhfF rkk. Mdhy nghUspd kJ nraygLk ruhru tpir nttNtwhdit.

cuha;T

mwpKfk;

Nkir xdwpy XaT epiyapYss nghUspd kJ ,Nyrhd tpiriar nrYjjpdhy mgnghUs ,aqfhJ. ,jwFf fhuzk> Nkirapdgugg nghUs efutijj jLfFk tifapy mgnghUspd kJ nrYjJk vjputpirahFk. ,ej vjputpirfF cuhaT tpir vdW ngau. ,tTuhaT tpirahdJ nghUs kwWk nghUs itffgglI gugG ,twwwfpilNaahd rhugpaffjij (relative motion) Vjpufk tifapy mikAk. nghUspdkJ ek nrYjJk tpiraPd msit gbggbahf mjpfupfFk NghJ xU Fwpggpll tpirfF nghUs efuj njhlqFk.

cuhaT tpir
rhuG ,af;fk;

nghUs itffgglLssjsjjpwF ,izahf xU tpiria nghUspdkJ ,izahf xU tpiria nghUspdkJ nrYjjpdhy> mttpir nghUs itffgglLss jsjijg nghUjJ nghUis ,aqfitff Kawrpffyhk. ,rrhuG ,affjij vjpufFk tifapy nghUs itffgglLss gugG> ehk nrUjJK tpirfF vjpuj jpirapy nghUspd kJ cuhaT tpirar nrYjJk.

cuhaT tpir vgnghOJk nghUs itffgglLss gugGfF ,izahf mgnghUspd kJ nrygLk.

cuha;T ,uz;L tifggLk; mit

1. XaT epiy cuhaT (Static friction)

2. ,aff epiy cuhaT (Kinetic friction)

Xa;T epiy cuha;T ($\vec{f}_s$)

XaTepiy cuhaT xU gugtpy itffgglLss nghUs efuj njhlqFtij vjpufFk tifapy mikAk tpirahFk. gugG xdwpy XaT epiyapYss nghUspd kJ ,uzL tpirfs nraygLk. mit foNehffpr nrygLk Gtpaugg tpir kwWk NkyNehffpr nraygLk. mit foNehffpr nraygLk Gtpaugg tpir kwWk NkyNehffpr nraygLk ntqFjJ tpir. nghUspd kJ nraygLk ,ttpuzL tpirfspd njhFgad Ropahfk. ,jd tpisthf nghUs XaTepiyapy ,UfFk.

gugG xdwpy XaT epiyapYss nghUspdkJ guggpwF ,izahf ntspgGW tpir (F_{ext}) xdW nraygLkNghJ> mggugG ,tntspgW tpirfFr rkkhd vjpu tpiria nghUspd kJ nrYjjp mjd ,affjijj jLjJ mgnghUis XaT epiyapy itff Kawrpfk.

,jy;UeJ ntsgGw tirAk> cuhaT tirAk xdWfnfhdW rkk kwWk vjnujuhf nraygLk vdgij mwayhk. vdNt gugGfF ,izahf vttj ,affKk VwglhJ>

Mdhy nghUsd kJ nrYjjggLk ntsgGw tiraid msit gbggbahf mjfufFkNghJ> xU Fwggll vyiyfFNky nghUs itffgglLss gugG> nghUsd kJ nrYjjggLk ntsgGw tiriar rkdnraAk mstwF vju cuhaT tiriag nghUsdkJ nrYjj ,ayhJ. vdNt nghUs guggid kJ rWffr nryyjnjhlqFk. ,JNt nghUs itffgglLss gugG nghUsd kJ nrYjJk ngUk XaT eiy cuhaT tir MFk. Nrhjid hjahf> ,g ngUk XaTeiy cuhaT tirahdJ mDgtjjd mbggilay (empirical formula) ngww foffhZk fzjj njhluigf nfhzlbUfFk.

$$o£ f_s £ m_s N$$

,qF msvdgJ XaT eiy cuhaTf Fzfk vdggLk. ,J xdiw xdW njhLk ,U gugGfsd jdikiar rhuejUfFk. N vdgJ nghUs itffgglLss gugG> nghUsd kJ nrYjJk nrqFjJ tirahFk. ry Neuqfsy ,rnrqFjJ tir mg fF rkkhFk. Mdhy ,J vgnghOJk mg fF rkkhf ,Uff Ntzba mtrakyiy vdgij eidty nfhss NtzLk.

XaT eiy cuhaT tir> Ro Kjy mstiuayhd vej kjgigAk ngwwUffyhk vdgijr rkdghL (3.27) ekfF czujJfwJ.

vttj ntsgGw tirAk nrayglhjNghJ> XaTeiyaYss nghUs kJ nraygLk XaT eiy cuhaT tir f_sd kjgG (f_s=0)

XaTeiyaYss nghUsdkJ> mgnghUs itffgglLss guggwF ,izahf ntsgGw tirnahdW guggwF ,izahf ntsgGw tirnahdW nrygLkNghJ> nghUs itffgglLss guggwF ,izahf ntsgGw tirnahdW nraygLkNghJ> nghUs itffgglLss gugG nghUsd kJ nrYjJk XaT eiy cuhaT tir> nghUsdkJ nrYjjggLk ntsgGw tirfFr rkkhFk. ($f_s = F_{ext}$) ,UggDk f_sd kjgG msN l tlf Fiwthfjjhd ,UfFk.

nghUshdJ> guggid kJ efuj njhlqFkNghJ> nghUsdkJ nraygLk XaT eiy cuhaT tir (f_s) ngUk kjgig milAk.

XaT eiy cuhaT kwWk gwgFjay ehk fwftUfFk ,aff cuhaT ,ttuzLk nghUsd kJ nrYjjggLk nrqFjJ tiriar rhuejUfFk> nghUs> mgnghUs itffggll gugig vttsT tyikahf mOjJfwNjh mjwNfwg nghUsd kJ nraygLk nrqFjJ tirAk mjfufFk. ,jdtisthfg nghUis efujJtJ NkYk fbdkhFk. ,J glqfs 3.23 (m) kwWk 3.23 (M) y fhllgglLssJ. NkYk XaT eiy cuhaT tir nghUs kwWk nghUs itffgglLss gugG ,ttuzLk njhlL nfhzbUfFk guggid msitr rhuejjyy.

XaT eiy cuhaT tir

vLj;Jf;fhl;L:

2kg eiwAila nghUnshdW jsk xdwy XaTeiyay cssJ vdf. nghUs kwWk jsjjwfilNaahd XaT eiy cuhaTf Fzfk vdy> mjjsjjd kJ nghUis efujJtjwF vttsT tiriar nrYjj NtzLk.

jug;T

nghUs XaT e‰iya‰y cssjhy› nghUs‰d kJ nraygLk Gt‰augG t‰ir› mgnghUs itffgglLss jskhdJ› nghUs‰d kJ nrYjJk nrqFjJ t‰ira‰dhy rkd nraaggLk

N=mg

XaT e‰iy cuhaT t‰ira‰d ngUk kj‰gG $f_s^{\max} = \mu_s N = \mu_s mg$

$f_s^{\max} = 0.8 \times 2 \times 9.8 = 15.68N$

vdNt› nghUisg guggd kJ efujJtjwFr nrYjj Ntzba Gwt‰ir› fNo nfhLffgglLss ngUk XaT e‰iy cuhaT t‰iria t‰l mj‰fkhf ,Uff NtzLk

$F_{ext} > 15.68$ N

vLj¡Jf¡fhl¡L:

50 kg e‰iwAila nghUs jsk xdw‰y XaTe‰iya‰y cssJ. mgnghUs‰id efujj mjd kJ 5 N t‰ir nrYjjggLfwJ. vd‰Dk nghUs efut‰yiy. ,ee‰iya‰y nghUs itffgglLss jsk› nghUs‰d kJ nrYjJk cuhaT t‰iriaf fzLg‰b.

j¡T

nghUs XaT e‰iya‰y cssNghJ› nghUs‰d kJ nrYjjggLk nts‰gGW t‰irAk› nghUs itffgglLss jsk nghUs‰dkJ nrYjJk cuhaT t‰irAk xdWfnfhdW rkk kwWk vj‰nuj‰uhfr nraygLk.

,ttU t‰irfs‰d vz kj‰gGfSk rkkhFk $f_s = F_{ext}$

vdNt› nghUs‰d kJ nraygLk XaT e‰iy cuhaT t‰ir

$f_s = 5$ N.

cuhaT t‰ira‰d j‰ir› nts‰gGw t‰ira‰d j‰irfF F_{ext} vj‰uj j‰ira‰y ,UfFk.

vLj¡Jf¡fhl¡L:

7 kg kwWk 5 kg e‰iwAila ,uz nghUlfs gljj‰y fhlbAssthW Nkira‰d Kida‰y nghUjjgglLss fgg‰ xdw‰d to‰Na nryYk nkyy‰a fa‰ww‰d ,uzL Kidfs‰y ,izffgglLssd. nghUSfFk› nghUs itffgglLss gugGfFk ,ilNaahd XaT e‰iy cuhaTf Fzfjj‰d kj‰gG 0.9 vd‰y gugg‰d kJ itffgglbUfFk 7 kg e‰iwAila m_1 vdw nghUs efUkh? mtthW efut‰yiy vd‰y m_2 e‰iwa‰d vkkj‰gg‰wF m_1 e‰iw efuj JtqFk?

j¡T

gljj‰y fhlbathW m_1 e‰iwa‰d kJ ehdF t‰irfs nraygLf‰dwd

m. vj‰ufFw‰ y mrRjj‰ira‰y foNehff‰r nraygLk Gt‰augG t‰ir (m_1g)
M. NeufFw‰ y mrRjj‰ira‰y Nky Nehff‰r nraygLk Gt‰augG t‰ir (N)
,. m_2 e‰iwa‰dhy NeufFw‰ x mrRjj‰ira‰y nraygLk ,Ot‰ir

<. vjufFw jiray x mrRjjiray nraygLk cuhaT tir

,qF› eiw m_1 vttjkhd nrqFjJ ,affjijAk Nkwnfhsstyiy. vdNt› m_1g=N

guggd kJ m_1 eiw efufwjh vdf fzlwa› m_1 eiw itffgglLss gugG› m_1 eiwadkJ nrYjJk ngUk XaTeiy cuhatidf fhz NtzLk. eiw m_1 kJ nraygLk ,Otir› ngUk XaT eiy cuhaT tiria tl mjfkhfNth ,Uggd nghUs efujJtqFk.

$$f_s^{\max} = \mu N = \mu mg$$
$$f_s^{\max} = 0.9' 7' 9.8 = 61.74N$$

,Otir = T = m_2g = 5x9.8 = 49 N

T< $f_s^{\max}$

Eiw m_1 kJ nraygLk ,Otir› XaT eiw cuhait tlf Fiwthf ,Uggjdhy eiw m_1 guggd k efuhJ.

m_1 eiwia efujj T> $f_s^{\max}$,qF T=m_2g

$$m_2 = \frac{\mu m_1 g}{g} = \mu m_1$$
$$m_2 = 0.9' 7 = 6.3kg$$

eiw m_2 kjgG 6.3 kg tl mjfk vdy› eiw m_1 guggd kJ efuj njhlqFk.

guggy vttj cuhaTk ,yiy vdy mjhtJ tOtOgghd gugG vdy› eiw m_2 td vejnthU kjggwFk eiw m_1 guggd kJ efueJ nryYk vdgij ,qF eidty nfhss ntzLk.

NrhbgnghUlfsid gugGfSffilNaahd XaT eiy cuhaTf Fzfjjd kjgG› mlltiz 3.1 ,y fhllgglLss gdfflbj JzLfSffilNaahd XaT eiy cuhaTf Fzfk kffFiwej kjgigg ngwWssij ,qF ftdffTk. xU gdfflbjJzil kwnwhU gdfflbj JzbdkJ vsjhf efujj KbAk vdgij ,J RlbffhlLfwJ.

,affcuhaT (kinetic friction)

nghUsid kJ nrYjjggLk Gw tir› XaT eiy cuhaT tiraid ngUk kjgigtl mjfkhf ,UfFkNghJ› nghUs guggd kJ efueJ nryyj JtqFk. mtthW efueJ nryYk nghUsid kJ› nghUs efueJ nryYk gugG xU cuhaT tiriar nrYjJk› mtTuhaT tirNa ,affeiy cuhaT vdggLk.

,ttaff cuhaT› rWfF cuhaT vdWk mioffggLk. nghUnshdiw ruhd jirNtfjjy ,aff› mgnghUsid kJ nraygLk ,aff cuhatid vzkjggwFr rkkhfTk mjwF vjujjiraYk xU tiraidg nghUsidkJ nrYjj NtzLk.

,affcuhaT

,aff cuhatid vzkjgG foffhZk rkdghlbdgb mika NtzLk vdW Nrhjidfsid mbggilay fzlwaggllLssJ.

Nrhbg nghUlfSfpilNaahd XaTepiy cuhaTf Fzfk

Nrhbg nghUsfs	XaTepiy cuhaTf Fzfk
fz zhb kwWk fz zhb	1.0
gdpfflb kwWk gdpfflb	0.10
v/F kwWk v/F	0.75
kuffliil kwWk kuffliil	0.35
,uggu lau kwWk fhdfupl rhiy	1.0
,uggu lau kwWk <ukhd rhiy	0.7

$f_k = m_k N$

,qF mkvdfF ,aff cuhaTf Fzfk kwWk N vdgJ nghUs efueJ nryYk gugG nghUspd kJ nrYjJk nrqFjJtpir.

NkYk $m_k < m_s$

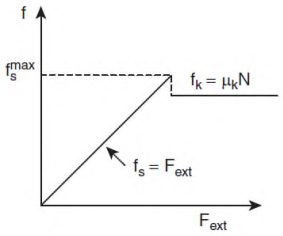
,jpypUeJ ehk mwpeJ nfhstJ vddntdpy ,aqFk nghUs mdiwj njhlueJ ,aqfitggijtpl› mgnghUspd ,affjijj njhlqFtJ fbdkhFk.

XaT epiy cuhaTkwWk ,affepiy cuhaT Mfpatwwpd rpwgGf$Wfs mlltiz 3.2 ,y nfhLffgglLssd.

XaTepiy cuhaT kwWk ,aff cuhatpd rpwgGf $Wfs

XaT epiy cuhaT	,aff cuhaT
nghUs efujnjhlqFtij vjpufFk	nghUs efUk gugigg nghUjJ nghUspd rhugpaffjij vjpufFk
njhLk guggpd mstpidr rhuejjpyiy nfhLffggLk tpirapd vz kjpgigr rhuejJ	njhLk guggpd mstpidr rhuejjpyiy tpirapd vz kjpgigr rhuejjpyiy
XaT epiy cuhaTf Fzfk mxdiw xdW njhLk gugG nghUlfspd jdikia (Nature of materials) rhuejpUfFk.	,aff cuhaTf Fzfk mkxdiw xdW njhLk gugGfspd jdik kwWk gugGfspd ntggepiy Mfpatwiwr rhuejpUfFk
Ropaypypy UeJ msN tiu css vej xU kjpggpidAk ngwwpUfFk.	,J vgnghOJk Ropl kjpggpidg ngwhJ. NkYk nghUs vej Ntfjjpy ,aqfpdhYk ,jdkjpgG vgnghJk mkfFr rkkhFk. (nghUspd Ntfk $10ms^{-1}$ ltpl Fiwthf css NghJ ,J nghUeJk vdgij epidtpy nfhssTk)
$f_s^{max} > f_k$ XaTepiy cuhaT tpirapd ngUk kjpgG mjpfkhf ,UfFk.	,affepiy cuhaT tpir Fiwthf ,UfFk
$m_k > m_s$ XaTepiy cuhaTf Fzfk mjpfkhd kjpgigg ngwwpUfFk.	,affepiy cuhaT Fzfk› Fiwthd kjpgigg ngwwpUfFk.

nghUspd kJ nrYjjggLk Gwtpirapidg nghUjJ VwgLk XaT epiy cuhaTtpir kwWk ,affepiy cuhaT tpirapd khWghL tiuglk 3.25 ,y fhllgglLssJ.



Gwtpirapidg nghUjJ XaT epiy cuhaT tpir kwWk ,aff cuhaT tpirapy VwgLk khWghL

glk 3.25 ypUeJ> XaT epiy cuhaT tpirahdJ> xU ngUk kjpgig milAktiu> ntspgGjjpypUeJ nghUspd kJ nrYjjggLk Gwtpirnahl NeufNfhlLj njhlugpy mjpfupfFk. nghUs ,aqfj njhlqFkNghJ ,affepiy cuhaT tpir XaT epiy cuhaT tpirapd ngUk kjpgigtplr rwNw Fiwthd kjpgigg ngWk. NkYk ,aff cuhaT tpir xU khwh kjpgigg ngwwpUggJld mJ nghUspd kJ nrYjjggLk ntspgGw tpiriar rhuejjyy vdgij epidtpy nfhssTk.

nghUs; xdwpid efujpj vspikahd Kiw vJ? mgnghUisj; jsStjh? mypyJ ,Oggjh?

nghUs xdiw ropKjy $\frac{p}{2}$ tiuapyhd xU Fwpggpll Nfhzjjpy jsSkNghJ> nghUspd kJ nrYjjggLk Gwtpiria F guggpwF ,izahf Fsinqvdwk guggpwFr nrqFjjhf F cosq vdWk ,U $Wfshfg gupffyhk. ,J glk 3.26 ,y fhllgglLssJ. nghUspd kJ nraygLk foNehffpa nkhjj tpir mg + Fcosq ,J nghUs kJ nraygLk nrqFjJ tpir mjpfupfFk vdgijf fhlLfpwJ. ,qF nrqFjJj jpiray vttpjkhd KLffKk ,yiy. vdNt> nghUspd kJ nraygLk nrqFjJtpir.

$$N_{push} = mg + F\cos q$$

nghUnshdiw qNfhzjjpy jsSjy

,jd tpisthf XaT epiy cuhatpd ngUk kjpgGk gpdtUk rkdghbdgb mjpfupfFk

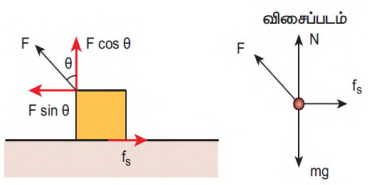
$$f_s^{\max} = m_s N_{push} = m_s (mg + F\cos q)$$

rkdghL (3.30) ypUeJ nghUisj jsStjd %yk efujJtjwW mjpf tpir Njitggl vdgJ Gydhfpwj.

nghUnshdiw Nfhzjjpy ,LfFkNghJ nghUspd kJ ehk nrYjJk tpirapid glk 3.27 ,y fhlbAssgb ,U $Wfshfg gupffyhk.

nghUspd kjhd nkhjj fONehfF tpir

$$N_{pull} = mg - F\cos q$$



nghUnshdiw q Nfhzjjy ,Ojjy

rkdghL 3.31 ypUeJ nghUs kJ nraygLk nrqFjJ tpir N_{pull} ,d kjpgG N_{push} ,d kjpgig tpl FiwNt vdgij mwpayhk. vdNt 3.29 kwWk 3.31 Mfpatwwpypue J xU nghUis efujJtjwFj jsStij tpl ,OggNj cspa topvdgJ GupfwJ.

cuhaTf Nfhzk

nrqFjJ vjpu tpir kwWk ngUk cuhaT tpir (f_s^{max}) Mfpa ,uzbd njhFgaDfFk (R) nrqFjJ vjputpir (N)fFk ,ilNaahd Nfhzk cuhaTf Nfhzk vdggLfpwJ.

glk 3.28 ypUeJ njhFgad tpir

$$R = \sqrt{\left(f_s^{max}\right)^2 + N^2}$$

$$\tan q = \frac{f_s^{max}}{N}$$

cuhaTf Nfhzk

cuhaTj njhluGfspypUeJ $f_s^{max} = m_s N$ Mf ,UfFkNghJ nghUs rWffj JtqFk mjid foffhZkhWk vOjyhk.

$$\frac{f_s^{ngUkk}}{N} = m_s$$

rkdghL (3.32) kwWk (3.33) Mfpatwwpypue J XaTepiy cuhaTwfhd Fzfk

$$m_s = \tan q$$

XaTepiy cuhatpwfhd Fzfk cuhaTf Nfhzjjpd lhdn[dl (tanq) kjpggpwFr rkkhf ,UfFk.

rWfpFfpNfhzkk; (Angle of repose)

glk 3.29 ,y fhlbathW nghUnshdW rhajsggugpy itffgglLssJ. ,rrhajsggugG fpiljjsjJld qNfhzjjpy cssJ. qtpd rpwpa kjpgGfSfF rhajsjjpy itffgglLss nghUs efuhJ. q tpd kjpgig gbggbahf cajjJk NghJ› xU Fwpggpll kjpggpwF› rhajsjjpy itffgglLss nghUs efuj njhlqFk. mfFwpggpll NfhzNk rWfFfNfhzk vdggLk. rhajsjjpy itffgglLss nghUs efuj njhlqFk. mfFwpggpll NfhzNk rWfFfNfhzk vdggLk. rhajsjjpy itffgglLss nghUs› fpiljjsg gugGld rhajsk VwgLjJk vfNfhzjjpy efuj njhlqFfpwNjh› mfNfhzNk› rWfFfNfhzk vdggLk.

rWfF Nfhzk

nghUspdkJ nraygLk gyNtW tpirfisf fUJf. Gtpaugtpir mg l ,U $Wfshfg gupffyhk. rhajsggugpwF ,izahd $W mg sinq kwWk rhajsggugpwF vjpu nrqFjjhd $W mg cosq MFk

rhajsggugg;wF ,izahfr nraygLk Gt;augG t;ira;d $W (mg sinq) nghUis foNehff; efujj Kawr;fFk. rhajsggugg;wF nrqFjjhfr nraygLk Gt;augG t;ira;d $W (mg cosq)› nrqFjJ t;ir (N) I rkd nraAk

vdNt N= mg cosq

nghUs efuj njhlqFk NghJ› XaTe;iy cuhaT t;ir

$$f_s = f_s^{\max} = \mu_s mg\cos\theta$$

,ej XaTe;iy cuhat;d ngUkkj;gG› g;dtUk rkdghlilAk e;iwT nraAk.

$$f_s^{\max} = mg\sin\theta$$

rkdghL (3.36) I (3.35) MytFffff;ilggJ›

$\mu_s = \sin\theta/\cos\theta = \tan\theta$

NkYk cuhaTfNfhz tiuaiwa;y;UeJ

$\tan\theta = \mu_s$

,qF vdgJ cuhaT Nfhzkhfk.

vdNt› rWfFfNfhzKk cuhaTf Nfhzkk xdWfnfhdW rkkhFk. Mdhy ,twwwf;ilNaahd NtWghL vddntd;y› rWfFfNfhzjij rhajsggugg;y klLNk gadgLjjKbAk. Mdhy cuhaTfNfhzjij vjifa gugg;Yk gadgLjjyhk.

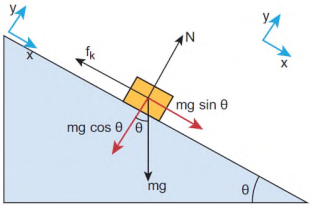
vLj¡Jf¡fhl¡L.

f;iljjsjJld 60° Nfhzjj;y rhaejss› rhajsjj;dkJ m e;iwAss nghUnshdW itffgglLssJ. mgnghUs $\frac{g}{2}$ vdw KLffjJld fonehff;r rWff; nrdwhy mgnghUs;d ,aff cuhaT Fzfjijf fhzf.

j¡T

nghUs rhajsjj;y rWff;r nryYkNghJ ,aff cuhaT VwgLf;wJ.

nghUs;dkJ foffzl t;irfs nraygLf;dwd mit jsjj;wF nrqFjjhf nraygLk. nrqFjJ t;ir› f;oNehff;r nraygLk Gt;augGt;ir kwWk jsjj;wF ,izahfr nraygLk ,aff cuhaT t;ir



x mrRjj;iray

$$mg\sin\theta - f_k = ma$$

Mdhy a = g/2

$$mg\sin 60^0 - f_k = mg/2$$

$$\frac{\sqrt{3}}{2}mg - f_k = mg/2$$

$$f_k = mg\left(\frac{\sqrt{3}}{2} - \frac{1}{2}\right)$$

$$f_f = \left(\frac{\sqrt{3}-1}{2}\right)mg$$

y-mrRjjpiray vttpj ,affKk ,yiy. vdNt nrqFjJ tpir (N) mG cos vdw $wpdhy rkd nraaggLfpwJ.

$$mg\cos\theta = N = mg/2$$

$$f_f = \mu_k N = \mu_k mg/2$$

$$\mu_k = \frac{\left(\frac{\sqrt{3}-1}{2}\right)mg}{\frac{mg}{2}}$$

$$\mu_k = \sqrt{3}-1$$

rWfFf; Nfhzjjpd; gadfs;

1. vWkGfis czthff nfhsSk FsshkGh (Antlion) vdggLk xU tifg Grrpapdk kzw guggpy rpW rpW Fopfis VwgLjjpapUfFk. mfFopFs nryYk vWgG Nghdwit jggpr nryy KbahJ. Fopapd mbapy fhjjpUfFk FsshkGrrp vWkgpid clnfhsSk. Fopfspd rhaNfhzk rWfFf NfhzjjpwFr rkkhf ,UfFkgb Fopfs cUthffgglbUggij glk 3.30 ,y fhzyhk.

Fsshk Grrpfspdhy (antlions) cUthffgglbUfFk kzwFopfs

2. Foeijfs MutKld tpisahLk rWfFku tpisahlL glk 3.31 ,y fhllgglLssJ. rWfF kujjpd rhaNfhzk mjd rWfFf Nfhzjij tpl mjpfkhf cssNghJ rWffp tpisahLtJ RygkhFk. mNj Neujjpy rWfFfNfhzk kpfTk mjpfkhf ,Uejhy rWffp tpisahLk Foeij kpf mjpf NtfjJld mbggugig milAk ,J FoeijfSfF cly tpypia VwgLjjptpLk.

rWfFkuk

cUSk; cuhaT (Rolling friction)

kdpj ehfupf tsurrpapy rffujjpd gqF kfjjhdJ. gazg nglbfspd (Suitcases) mbapy rffuqfisg nghUjjp mtwiw RkeJ nryyhky ,OjJr nrytij (Rolling

Suitcase) ehk mdwhl thotpy ghuffpNwhk. nghUnshdW guggpy ,aqFfpwJ vdpy mbggilapy mgnghUs guggpy rWffpr nryfpwJ. Mdhy rffuqfs cUStjd %yk guggpy ,aqFfpdwd.

rffuk guggpy ,aqFkNghJ› rffujjpd vgGsspgugigj njhLfpwNjh› mgGsspvgnghOJk XaTepiyapy ,UfFk. mjhtJ› rffujjpwFk› guggpwFk ,ilNa vttpjkhd rhugpaffKk ,yiy. vdNt cuhaT tpirAk kpffFiwT. mNj Neujjpy nghUnshdW guggpdkJ rffuqfs ,dwp nryYkNghJ› nghUSfFk guggpwFk ,ilNa xU rhugpaffk VwgLfpwJ. ,jd tpisthf mjpf cuhaTtpir VwgLfpwJ. ,jdhy nghUspid efujJtJ fbdkhFk. glk 3.32 cUSjypd cuhatpwFk› ,aff cuhatpwFk css NtWghlilr Rlbf fhlLfpwJ.

cUSjypd cuhaT kwWk ,aff cuhaT

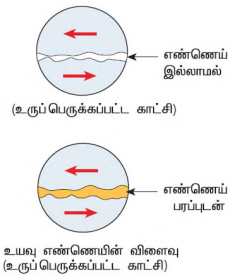
rWffyww cUSk ,affjjpy guggpidj njhLkGsspXaTepiyapy ,UggJ ,ylrpaepiyapy klLNk rhjjpakhFk. Mdhy eilKiwapy mtthW ,Uggjpyiy. nghUlfspdnefpoTj jdik (elastic) fhuzkhf jiuiaj njhLkGssprwNw jiuapy mOjjpkpffFiwthd cuhatpid VwgLjJfpwJ. ,J glk3.33 ,y fhllgglLssJ. vdNtthfdjjpd rffujjpwFk› rhiyapd guggpwFkpilNa cuhaTtpir VwgLfpwJ. ,tTuhaT› ,aff cuhait tpl kpfTk typik FiwejJ MFk.

cuhaitf; Fiwfpfk; Kiwfs;

cuhaT eilKiw thofifapy edik› jik ,uzilAk VwgLjJfpwJ. rpy #oepiyfspy cuhaT kpfTk mtrpakhdjhFk. Cuhatpd fhuzkhfjjhd ekkhy elff KbfpwJ. thfdqfspd rffuqfSfFk› rhiyapd guggpwFk ,ilNa VwgLk cuhaTtpirapd fhuzkhfjjhd thfdqfshy ,aqfKbfpwJ.

rffujjil mikgGfspy (braking systems) cuhaT kpf Kffpag gqfhwWfpwJ. ehk KwgFjpapy fwwthW ,uzL gugGfSfF ,ilNa rhugpaffk epfOkNghJ mqF cuhaTtpir VwgLfpwJ.

njhopwrhiyfspy css fduf ,aejpuqfspd gugGfs xdWld xdW rhugpaffjjpycssNghJ cuhaT VwglL ntgg tbtpy Mwwy ,offggLfpwJ. ,jdhy fduf ,aejpuqfspd nrapy jpwd FiweJ tpLfpwJ. ,tthW VwgLk ,aff cuhatpid Fiwggjwfhf caT vznzafs (lubricants) vtthW gadgLfpdwd vdgij glk 3.34 tpsfFfpwJ.



caT vznziag gadgLjjp ,aff cuhatpidf Fiwjjy

geJ jhqfp mikgG (Ball bearings) ,aejpuqfspy ,aff cuhaitf Fiwggjpy ngUkgqfhwWfpdwd. ,J glk 3.35 ,y fhllgglLssJ. ,uzL gugGfSfF eLNt geJ jhqfp mikgigg nghUjJtjd %ykhf ,uzLgugGfspd rhugpaffk eilngWk Neutfspy ,aff cuhatpid KOtJkhf jLjJ cUSjypd cuhaT klLNk geJ jhqfpmikggpdhy VwgLfpwJ. ehk KwgFjapy fwwthW cUSjypd cuhaT› ,aff cuhait

tpl kpff FiwT. vdNt ,aejpuqfspd Njakhdjijf FiwjJ geJ cUis mikgG mtwiw ezl fhyjjpwfF ,aqf itffpwJ.

epA+lld kwWk fypyNah thoej fhyflljjpy cuhaT tpirahdJ› GtpaugG tpir Nghdwnjhu ,awif tpir vdW ekgggllJ. Mdhy ,Ugjhk E}wwhzby› mZffs› vyfluhdfs kwWk GNuhllhdfs Nghdwtwiwg gwwpa mwpT› cuhaT tpir gwwpa Gupjiy khwwpaikjJ. cuhaT tpirahdJ czikapy rhugpaffjjpYss ,uzL gugGfspd mZffSfpilNaahd kpdfhejtpirahfk. edF tOtOgghffggll gugGfSk kEz zstpy (microscopic level) NkL gssqfisg ngwWssd. ,jid glk 3.36 tpsfFfpwJ.

geJ jhqfp mikgigg gadgLjjp ,aff cuhaitf Fiwjjy

cUgngUffggll gljjpy jsqfspd ruww jdik

vLj;Jf;fhl;L:

nghUnshdW khwhj jpirNtfjjpy fpiljjsg guggpy ,aqFfpdwJ vdf fUJf. ntspg Gwtpir mgnghUspd kJ nrayglL mjid khwhj jpirNtfjjpy ,affpdhy› mgnghUspd kJ nraygLk njhFgad tpirapd kjpggG vdd?

jpuT

nghUs khwhj jpirNtfjjpy ,aqFkNghJ mgnghUspd KLffk Rop. epA+lldpd ,uzlhk tpjpggb nghUspkkJ vttpjkhd njhFgad tpirAk nrayglt pyiy. ntspgGw tpirahdJ ,aff cuhatpdhy rkd nraaggLfpwJ.

tl;l ,af;fj;jpd; ,af;f tpirapay;

KwgFjpapy epA+lldpd tpjpfisg gadgLjjp nghUlfspd NeufNfhlL ,affjij vtthW gFgghaT nratJ vdW mwpeJ nfhzNlhk. ,Nj NghdW epA+lldpd tpjpfis tll,affjjpwF vtthW gadgLjjtJ vdW mwpeJ nfhstJk mtrpakhFk.

Vnddpy tll ,affk ek thofifapy jtpuff Kbahj xdwhFk. Gwtpir nrayglhYk myyJ nrayglhtpllhYk xU nghUshdJ NehfNfhlL ,affjij Nkwnfhssyhk. Mdhy nghUspdkJ tpir nrayglhy klLNk tll ,affjjpwf epA+lldpd Kjy tpjp vdw xdW ,yiy. mjhtJ nghUspdkJ tpir nrayglhky mgnghUspdhy tll ,affjij Nkwnfhss ,ayhJ. nghUspdkJ nraygLk tpir mgnghUspd jpirNtfjij %dW topfspy khwwpaikfFk.

1. jpirNtfjjpd jpiria khwwhkNyNa mjd vzkjpgig klLk khwWtJ. ,eepfotpy Jfs xNu jpirapay KLffjJld ,aqFk.

vLj;Jf; fhl;Lfs;

nrqFjjhff fNo tpOk nghUs› KLffjJld Neuhd rhiyapy nryYk thfdk

2. jpirNtfjjpd vzkjpgig (Ntfk) khwwhky mjd jpiria klLk khwWtJ. ,tthW ,aqFk ,affij ehk ruhd tll ,affk vdW miofpNwhk.

3. jpirNtfjjpd vzkjpgG (Ntfk) kwWk jpir ,ttpuzbYk khwwk Vwgllhy tllkww ,affk VwgLk (Non circular motion) vLjJffhlLfs

CQry› jd› Cry› es tllgghijaiy #haidr Rww› tUk Nfhsfs›d ,affk Nghdwit.

,gg›u›t›d ruhd tll ,affk kwWk ruww tll ,affqfisg gww› mw›ayhk.

ikaNehf¡F t›ir:

JfnshdW ruhd tllgghijaiy Rww› tUkNghJ tllikajij Nehff› tllgghija›d Muk to›ahf ikaNehfF KLffk VwgLk. e›A›lld›d ,uzlhk t›j›ggb KLffk Vwgllhy e›iyikf Fw›gghajijg nghUjJ Jfs›dkJ xU t›ir nraygl NtzLk. mtthW Jfs›d kJ nraygLk t›irNa ikaNehfF t›ir vdggLk.

myF 2 ,y ehk fwwgb› tllgghija›y ,aqFk Jfs›d kJ nraygLk ikaNehfFk KLffk $a = \frac{v^2}{r}$ MFk. ,kKLffk tllikajij Nehff›r nraygLf›wJ. e›A›lld›d ,uzlhk t›j›ggb› ikaNehfF t›ir

$$F_{cp} = ma_{cp} = \frac{mv^2}{r}$$

$$F_{cp} = \frac{\frac{1}{4}\acute{}(2)^2}{3} = 0.333N.$$

$$a_m = w^2 R_m$$

$$w = \frac{2p}{T}$$

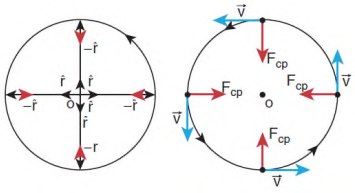
$$R_m = 60R = 60\acute{}6.4\acute{}10^6 = 384\acute{}10^6 m$$

,qF ikaNehfF t›ir vdgjd nghUs› Jfs tllgghija›y vqF ,Ugg›Dk mjd KLffk vgNghJk ikajij Nehff›Na ,UfFk vdgijf Fw›ff›wJ.

ntflu Fw›albd gb $\vec{F}_{cp} = -\frac{mv^2}{r}\hat{r}$

ruhd tll ,affjj›wF $\vec{F}_{cp} = -mw^2 r\hat{r}$

,qF-$\hat{r}$,d j›ir tll ikajij Nehff›f Fw›ff›wJ. NkYk ,JNt ikaNehfF t›ira›d j›iriaf Fw›ff›wJ. ,Jglk 3.38 ,y njs›thf Fw›gg›lLf fhllgglLssJ.



ikaNehfF t›ir

ikaNehfF t›ir› Gt›augG t›ir myyJ RUs t›y t›ir Nghdw xU ,awif t›irayy vdgij ,qF ftd›ff NtzLk. ikajij Nehff›r nraygLk xU t›ir vdNw milffggLf›wJ. Gt›augG t›ir› fa›ww›d ,Ot›ir› cuhaT t›ir› $Yk t›ir Nghdw VNjDk xU t›irNa ikaNehfF t›irahfr nraygLf›wJ.

1. nkyypa fapwpd xU Kidapy flb RowwggLk fyypd ,affjjpy; fapwpd ,Otpirna ikaNehfF tpirahfr nraygLfpwJ. nghOJNghfFg Gqfhffspy ,affggLk ,uhlbdk Nghdw Rowrp ,affjjpy; ,uhlbdjijj jhqfk ,UkGf fkgpfspd ,Otpir ikaNehfF tpiria mspffpwJ.

2. Gtpapidr Rwwp tUk nrawiff Nfhspd ,affjjpy; Gtp nrawiff Nfhspd kJ nrYjJk GtpaugG tpirNa ikaNehfF tpirahfr nraygLfpwJ. nrawiffNfhs ,affjjpwF epA+lldpd ,uzlhk tpjpia fofhZkhW vOjyhk

$$F = Gtp<ugG\ tpir = \frac{mv^2}{r}$$

,qF r vdgJ Gtapd ikajjpypUeJ nrawiffNfhs css njhiyT

Roy ,affg nghUsfs

m – vdgJ nrawiffNfhspd epiw
v – vdgJ nrawiff Nfhspd Ntfk

3. fhu xdW tlltbtgghijapy nryYk NghJ; ikaNehfF tpirahdJ fhupd laUfFk; rhiyfFk ,ilNa VwgLk cuhaT tpiraphy VwgLfpwJ.

tll tbtgghijapy nryYk fhu

,eepfotpwfhd epA+lld ,uzlhk tpjpia foffhZkhW vOjhyk

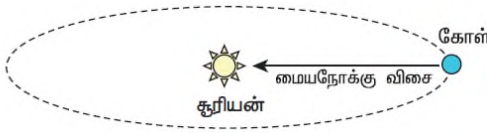
$$cuhaT\ tpir = \frac{mv^2}{r}$$

m – vdgJ fhupd epiw
v – vdgJ fhupd Ntfk
r – vdgJ ghijapd tisT Muk

fhutisTg ghijapy nryYk NghJk; ikaNehfF tpiriag ngWfpwJ. fhupd laUfFk; rhiyfFk ,ilNa VwgLk cuhaT tpiraphy ,kikaNehfF tpir VwgLfpwJ. ,J glk 3.41 ,y fhllgglLssJ.

fhupd laUfFk; rhiyfFk ,ilNa VwgLk cuhaT tpiraphy VwgLk ikaNehfF tpir

4. Nfhsfs #hpaidr Rwwp tUkNghJ mit #hpadpd ikajij Nehffpa; xU ikaNehfF tpiriag ngWfpdwd. ,qF Nfhsfspd kjhd #hpadpd <ugG tpir; ikaNehfF tpirahfr nraygLfpwJ. ,J glk 3.42,y fhllgglLssJ.



#hpadpd <ugG tpiraphy #hpaidr RwwptUk Nfhspd kJ VwgLk ikaNehfF tpir

,eepfotpwfhd epA+lldpd ,uzlhk tpjpia gpdtUkhW vOjyhk

Nfhsfsd kJ #hadd <ugGtir = $\frac{mv^2}{r}$

vLj;Jf;fhl;L:

0.25 kg epiwAila fy xdW fawwd Kidaay fllgglL 2ms^{-1} Ntfjjy 3m MuKila ruhdtll ,affjij Nkwnfhsfwj. fyyd kJ nraygLk ,Otiraidf fzLgb

jtuT:

$$F_{cp} = \frac{\frac{1}{4} \times (2)^2}{3} = 0.333N$$

vLj;Jf;fhl;L

eyh› Gtaid tllgghijfF xjj xU ghijaay 27.3 ehlfsy KOikahfr Rwwtuf wJ. Gtaid Muk 6.4x10^6 m vdy eyhtd kJ nraygLk ikaNehfF KLffjijf fhzf.

jtuT

ikaNehfFKLffk $a = \frac{v^2}{r}$,r rkdghL ntsggilahfNt eytd Ntjijr rhuejJ. ,ej Ntfjij fzffLtJ RwWf fbdkhFk. vdNt ehk gdtUk rkdghlbidg gadgLjjyhk.

$$w^2 R_m = a_m$$

,qF a_m vdgJ Gtaid <ugG tiradhy› eyh ngWk ika NehfF KLffkhFk.

wvdgJ Nfhzj jirNtfk

R_m vdgJ Gtayiuej eyh tiu css njhiyT. ,J Gtaid Mujijg NghdW 60 klqfhFk.

$$R_m = 60R = 60 \times 6.4 \times 10^6 = 384 \times 10^6 m$$

ehkwe gb Nfhzj jirNtfk $w = \frac{2p}{T}$

NkYk T =27.3 ehlfs =27.3x24x60x60

=2.358 x 10^{6}s

,kkjghGfis KLffr rkdghlby guja Lk NghJ $a_m = w^2 R_m$

$$= \left(\frac{2\pi}{T}\right)^2 R_m$$

$$= \frac{4\pi^2}{T^2} R_m$$

$$a_m = \frac{\left(4\pi^2\right)\left(384 \times 10^6\right)}{\left(2.358 \times 10^6\right)} = 0.00272 ms^{-2}$$

Gtpia Nehffp epyhtpd ikaNehfF KLffk $0.00272 ms^{-2}$

rup rkkhd tl;lr; rhiyapy; nry;Yk; thfdk;

thfdnkhdW tisTgghijapy nryYk NghJ> mtthfdjjpd kJ ikaNehfF tpir nraygLfpwJ. thfdjjpd lau kwWk rhiyapd NkwgugG ,twwpwfpilNaahd cuhaT tpirapd fhuzkhf ,kikaNehfFtpir VwgLfpwJ. m epiwAila thfdnkhdW r MuKila tlltbtg ghijapy v Ntfjjpy ,aqFfpwJ vdpy> mtthfdjjpd kJ %dW tpirfs nraygLfpdwd. mit glk 3.34 ,y fhllgglLssd.

1) foNehffpr nraygLk Gtp<ugGtpir (mg)
2) Nky Nehffpr nraygLk nrqFjJtpir N
3) Rhiyapd fpiljjsg guggpd topNa csNehffpr nraygLk cuhaT tpir (F_S)

rhiy fpiljjskhf ,Uggpd> nrqFjJ tpirAk> Gtpaugd tpirAk xdWfnfhdW rkk kwWk vjpnujpuhf ,UfFk. thfdjjpd laUfFk> rhiyapd guggpwFk ,ilNa VwgLk cuhaT tpir Njitahd ikaNehfF tpiria mspffpwJ. ,kikaNehfF tpir tllrrhiyapd ikajij Nehffpr nraygLfpwJ.

rup rkkhd tllgghijapy nryYk thfdjjpd kJ nraygLk tpirfs

ehk KwgFjapy fwwgb> epiy cuhaTtpir Ropl Kjy ngUk kjpgG tpir tiu vej kjpgigAk ngwyhk. vdNt

,qF ,uzL epgejidfs rhjjpakhfpwJ:

a. thfdk rWffhky tistjwfhd

epgejid $\frac{mv^2}{r} £ mg$,

myyJ $m = \frac{v^2}{rg}$ myyJ $\sqrt{rg} = v$

(ghJfhgghf tisjjy)

tisTrrhiyapy> thfdk tistjwFj Njitahd ikNehfF tpiria epiy cuhaT nfhLfpwJ. vdNt thfdjjpd lau kwWk rhiyapd gugG ,twwpwfpilNaahd epiy cuhaTf Fzfk thfdk rWffhky tisTgghijapy tistjwfhd ngUkNtfjij epuzaffpwJ.

b. thfdk rWfFtjwfhd epgejid

$\frac{mv^2}{r} > m_s mg$, myyJ $m_s < \frac{v^2}{rg}$ (rWfFjy)

thfdk tistjwFj Njitahd ikaNehfF tpiria epiy cuhaTtpirapdhy nfhLff ,aytpyiy vdpy› thfdk rWffj njhlqFk

vLj¡Jf¡fhl¡L:

Muk 10 m kwWk epiy cuhaTf Fzfk 0.81 nfhzl ruprkkhd tlltbtr rhiy xdiwf fUJf. mrrhiyapd %dW fhufs (A›B kwWk C) KiwNa 7 ms^{-1}› 8 ms^{-1}› 10 ms^{-1} Ntfjjpy nryfpdwd. ,twWs vej fhu tll tbtrrhiyapy nryYk NghJ rWffp tpOk? (g=10 ms^{-2})

ju¡T

rup rkkhd tllrrhiyapy nryYk thfdk rWffhky ,Uffj NJitahd epgejid› thfdjjpd Ntfk (v) ,d kjpgG $\sqrt{m_s rg}$ I tplf FiwthfNth myyJ rkkhfNth ,Uff Ntz Lk.

$$v £ \sqrt{m_s rg}$$

$$\sqrt{m_s rg} = \sqrt{0.81 \acute{} 10 \acute{} 10} = 9 ms^{-1}$$

c. fhupidg nghUjjtiu $\sqrt{m_s rg}$,d kjpgGfhupd Ntfk v I tplf FiwT. fhu A kwWk B ,uzLk ghJfhgghf tisAk› Mdhy fhu C ,d Ntfk› epuzapffggll Ntfjij tpl ($\sqrt{m_s rg}$) mjpfkhf cssjhy mJ rWffp tpLk.

ntsptpspkG caujjggl¡l rhiy

ruprkkhd tllr rhiyapy› thfdqfs rWffp tpgjJfFsshtJ› rhiyg guggpd epiy cuhaTf Fzfjij rhuejpUffpwJ. ,ej epiy cuhaTf Fzfjjpd ngUk kjpgG guggpd jdikiar rhuejjhFk. ,jd fhuzkhf thfdqfSfF VwgLk tpgjjpidj jLggJwfhfr rhiyapd ntsptpspkG clGw tpspkig tpl rwNw caujjp mikffgglbUfFk. ,jwF ntsptpspkG caujjggll rhiy (banking of tracks) vdW ngau. ntsptpspkG caujjgglbUggjhy ,J xU rhajsk NghdW mikAk. fpiljjsg gugGld ,ejr rhajsk VwgLjJk Nfhzk ntsp tpspkGf Nfhzk (banking angle) vdggLk.

thfdqfs rWfFtijj jtpuggjwfhf ntsptpspkG rwNw caujjgglbUfFk rhiy

fpiljjsjJldq Nfhzjjpy css rhiyapd gugigf fUJf. nrqFjJtpir› nrqFjJ mrRld ,NJ qNfhzjij VwgLjJk. ,rrhiyapy nryYk fhu xdW tisAkNghJ mjd kJ ,uzL tpirfs nraygLk.

m. foNehffpr nraygLk Gtpaugg tpir (mg)

M. rhiyapd guggpwFr nrqFjjhfr nraygLk nrqFjJ tpir (N)

nrqFjJ tpir N l ,uzL $Wfshfg gpuffyhk. ,it N cosq kwwk N sinq MFk. ,it glk 3.44 ,y fhllgglLssd. N cosq $W› foNehffpr nraygLk Gtpapugg tpiria (mg) rkd nrafpwJ. N sinq $W Njitahd ikaNehfF tpiriaf nfhLffpwJ.

epA+lldpd ,uzlhk tpjpiag gadgLjjp gpdtUk rkdghLfis mikffyhk

$$N\cos\theta = mg$$

$$N\sin\theta = \frac{mv^2}{r}$$

,ttpU rkdghLfisAk tUfFk NghJ $\tan\theta = \frac{v^2}{rg}$ vdf fpilfFk

$$v = \sqrt{rg\tan\theta}$$

ntspt spkGf Nfhzk kwWk rhiyapd tisT Muk (r) ,ttpuzLk tisTr rhiyapy ghJfhgghf thfdqfis ,aff Ntzba Ntfjij (v) jukhdpffpdwd. thfdk xdwpd Ntfk epuzapffgggll Ntfjijtpl mjpf Ntfjjpy nryYk NghJ rhiyapd ntspgGwjij Nehffp rWffj njhlqFk. Mdhy cuhaT tpir nrayglL $Ljy ikaNehfF tpirapidf nfhLjJ ntspgGwr rWfFjiyj jLfFk. mNj Neujjpy fhupd Ntfk epuzapffgggll Ntfjij tpl Fiwthf ,Uggpd fhu clGwjij nrayglL ikaNehfF tpiriaf FiwjJ clgwjij Nehffp rWfFtijj jLfFk. ,UggpDk fhupd Ntfk kpf mjpfk vdpy cuhaT tpirapdhy fhu rWfFtijj jLff KbahJ.

vLj;Jf;fhl;L

20 m MuKila tllrrhiyiaf fUJf. mjd ntsptspkGf Nfhzk 15° vdf. mrrhiyapy nryYk thfdk eOtp tpohky ghJfhgghf tistjwFj Njitahd Ntjijf fhzf.

jug;T

$$v = \sqrt{(rg\tan\theta)} = \sqrt{20' 9.8' \tan 15^0}$$

$$= \sqrt{20' 9.8' 0.26} = 7.1 ms^{-1}$$

rWffp tohky ghJfhgghf tistjwFj Njitahd Ntdk = $7.1 ms^{-1}$

ikatpyf;F tpir

tll ,affjij ,UNtW Fwpgghaqfisg nghUjJ MaT nraayhk. mtwWs xdW epiykf FwpgghakhFk. ,fFwpgghak XaTepiy myyJ ruhd ,affepiy ,twWs VNjDk xU epiyapy ,UfFk. ,qF ,affjjpy css nghUlfs epA+lldpd ,aff tpjpfSfFk flLgglL ,aqFk. kwnwhU Fwpgghak KLffkilfpdw› epiykkww Fwpgghakhd Rowrpf FwpgghakhFk. (rotational frames). tll ,affjjpid ,ttpU Fwpgghaqfisg nghUjJ nttNtW fzNzhlljjpy MaT nraayhk. Rowrpf Fwpgghajjpy epA+lldpd Kjy tpjp kwWk ,uzlhk tpjpiag gadgLjJk NghJ xU Nghypahd tpiria (Pseudo force) NrujJf fUj NtzLk. ,ejg Nghypahd tpirNa ikatpyfF tpirahFk. ,jjifa ikatpyfF tpir Rowrpf Fwpgghajijg nghUjJ nghUspd kJ nraygLk. ikatpyfF tpirapidg GupeJ nfhss foffzl tpsffk ngupJk Jiz GupAk.

nkyypa fapwwpd xU Kidapy fllgglL Rowrp ,affjij Nkwnfhs Sk fy xdiwf fUJNthk. XaTepiyapYss epiykf Fwpgghajijg nghUjJ fyypd Nfhzj jpirNtfk w vdf. w Nfhzj jpirNtfjjpy fyYld NrueJ Rowrp ,affjjpYss kwnwhU FwpgghajjpypUeJ fyypidg ghufFkNghJ mffy XaTepiyapy ,UggJ NghdW NjhdWk

Rowrpf Fwpgghajijg nghUjJ› tllikajij Nehffpr nraygLk ikNehfF tpirahd $-mw^2r$ cld› mjwFr rkkhd vjpujpirapy ntspNehffpr nraygLk $+mw^2r$ vdw tpir fyypd kJ nraygLfpwJ. vdNt Rowfp ,affjjpYss Fwpgghajijg nghUjJ fyypd kJ nraygLk njhFgad tpir Ropahfk vdgij ,J fhlLfpwJ. ($-mw^2r+mw^2r=0$) ,qF ntspNehffpr nraygLk $+mw^2r$ tpirfF ikatpyfF tpir vdW ngau.

ikatpyfF vdgjd nghUs ikajij tplL ntspNehffpr nraygLtJ vdgjhFk. Rowrpf Fwpgghajijg nghUjJ fyypd Rowrp ,affjij MaT nraAkNghJ klLk ikatpyfF tpir fyypd kJ nraygLtjhfj NjhdWk. ,ffhuzjjpdhy tpir vdW miofpNwhk. ,gNghypahd tpir vej %yjjpypUeJk NjhdWtjpyiy (it has origin). ,qF Nghyp tpir NjhdWtjwfhd fhuzk› ehk fUJk Rowrp Fwpgghak xU epiykkww Fwpgghak vdgjhNy MFk.

epiykf Fwpgghajijg nghUjJ fyypd Rowrp ,affjij MaT nraAkNghJ ikaNehfF tpir klLNk nraygLk. ,kikaNehfF tpir fy fllgglbUfFk nkyypa fapwwpd ,Otpirahy ngwggLfpwJ. Rowrp Fwpgghajij nghUjJ Rowrp ,afff fzfFfisj juT nraa tiuaggLk jdpjj nghUspd tpirgglqfspy glk 3.45 ,y cssthW ikatpyfF tpir fzbgghff fhllggl NtzLk.

ikatpyfF tpirAld tiuaggll jdpjj nghUspd tpirgglk

ika tpyfpF tpirapd; tpisTfs;

ikatpyfF tpir xU Nghypahd tpirahf ,UggpDk mjd tpisTfs czikahFk. fhu xdW tisTgghijapy jpUkGkNghJ› fhupd csNs mkuejpUggtu xU ntspGwtpiria czuthu. mttpir mtiu ntspNehffpj jsSk. ,tntspNehffpa tpiriaAk ikatpyfF tpir vdNw mioffyhk. fhupd ,UfiffFk› mkuejpUfFk egUfFk ,ilNa css NghJ khd cuhaTtpir ,Uejhy mtu ntspNa jssggLtJ jtpuffg gLfpwJ.

NeufNfhllLg ghijapy nrdW nfhzbUfFk fhu xdW jpBnudW jdghijapypUeJ tisAkNghJ› fhupd csNs epiyahfg nghUjjgglhj nghUs› jpirapy epiykg gzgpd (Inertia of direction) fhuzkhf NeufNfhllLg ghijapNyNa njhlueJ ,aqf KawrpfFk.

katpyfF tpirapd tpisT

,ttpaffjij epiykf Fwpgghajjpypy UeJ ghufFk NghJ glk3.46 ,y fhlbAssthW NeuNfhlL ,affkhjj njhpAk. Mdhy Rowrpf Fwpgghajjpypy UeJ ghufFkNghJ ,affk ntspNehffpr nrytJ NghdW NjhdWk.

RoYk Nkilapy epdW nfhzbUfFk egu ntspGw ikatpyfF tpiria czuthhu. ,jd fhuzkhf Nkilapypy UeJ mtu ntspNa jssggl thagG mjpfk. epdW nfhzbUfFk egUfFk› NkilfFkhd cuhaTtpir ntspNehffpj jssggLk tpirapidr rkd nraag NghJkhdjyy. ,jidj jtpuggjwfhf Nkilapd ntspGw tpspkG rwNw NkyNehffp caujjgglbUfFk. ,t cauT epdW nfhzbUfFk egupd kJ xU nrqFjJ tpiriar nrYjjp mtu ntspNa tpOtijj jLfFk. ,J glk 3.47 ,y fhllgglLssJ.

Gtpapd; Rowrpahy; VwgLk; ikatpyfpF tpir

Gtpapid xU epiykf Fwpgghakhff fUjpdhYk cz ikapy mtthW ,yiy. Gtp wvdw Nfhzj jpirNtfjjpy jd mrrpidg nghUjJ jdidjjhNd Rwwp tUfpwJ. Gtpggugpgpy Yss vej xU nghUSk (Rowrpf Fwpgghajjpy css nghUs) ikatpyfpF tpiria czUk. ,ikatpyfpF tpir Roy mrrpypUeJ kpfr rhpahf vjpu jpirapy nraygLtjhfj NjhdWk. ,J glk 3.48 ,y fhllgglLssJ

Gtpggugpgpy epdW nfhzbUfFk kdpjupd ikatpyfpF tpir $F_{cf} = mw^2r$

,qF r vdgJ Roy mrrpwFk kdpjDfFk ,ilNa css nrqFjJj njhiyT. glk 3.48 ,y fhllgglLss nrqNfhz KfNfhzjjpypUeJ njhiyT $r = R\cos q$.

,qF R vdgJ Gtpapd Muk.

NkYk qvdgJ kdpjd epdW nfhzbUfFk Gsspapy Gtpapd FWfFf NfhL (latitude) MFk.

vLj;Jf;fhl;L

nrdidapYss 60 kg epiwAila kdpjupd kJ nraygLk ikatpyfpF tpiriaf fhzf

(nfhLffgglliit: nrdidapy FWfFf NfhL q=13˚)

jpuT

ikatpyfpF tpir $F_{cf} = mw^2 R\cos q$

Gtpapd Nfhzj jpirNtfk (w) $= \frac{2p}{T}$

,qF T vdgJ Gtpapd miyT Neuk (24 kzpNeuk)

$$w = \frac{2p}{24 \times 60 \times 60} = \frac{2p}{86400}$$
$$= 7.268 \times 10^{-5} rad\,\sec^{-1}$$

Gtpapd Muk R = 6400 km =6400x10³m

nrdidapd FWfF NfhL (Latitude) =13˚

$$F_{cf} = 60 \times (7.268 \times 10^{-5})^2 \times 6400 \times 10^3$$
$$\times \cos(13^0) = 1.9678N$$

60 kg epiwAila kdpjnuhUtu czUk ikatpyfpFtpir Njhuakhf 2 epA+lldhFk. Mdhy Gtpapd <ugG tpirapd fhuzkhf 60 kgepiwAila mkkdpju czUk tpir = mg = 60 x 9.8 = 588 N. ,ej tpiriatpyfpF tpiria tpl kpf mjpfk.

ikaNehf;F tpir kwWk; ikatpyf;F tpir – Xu; xggL:

ikaNehfF tpir kwWk ikatpyfF tpir Mfpatwwpy rpwgGf $Wfs mlltiz 3.4 ,y xggplLf fhllgglLssd.

ikaNehfF tpir kwWk ikatpyfF tpir ,twwpd rpwgGf $Wfs	
ikaNehfFtpir	ikatpyfFtpir
Gtpaug Gtpir› fkgpad ,Otpir› nrqFjJtpir Nghdw Gstpirfspdhy nghUspd kJ nrYjjggLk czik tpirahFk	,J Nghypahd myyJ nghaahd tpirahFk. ,ttpir Gtpaug Gtpir› ,Otpir› nrqFjJ tpir Nghdw Gw tpirfspdhy NjhdwhJ.
epiyk kwWk epiyk kww Fwpgghaqfs› ,uzbYk ,ttpir nraygLk	epiykkww RoYk Fwpgghaqfspy klLNk ,ttpir nraygLk
Roy mrrpid Nehffpr nraygLk tllgghij ,affjjpy tlljjpd ikajij Nehffp nraygLk $\left\|F_{cp}\right\| = m\omega^2 r = \frac{mv^2}{r}$	Roy mrrpypUeJ ntspNehffpr nraygLk. NkYk tll ,affjjpy tllikajjpypUeJ Mujjpd topNa ntspNehffpr nraygLk $\left\|F_{cf}\right\| = m\omega^2 r = \frac{mv^2}{r}$
,J xU czikahd tpir. ,jd tpisTfSk czikahdit	,J xU Nghyptpir. Mdhy ,jd tpisTfs czikahdit.
,uzL nghUlfSffpilNaahd cwNt (interation) ikaNehfF tpirfF mbggilahf mikfpwJ	xU nghUspd epiykj jdikNa (inertial property) ikatpyfF tpirfF mbggilahf mikfpwJ. ,ttpir nghUlfSffpilNaahd cwthy (interaction) NjhdwhJ. epiykf Fwpgghak xdwpy ,aqFk nghUspd epiyk ,affk jhd› Rowrpf Fwpgghajjpy ikatpyfF tpirahfj NjhdWfpwJ.
epiykf Fwpgghajjpy jdjjnghUspd tpirgglk tiuAkNghJ› ikaNehfF tpiria Fwpggpl NtzLk.	epiykf Fwpgghajjpy ikatpyfF tpir ,yiy RoYk Fwpgghajjpy› ikaNehfF tpir kwWk ikatpyfFtpir ,uzilAk jdpjj nghUspd tpirgglpjjpy Fwpggpl NtzLk.

Ntiy› Mwwy; kwWk; jwd;
(Work, Energy and Power)

mwpKfk;

mdwhl thotpy Ntiy vdw nrhy gyjuggll jUzqfspy gadgLjjggLfwJ. ,J cly rhuej Ntiy kwWk kdk rhuej Ntiy Mfpa ,uzilAk FwpfFk. czikapy vej xU nraygh Lk nghJthf Ntiy vdNw mioffggLk. Mdhy ,awgpaypy Ntiy vdw nrhy Jyypakhd tiuaiwiaf nfhzLss xU ,ay msthff fUjggLfwJ. xU nghUspd kJ nraygLjjggll tpir mjid ,lkngaur nrajhy tpirapdhy Ntiy nraaggLfwJ. Ntiy nratjwfhd jwd Mwwy vd tiuaWffggLfwJ. vdNt NtiyAk MwwYk xjj gupkhzjijg ngwWssd. ,awgpaypy Mwwyhd J ,aejpu Mwwy› kpd Mwwy› ntgg Mwwy› mZffU Mwwy Nghdw gyNtW tbtqfspy cssd. gy ,aejpuqfs xU tifahd Mwwiy vLjJfnfhzL NtW tifahd Mwwiy ntspggLjJfpdwd. ,gghlg gFjpapy Kffpakhf ,aejpu Mwwypd ,U tif Mwwyfshd ,aff Mwwy kwWk epiy Mwwy Mfpatwiwf fhzNghk. mLjJ tpthjpffggl ,UggJ› Ntiy nraAk tjk myyJ Mwwy ntspaplggLk tjk MFk. Ntiy nraaggLk tjk jwd vdggLk. fupfnfl tpisahlby xU rfjpthaej mb vdgJ klilahy geij Ntfkhf mbggijf Fwpffwj. ,ejg ghlggFjpahdJ Ntiy› Mwwy kwWk jwd Mfpa %dW ,ay msTfs kwWk mtwwpd Kffpajtk Fwpjj xU eyy Gupjiy tsufFk Nehffjijf nfhzLssJ.

Ntiy (Work)

xU nghUspd kJ nraygLk $\vec{F}$ vdw tpir mjid $d\vec{r}$ vdw ,lngaurrp VwgLjjp efujJtjhff fUJNthk.

fzpjtpaypdgb› nghUspd kJ tpirapdhy nraaggll Ntiy (W) gpdtUkhW vOjggLfwJ.

$$W = \vec{F}.d\vec{r}$$

tpirapdhy; nraaggl;l Ntiy

,qF $\vec{F}.d\vec{r}$,d ngUffygyd xU]Nfyu ngUffy myyJ Gsspg ngUffy MFk. ,U ntflufspd]Nfyu ngUffy gyd xU]Nfyu kjpgghFk. (gFjp 2.5.1 lf fhzf). vdNt nraaggll Ntiy xU]Nfyu msthFk. ,J vzkjpgig klLk ngwWssJ kwWk jpirawwJ. SI myF Kiwapy nraaggll Ntiyapd myF N m myyJ [y (J) MFk. mjd gupkhz thagghL [ML^2T^{-2}] MFk.

$$W = F\,dr\cos\theta$$

($\vec{a}.\vec{b} = ab\cos\theta$ vdgjhy). ,qF qvdgJ nghUspd kJ nraygLjjggll tpirfFk mejgnghUspd ,lngaurrpfFk ,ilNa css Nfhzkhfk.

tpirapdhy nraaggll Ntiy vdgJ tpir ($\vec{F}$) ,lngaurrp ($d\vec{r}$) kwWk mtwwpwfpilNa css Nfhzk qMfpatwiw rhuejJ.

fofzl NeuTfspy nraaggll Ntiy Ropahfk.

(i) tpir RopahFk; NghJ (F = 0)

cjhuzkhf› cuhatww xU fpiljjsg guggpy khwh jpirNtfjjpy efUk (cuhaT ,yyhjjhy) xUnghUs njhlueJ ,aqfpf nfhzNl ,UfFk. (,J xU ,ylrpa (ideal) #oepiy)

(ii) ,lgngaurrp RopahFk; NghJ (dr = 0)

cjhuzkhf› jplkhf css xU Rtupd kJ tpir nrYjjggllhy tpirahdJ vej ,lgngaurrpiaAk VwgLjjhJ.

(iii) tpirAk ,lgngaurrpAk xdWfnfhdW nrqFjjhf cssNghJ (q = 90°).

xU nghUshdJ fpiljjsj jpirapy efUkNghJ Gtpaug Gtpir (mg) nghUspd kJ Ntiy VJk nraahJ› Vnddpy mJ ,lgngaurrpfF nrqFjjhf nraygLfpwJ.

tll ,affjjpy css nghUspdkJ nraygLk ikaNehfF tpirahdJ Ntiy VJk nraahJ. Vnddpy mJ vgNghJk ,lgngaurrpfF nrqFjjhf cssJ.

nfhLffggll tpir (F) kwWk ,lgngaurrp (dr) fF njhFjJssthW mtwwpwfpilNa css Nfhzkq MdJ nraaggll Ntiyapd kjpgig KbT nrafpwJ.

tpirapdhy nraaggLk vjpufFwp NtiyfF gy cjhuzqfs cssd. fhygeJ tpisahlby› tuu (Goal keeper) mtiu Nehffp tUk geij xU tpiriar nrYjjpg gpbffpwhu. mttpirahdJ gejpd ,affjjpwF vjpujpirapy geJ mtuJ iffspy XaTepiyfF tUk tiu nrYjjggLfpwJ. tpiriar nrYjJk Neujjpy mtu gejpdkJ vjpuNtiy nrafpwhu. ,ejg ghlggFjpapy NkYk gy vjpuNtiyffhd #oepiyfs gwwp fwgNghk.

vLj;Jf;fhl;L

xU nglb 25 N tpirapdhy 15 m ,lgngaurrp VwgLkhW ,OffggLfpwJ. tpirfFk ,lgngaurrpfFk ,ilNa css Nfhzk 30° vdpy tpirapdhy nraaggll Ntiyiaf fhzf.

jpuT

tpir F = 25 N

,lgngaurrp dr = 15 m

FkwWk dr ,ilNa css Nfhzk q = 30° nraaggll Ntiy W = F dr cos q

$$W = 25 \times 15 \times \cos 30° = 25 \times 15 \times \frac{\sqrt{3}}{2}$$

W = 324.76 J

Nfhzk (q) kwWk; Ntiyapd;ik jd;ik		
Nfhzk (q)	cosq	Ntiy
q = 0°	1	NeufFwp› ngUkk
0 < q < 90° (FWqNfhzk)	0< cosq < 1	NeufFwp
q =90° (nrqNfhzk)	0	Ropl
90°< q < 180°	-1 < cosq < 0	vjpufFwp

q=180°	-1	vjufFw ngUkk

khwh tiraidhy nraaggliL Ntiy

xU nghUsid kJ F vdw khwh tir nraygLkNghJ tiraidhy dr vdw riW ,lngaurrpia VwgLjjr nraaggll riW Ntiy dWffhd njhluG

$$dW = (F\cos q)\,dr$$

njhlff epiy r_i Kjy ,Wjp epiy r_f tiu ,lngaurrp VwgLjj nraaggLk nkhjj Ntiy

$$W = \int_{r_i}^{r_f} dW$$

$$W = \int_{r_i}^{r_f} (F\cos q)dr = (F\cos q)\int_{r_i}^{r_f} dr$$

$$= (F\cos q)(r_f - r_i)$$

fo css gugG khwhj tiraidhy nraaggll Ntiyiaf Fwpffpwj.

khwhj tiraidhy nraaggliL Ntiy

vLj;Jf;fhl;L

epiwAss xU nghUs 5 m caujjpy ,UeJ jiuapy tpOfpwJ. Gtpaugg tiraidhy nghUsidkJ nraaggll Ntiy vdd? (fhwpd jiliag Gwffzpffjk. GtpaugG KLffk g = 10 ms^{-2} vdf nfhsf).

jug;T

,eNeutpy nghUsid kJ nraygLk tpir fo Nehffpa GtpaugG tpir $m\vec{g}$ MFk.,J khwh tirahFk.

GtpaugG tiraidhy nraaggll Ntiy

$$W = \int_{r_i}^{r_f} \vec{F}.d\vec{r}$$

$$W = (\cos q \int_{r_i}^{r_f} dr = (mg.\cos q)(r_f - r_1)$$

NkYk nghUshdJ gljjpy fhlbAssthW foNehffpa GtpaugG tiraid $\vec{F} = m\vec{g}$ jpiraiy efUfpwJ. vdNt mtwwpwfpilNa css Nfhzk q = 0°, cos0° = 1 kwWk ,lngaurrp $(r_f - r_i)$ = 5 m

$$W=mg(r_f - r_1)$$

$$W = 2 \times f \times 5 = f$$

vdNt nghUspd kJ nraygLk Gtpaugg tpiraphy nraaggll Ntiy NeufFwp kjpgigg ngWfpwJ.

vLj;Jf;fhl;L

gljjpy fhlbAsstW epiw m = 1kg nfhzl xU nghUs q= 30°rhaTfNfhzk nfhzl 10m esKss cuhatww jsjjpy Nkypueh foNehffpr rWfFfpwJ. Gtpaugg tpir kwWk nrqFjJ tpiraphy nghUspd kJ nraaggll Ntiyiaf fzffpLf. Gtpaugg KLffk (g) = 10 ms^{-2} vdf fUJf.

jpuT:

rhaTjjsjjpy nghUs milAk KLffk gsinq vd Keija ghlggFjpapy fzffplLsNshk.

epA+lldpd ,uzlhk tpjpggb› rhaTjjsjjpy nghUspdkJ nraygLk tpir F = mg sinq. ,ej tpirahdJ nghUspd ,affk KOtJk khwhJ vdgij mwpaTk.

Gtpaugg tpiraphd rhaTjjsjjpd fpiljjsf $wpdhy (mgsin q) nraaggll Ntiy

$$W = \vec{F}.d\vec{r} = Fdr\cos f$$

,qFf vdgJ tpir (mg sinq) kwWk nghUs nryYk jpirfFk (dr) ,ilNa css NfhzkhFk. ,eNeutpy› tpir (mg sinq) kwWk ,lgngaurrp dr Mfpait xNu jpirapy cssd. vdNt f = 0°kwWk cos f =1

$$W = F\,dr = (mg\sin\theta)(dr)$$

(dr = rhajsjjpd esk)

$$W = 1 \times 10 \times \sin(30°) \times 10 = 100 \times \frac{1}{2} = 50J$$

mg cosqvdw $W kwWk nrqFjJ tpir N Mfpait nghUs nryYk jpirfFr nrqFjjhf cssjhy mit vej NtiyAk nraahJ.

vLj;Jf;fhl;L

NkyNehffp vwpaggll 2kg epiwAss xU nghUs 5m caujij mileJ gpddu jiuapy teJ tpOfpwJ (fhwWjjiliag Gwffzpffk) vdpy gpdtUtdtwiw fzffpLf.

(a) nghUs 5 m caujij milAkNghJ Gtpaugg tpirahy nraaggll Ntiy

(b) nghUs kzLk jiuia milAkNghJ Gtpaugh tpirahy nraaggll Ntiy

(c) Gtpaugh tpirapdhy NkyNehffpa kwWk foNehffpa ,affjjpy nraaggll nkhjjNtiy kwWk Kbtpd ,awgpay Kffpajjtjijf Fwpggpf.

jtpT

nghUs NkyNehffpr nryYkNghJ ,lgngaurrp NkyNehffpa jpirapYk nghUspd kJ nraygLk Gtpaugh tpir foNehffpa jpirapYk nraygLfpdwd. vdNt ,lgngaurrpfFk Gtpaugh tpirfFk ,ilNa css Nfhzk 180° MFk.

(a) Nky Nehffpa ,affjjpy Gtpaugh tpirapdhy nraaggll Ntiy ,qF dr=5m kwWk F=mg

$$W_{Nky} = Fdr\cos q = mgdr\cos 180^{o}$$

$$W_{Nky} = 2´10´5´(-1) = -100\,joule.$$

$$[\cos 180^{o} = -1]$$

(b) nghUs foNehffp tpOkNghJ Gtpaugh tpir kwWk ,lgngaurrp ,uzLk xNu jpiray cssd. ,jd %yk Gtpaugh tpirfFk ,lgngaurrpfFk ,ilNa css Nfhzk q=0°vd mwpayhk.

$$W_{fo} = Fdr\cos 0^{o}$$

$$W_{fo} = 2´10´5´(1) = 100\,joule$$

$$[\cos 0^{o} = 1]$$

(c) nghUspd KO gazjjpd NghJ (NkyNehffpa kwWk fo Nehffpa ,affk) Gtpahgh tpirapdhy nraaggll nkhjj Ntiy

$W_{nkhjjk} = W_{Nky} + W_{fo}$

= -100J + 100J = 0

Gtpahgh tpirahdJ nghUspwF vttpj MwwiyAk khwwtpyiy vdgij ,J Fwpffpwj. nghUs NkyNehffp vwpaggLkNghJ Gwffhuzpfshy nghUSfF Mwwy mspffggLfpwJ. nghUs jpUkg teJ jiuapy NkhJkNghJ nghUs ngww MwwyhdJ Gtpggugpwf khwwggLfpwJ (jiuapDs nryfpwJ)

vLj;Jf;fhl;L:

(a) xU gS J}fFgth 250 kg epiwia 5000 N tpirahy 5 m caujjpwF J}fFfpwhh.

(a) gS J}fFgtuhy nraaggll Ntiy vdd?

(b) Gtpahgh tpirahy nraaggll Ntiy vdd?

(c) nghUspd kJ nraaggll epfu Ntiy vdd?

jhT:

a. gS J}fFgth epiwiaj J}fFkNghJ tpirAk ,lgngahrrpAk xNu jpiray cssjhy mtwwpwfpilNa css Nfhzk q=0°vdNt gS J}fFgtuhy nraaggll Ntiy.

$W_{g.J} = F_w h\cos\theta = F_w h(\cos 0°)$

= 5000 × 5 × (1) = 25000 J = 25 kJ

(b)gS J}fFgth epiwiaj J}fFkNghJ Gtpahg Gtpir foNehffp nraygLtjhy tpirAk ,lngahrrpAk vjpnujph jpiratpy cssd. vdNt mtwwpwfpilNa css Nfhzk θ= 180°

$W_< = F_g h \cos\theta = mgh (\cos 180°)$

= 250 × 10 × 5 (-1)

= -12500 J = - 12.5 kJ

(c) nghUspd kJ nraaggll epfu Ntiy (nkhjj Ntiy)

$W_{epfuk} = W_{g.J} + W_<$

= 25 kJ – 12.5 kJ = + 12.5 kJ

khWgLk; tpiraidhy; nra;aggl;l Ntiy

khWgLk tpir (F) xdwpd $W xU nghUspd kJ nraygLk NghJ dr vdw rpW ,lngahrrpia VwgLjj tpiraidhy nraaggll rpW Ntiy (dw) ffhd njhlhG

dW = (F cos) dr

(F cos θvdgJ Fvdw khWk tpiraid $W MFk)

,qF›F kwWk θMfpait khwpfs MFk. njhlff epiy ri;Kjy ,Wjpepiy rftiu ,lngahrrp VwgLjj nraaggll nkhjj Ntiy

$$W = \int_{r_i}^{r_f} dW = \int_{r_i}^{r_f} F\cos q\, dr$$

khWgLk tpiraidhy nraaggll Ntiy tiuglk %yk fhzgpffgglLssJ. tiugljjpd fo css gugG khWk tpiraidhy nraaggll Ntiyiaf Fwpffpwj.

vLj;Jf;fhl;L:

njhlffjjpy xatpy css xU nghUspd kJ $F = kx^2$ vdw khWk tpir nraygLfpwJ. nghUshdJ x = 0 m Kjy x = 4m tiu ,lngahrrp mila tpiraidhy nraaggll Ntiyiaf fzffpLf. (khwpy; k = 1 N m^{-2} vdffUJf)

jhT:

nraaggll Ntiy

$$W = \int_{x_i}^{x_f} F(x)dx = k\int_0^4 x^2\, dx = \frac{64}{3} Nm$$

Mwpwy; (ENERGY):

Mwwy vdgJ Ntiy nraAk jpwikNa MFk. mjhtJ› nraaggll Ntiy vdgJ Mwwypd nrayghNl MFk. mjdhy jhd Ntiy kwWk Mwwy ,uzLk xNu ghpkhzjijf nfhzLssd(ML^2T^{-2}).

Ntiy Û Mwwy

Mwwypd Kffpakhd mkrk ahnjdpy xU jdpjj mikggpwF midjJ tif Mwwyfspd $Ljy› mjhtJ nkhjj Mwwy vejr nrayghlbYk vttifahd mfkhwwqfs VwglhYk khwhky ,UfFk. ,jd nghUshdJ xU tbtpy kiwAk Mwwy kwnwhU tbtpy ntspggLk. ,JNt Mwwy khwh tpjp vdggLk. ,gghlggFjpapy ehk ,aejpu Mwwy gwwp klLk fwgNghk.

,ejpu Mwwy ,U tifggLk.

1. ,aff Mwwy
2. epiy Mwwy

xU nghUs jdJ ,affjjpdhy nfhzLss Mwwy ,aff Mwwy vdggLk. xU nghUs jdJ epiyggh lbdhy nfhzLss Mwwy epiy Mwwy MFk.

Mwwypd SI myfhdJ nraaggll Ntiyapd myNf MFk.mjhtJ N m (myyJ) [y (J). Mwwypd ghpkhzk› nraaggll Ntiyapd ghpkhzNk MFk. mjd ghpkhzk (ML^2T^{-2}) MFk. Mwwypd NtW myFfs kwWk mtwwpd SI kjpgGfs mlltiz ,y fhzgpffgglLssd.

Mwwypd; kwww myFfSf;Fr; rkkhd SI kjpgGfs;

myF	,izahd [{y; kjpgGfs;
1 Vhf (CGS myF)	10^{-7}J
1 vyfluhd Nthyl (eV)	1.6×10^{-19} J
1 fNyhhp (cal)	4.186 J
1 fpNyhthl kzp (kWh)	3.6×10^{6} J

,af;f Mwwy; (Kinetic Energy):

,aff Mwwy vdgJ xU nghUs mjd ,affjjhy ngwWss MwwyhFk. midjJ ,aqFk nghUlfSk ,aff Mwwiyf nfhzLssd. ,affjjpy css xU nghUs Ntiy nratjwfhd jpwikiag ngwwpUfFk. cjhuzkhf› xU Mzpapd kJ xaT epiyapy itffggll xU Rjjpay Mzpia kujjpDs nrYjjhJ. mNjrkak glk fhlbathW mej Rjjpayhy Mzpia mbfFk NghJ mJ Mzpia kujjpDs nrYjJfpwJ. xU nghUs ,aqFkNghJ› ,affjjpwfhf nraaggLk Ntiyapd msthf ,aff Mwwy mstplggLfpwJ. ,aqFk nghUspd ,affjjpwfhf nraaggll Ntiyapd msT nghUspd epiw kwWk jpirNtfjjpd vz kjpgG Mfpatwiwr rhhejJ. ,affjjpy ,yyhj xU nghUs ,aff Mwwiyf nfhzbUffhJ.

Ntiy - ,af;f Mwwy; Njwwk;

NtiyAk MwwYk rkkhdit. ,J ,aff MwwYfFk nghUeJk. ,jid epa&gpff m epiwAss xU nghUs cuhatww fplljjsg guggpy xatpy ,Uggjhff fUJNthk.

(F) vdw khwh tpirapdhy mNj jpirapy (s) vdw ,lngahrrpia VwgLjj nraaggl Ntiy

$$W = Fs$$

khwhj tpirffhd rkdghL›

$$F = ma$$

%dwhtJ ,affr rkdghlil ,tthW vOjyhk.

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s}$$

a ,d kjpgig rkdghL ,y gujpapl

$$F = m\left(\frac{v^2 - u^2}{2s}\right)$$

rkdghL› gujpapl

$$W = m\left(\frac{v^2}{2s}s\right) - \left(\frac{u^2}{2s}s\right)$$

$$w = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

,aff MwwYffhd Nfhit:

Nkwfzl rkdghlby $\left(\frac{1}{2}mv^2\right)$vdgJ (v) jpirNtfjjpy ,aqFk (m) epiwAss nghUspd ,aff Mwwiyf Fwpfk.

$$KE = \frac{1}{2}mv^2$$

nghUspd ,aff Mwwy vgnghOJk NehFwp kjpgGilajhFk.
rkdghL kwWk ,y ,UeJ

$$\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

vdNtW $= \Delta KE$

rkdghL ,y tyJ gffjjpy css Nfhit nghUspd ,aff Mwwy khWghL (ΔKE) MFk.

nghUspd kJ tpirapdhy nraaggll Ntiy nghUspd ,aff Mwwiy khwWfpwJ vdgij ,J Fwpffpwj. ,JNt Ntiy - ,aff Mwwy Njwwk vdggLk.

Ntiy - ,aff Mwwy NjwwkhdJ fofhzgtwiw czhjJfpwJ.

1. nghUspd kJtpirapdhy nraaggll Ntiy NehfFwpahf ,Uejhy mjd ,aff Mwwy mjpfhpffpwJ.

2. nghUspd kJ tpirapdhy nraaggll Ntiy vjphFwpahf ,Uejhy mjd ,aff Mwwy Fiwfpwj.

3. nghUspd kJ tpirapdhy Ntiy VJk nraaggltpyiy vdpy mjd ,aff Mwwy khwhJ. ,J› nghUspd epiw khwhj NghJ tpirapdhy nghUshdJ khwh Ntfjjpy ,aqfpaJ vdgij Fwpffpwj.

cejk; kwWk; ,af;f Mwwy; ,ilNa cs;s njhlhG:

m epiwAss xU nghUs; v vdw jpirNtfjjpy ,aqFtjhff fUJNthk. mjd NehNfhlL cejk $\vec{p} = m\vec{v}$ kwWk mjd ,aff Mwwy›

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\,(\vec{v}.\vec{v})$$

rkdghL ,d gFjp kwWk njhFjpia epiw m My ngUff

$$KE = \frac{1}{2}\frac{m^2(\vec{v}.\vec{v})}{m}$$

$$= \frac{1}{2}\frac{(m\vec{v}).(m\vec{v})}{m} \quad [\vec{p} = m\vec{v}]$$

$$= \frac{1}{2}\frac{\vec{p}.\vec{p}}{m}$$

$$= \frac{p^2}{2m}$$

$$KE = = \frac{p^2}{2m}$$

,qF $\left|\vec{p}\right|$ vdgJ cejjjd vz kjggFk. NehNfhlL cejjjd vz kjgig ,tthW ngwyhk.

$$\left|\vec{p}\right| = p = \sqrt{2m(KE)}$$

,aff Mwwy kwWk eiw nfhLffgglhy cejjjd vz kjgig klLNk fzffl ,aYk. Mdhy cejjjd jiriaf fzffl ,ayhJ vdgij mwaTk. vnddwhy ,aff Mwwy kwWk eiw Mfait]Nfyh msTfshFk.

vLj;Jf;fhl;L

2 kg kwWk 4 kg eiw nfhzl ,U nghUsfs 20 kg m s^{-1} vdw rk cejjJld ,aqFfdwd.

(a) mit rk ,aff Mwwiyg ngwwUfFkh?

(b) mit rk Ntfjijg ngwwUfFkh?

jhT:

(a) nghUsd ,aff Mwwy

$$KE = \frac{p^2}{2m}$$

2 kg eiwAss nghUsd ,aff Mwwy

$$KE_1 = \frac{(20)^2}{2 \acute{} 2} = \frac{400}{4} = 100J$$

4 kg eiwAss nghUsd ,aff Mwwy

$$KE_2 = \frac{(20)^2}{2 \acute{} 4} = \frac{400}{8} = 50J$$

KE_1 ¹ KE_2 vd mwaTk. mjhtJ ,UnghUlfSk rk cejjijg ngwwUejhYk mtwwd ,aff Mwwy rkkyy. fdkhd nghUs ,Nyrhd nghUis tl Fiwthd ,aff Mwwiyg ngwWssJ. Vnddwhy nfhLffggll cejjjwF ,aff Mwwyhd eiwfF vjh tffjjjy cssJ.

$$(KE \mu \frac{1}{m})$$

(b) cejk p = mvvdgjhy ,U nghUlfSk rk Ntfjijg ngwwUffhJ.

eiy Mwwy; (Potential Energy):

xU nghUsd eiy Mwwy vdgJ RwWgGwjijg nghWjJ mjd eiy kwWk mikgigr rhhejJ. Vnddwhy nghUsd kJ nraygLk gyNtW tirfSk mjd eiy kwWk mikgigr rhhejNj.

(P vdw Gsspay css xU nghUsd eiy Mwwy vdgJ mgnghUis xU njhlff eiyg Gss O (njhlff eiy) Kjy Gss P (,Wjeiy) tiu khwh jirNtfjjy efhjj Gwtirahy nraaggll Ntiyad msT vd tiuaWffggLfwJ). O vdw njhlffg Gsspay eiy Mwwy Ro vd vLjJf nfhssyhk.

fzjtayd gb› eiy Mwwy

$$U = \int_a^{\infty} \vec{F} . d\vec{r}$$

,qF njhifalbd vyiy (limit) njhlff eiygGss O Kjy ,Wj eiygGss P tiu mikAk.

eiy Mwwy gy tifggLk. xtnthU tifAk xU Fwggll tirAld njhlhGilaJ. cjhuzkhf›

1. Gt<hgG tiradhy nghUs ngwWss Mwwyhd J <hgG mOjj Mwwy MFk.

2. RUstpy tpir kwWk ,J Nghdw ,izahd tpirfspdhy ngwggLk Mwwyhdj klrpaOjj Mwwy MFk.

3. epiy kpddpay tpirahy ngwggLk Mwwy kpddOjj Mwwy MFk.

Mwwy khwwh tpirfisg gwwp ghlggFjp NkYk tphpthff fhzyhk. jwNghJ ehk <hgG mOjj Mwwy kwWk klrpaOjj Mwwy gwwp tphpthf tpthjpffyhk.

Gtpggugg,wF mUfpy; epiy Mwwy;

Gtpapypuej h caujjpy <hgG mOjj Mwwy (U) vdgJ nghUis jiuapypuej h caujjpwF khwh jpirNtfjjpy nfhzL nryyj Njitahd Ntiyapd msTfFr rkkhFk.

(m) epiwAss xU nghUs jiuapypuej h caujjpwF Gtpahgg tpirfF vjphf efhjjggLtjhff fUJNthk.

nghUspd kj nraygLk Gtp<hgG tpir $\left(\vec{F}_g\right)$ MdJ $\vec{F}_g = -mg\hat{j}$ (tpirahdJ y jpirapy cssjhy myF ntflh $\hat{j}$,qF gadgLjjggLfpwJ). ,qF vjphFwpahdJ tpir nrqFjjhf foNehffp nraygLtijf Fwpffpwj. nghUis KLffk ,dwp (khwh jpirNtfjJld) efhjj› Gtp<hgG tpir $\left(\vec{F}_g\right)$fF rkkhd vz kjpgigAk vjphjpiriaAk nfhzl $\vec{F}_a$vdw Gwtpir xdW nghUspd kJ nraygLjjgl NtzLk. mjhtJ $\left(\vec{F}_a = -\vec{F}_g\right)$,J $\vec{F}_a = +mg\hat{j}$vdgijf Fwpffpwj. NehfFwpahdJ nraygLjjggll tpir NkyNehffp nrqFjjhf cssJ vdgijf Fwpffpwj. vdNt nghUs NkyNehffp cahjjggLk NghJ mjd jpirNtfk khwhky ,UfFk. mjdhy mjd ,aff MwwYk khwhJ. 'h' caujjpy <hgG mOjj Mwwy (U) vdgJ nghUis jiuapypuej (h) caujjpwF nfhzL nryy Njitahd Ntiyapd msthFk.

$$U = \int_0^h \vec{F}_a.d\vec{r} = \int_0^h \left|\vec{F}_a\right|\left|d\vec{r}\right|\cos\theta$$

,lngahrrpAk nraygLjjggll tpirAk mNj NkyNehffpa jpirapy cssjhy mtwwpwfpilNa css Nfhzk›θ = 0°. vdNt cos 0° = 1 kwWk $\left|\vec{F}_a\right| = mg, \left|d\vec{r}\right| = dr$

$$U = mg\int_0^h dr$$

$$U = mg[r]_0^h = mgh$$

nghUspy Nrkpffgg lLss epiyahwwyhdJ Gwtpirapdhy nraaggll NehFwp kjpgGss Ntiyapd %yk tiuaWffggLfpwJ vdgij mwpaTk. ,ayghf ,J FwpggJ ahnjdpy Gwtpiriar nraygLjJk mikgG nghUSfF Mwwiy khwWfpwJ kwWk mJ epiyahwwyhfr Nrkpffgg Lfpwj.nghUshdJ h caujjpypuej tOejhy Nrkpffgg lLss epiyahwwy ,aff Mwwyhf khwwggLfpwJ.

xU nghUspd kJ Gwtpir nraygLk NghJ mgnghUs vtthW Rop KLffjJld (khwh jpirNtfjjpy) ,aqFk?
nraygLjjggLk Gwtpirfp rhpahf vjphjpirapy kwnwhU tpir nrayglhy ,J rhjjpaNk. mit ,uzLk rkkhd vzkjpgigf nfhzL› xdWfnfhdW vjph jpirapy nraygLtjhy› nghUspd kJ nraygLk epfutpir RopahFk. vdNt nghUshdJ Rop KLffjJld ,aqFk.
ehk epiyahwwiy tiuaiw nraAkNghJ nghUshdJ Vd khwh jpirNtfjjpy efhjjggl NtzLk? nghUshdJ khwh jpirNtfjjpy efutpyiy vdwhy mJ njhlff kwWk ,Wjp epiyfspy khWgll jpirNtfqfisf nfhzbUfFk. Ntiy

- ,aff Mwwy Njwwggb Gwtpirahdj $Ljyhf ,aff Mwwiyr nrYjJk. Mdhy ehk epiyahwwiy Gtpahgg tpir› RUstpy tpir kwWk $Yk tpir Nghdw tpirfSfF tiuaWjJsNshk. vdNt nghUis njhlff epiy Kjy ,Wjpepiy tiu efhjjkNghJ Gw mikgG (Gw tpir) vej ,aff MwwiyAk nrYjjf$lhJ.

vLj;Jf;fhl;L:

2 kg epiwAss nghUs jiuapypUeJ 5 m caujjpwFf nfhzL nryyggLfpwJ (g = 10 ms^{-2}) vdpy

(a) nghUspDs Nrkpffgg lLss epiyahwwy ahJ?

(b) ,ej epiyahwwy vqfpUeJ fpiljjJ?

(c) nghUis mej caujjpwF vLjJr nryy vttsT Gwtpir nraygl Ntz Lk?

(d). nghUshdJ 'h' caujjpwF vLjJr nryyggLk NghJ mjd kJ nraygLk epfu tpir ahJ?

jhT:

a. epiyahwwy $U = mgh = 2 \times 10 \times 5 = 100$ J ,qF NehfFwpahdJ nghUspDs Mwwy Nrkpffgg lLss ijf Fwpffpwj.

b. ,ej epiyahwwyhdJ› Gw tpiria nraygLjJk ntspgGw mikggpypUeJ nghUSfF khwwgg lLssJ.

c. nghUis 5 m caujjpwF vLjJr nryy nraygLjjggll Gw tpir MdJ $\left(\vec{F}_a\right)$ MdJ $\vec{F}_a = -\vec{F}_g$

$$\vec{F}_a = -(-mg\hat{j}) = mg\hat{j}$$

$\hat{j}$ MdJ nrqFjjhf NkyNehffpj jpirapy nraygLk xuyF ntflh MFk.

d) epiyahwwypd tiuaiwapy ,UeJ› nghUshdJ khwhj jpirNtfjjpy efhjjggl Ntz Lk. vdNt› nghUspd kJ nraygLk epfu tpir Ropl MFk.

$$\vec{F}_g + \vec{F}_a = 0$$

klrp epiy Mwpwy; (Elastic Potential Energy):

xU RUstpy elrpailar nraaggllhy mjDs xU kstpir cUthfpwJ. RUstpyiy elrpfff$ba myyJ mOfff$ba tpirapdhy RUstpy ngwWss epiy Mwwy klrp epiy Mwwy vdggLk. ks tpirfF vjpuhfr nraygLjjggll tpirapdhy nraaggll Ntiy RUstpypy klrp epiy Mwwyhfr Nrkpffgg Lfpwj.

xU RUstpy - epiw mikgigf fUJf. fhlbathW cuhatww fpiljjs Nkirapy m vdw epiw itffgg lLssjhf fUJNthk.

,qF x = 0 vdgJ rkepiyg Gsspl MFk. RUstpyypd xU Kid xU jplkhd Rthpyk kWKid epiwAlDk ,izffgg lLssJ.

RUstpyyhdJ rkepiyapy ,UfFk tiu mjd epiw Mwwy RopahFk. jwNghJ xU Gwtpir $\left(\vec{F}_a\right)$ RUstpy epiw kJ nraygLjjgglL tpirapd jpirapy (x) njhiyT elrpailfpwJ.

RUstpy tpir $\left(\vec{F}_s\right)$vdwioffggLk xU kstpir RUstpyypy cUthfp epiwia mjd njhlff epiyfFf nfhzLtu KaYfpwJ. nraygLjjggll tpir kwWk RUstpy tpir Mfpait vzkjpggpy rkkhfTk vjpnujph jpiraYk cssd. mjhtJ $\left(\vec{F}_a = -\vec{F}_s\right)$. `f tpjpapd gb› RUstpypy cUthFk kstpir›

$$\vec{F}_s = -kx$$

Nkwfzl rkdghlby css vjphfFwpahdJ RUstpytpir vgNghJk ,lgngahrrp $\left(x\right)$fF vjphjjpiraYy cssJ vdgijf Fwpffpwj kwWk k vdgJ tpir khwpyp MFk. vdNt nraygLjjggll tpir $\vec{F}_a = +kx$. NehFwpahdJ nraygLjjggll tpir ,lgngahrrpapd jpiraYy cssJ vdgijf Fwpffpwj. RUstpy tpir ,lgngahrrp xl rhhejpUggjhy ,J khWk tpirfF xU vLjJffhllhFk. RUstpy dx vdw rpW njhiyTfF elrpailtjhff fUJNthk. RUstpyypd kJ nraygLjjggll tpirapdhy x,lgngahrrp miltjwF nraaggll Ntiy klrp epiy Mwwyhf NrkpffggLfpwJ.

$$U = \int_0^x \vec{F}_a.d\vec{r} = \int_0^x \left|\vec{F}_a\right|\left|d\vec{r}\right|\cos q$$

$$= \int_0^x F_a dx \cos q$$

nraygLjjggll tpir $\vec{F}_a$kwWk ,lgngahrrp $d\vec{r}$ (mjhtJ ,qF dx) Mfpait xNu jpiraYy cssd. njhlff epiyiar rkepiy myyJ epLepiyahf vLjJfnfhzlhy x = 0 vdgJ njhifalbd fo vyiyahf cssJ.

$$U = \int_0^x kx dx$$

$$U = k\left[\frac{x^2}{2}\right]_0^x$$

$$U = \frac{1}{2}kx^2$$

njhlffepiy Ropapyiy vdpy epiwahdJ epiy xiKjy xftiu efhjjggllhy klrp epiy Mwwy

$$U = \frac{1}{2}k\left(x_f^2 - x_i^2\right)$$

rkdghL kwWk %yk mwptJ ahnjdpy ellggll RUstpyypd epiy MwwyhdJ tpir khwpyp k kwWk elrp myyJ mKffk xMfpatwiwr rhhejJ.

RUstpyypDs Nrkpffgglsss epiy MwwyhdJ RUstpyYld ,izffgglsss epiwiar rhhejjyy.

RUs; tpy;ypd; tpir - ,lgngahrrp tiuglk;

tpirAk ,lgngahrrpAk F = - kx vdw Nehtpfpjj njhlhgpy cssjhYk kwWk mit vjpnujph jpiraYy ,UggjhYk F kwWk x ,ilNa css tiuglkhdJ fhlbAssthW ,uzL kwWk ehdfhtJ fhygFjpapy klLNk mikej Neh Nfhlhf cssJ. ,J F – x tiuglk tiutjd %yk klrp epiy Mwwiy vspjhff fzffplyhk. epoypLggll gugG (KfNfhzk) RUstpy tpirahy nraaggll Ntiy MFk.

$$\text{gugG} = \frac{1}{2}\ (\text{mbggffk})\ (\text{cauk}) = \frac{1}{2}{}'(x)'(kx)$$

$$= \frac{1}{2}kx^2$$

RUstyyd epiy Mwwy - ,lgngahrr tiuglk

xU mKffggll myyJ ellggll RUstyy jdDs Nrkffggll epiy Mwwiy mjDld ,izffggll epiwad ,aff Mwwyhf khwWfwJ. epiy Mwwy - ,lgngahrr tiuglkhdJ fhllggllssJ. cuhatww #oyy› MwwyhdJ mikggd nkhjj Mwwy khwhjthW ,aff Mwwyy ,UeJ epiy MwwyhfTk kwWk epiy Mwwyy ,UeJ ,aff MwwyhfTk kzLk kzLk khwwkilfwJ rkepiyay›

$$\Delta KE = \Delta U$$

vLj;Jf;fhl;L :

xU RUstyyfs A kwWk B ad RUskhwyfs vdwthW cssd. mit rk tpirfshy elrailar nraaggllhy vej RUstyyd kJ mjf Ntiy nraaggl NtzLk?

jhT:

$F = k_A x_A = k_B x_B$

$x_A = = \frac{F}{k_A}; x_B = \frac{F}{k_B}$

RUstyfs kJ nraaggll Ntiy RUstyfsy epiy Mwwyhf NrkffggLfwJ.

$$U_A = \frac{1}{2}k_A x_A^2; U_B = \frac{1}{2}k_B x_B^2$$

$$\frac{U_A}{U_B} = \frac{k_A x_A^{\,2}}{k_B x_B^{\,2}} = \frac{k_A \left(\frac{F}{k_A}\right)^2}{k_B \left(\frac{F}{k_B}\right)^2} = \frac{\frac{1}{k_A}}{\frac{1}{k_B}}$$

$$\frac{U_A}{U_B} = \frac{k_B}{k_A}$$

$k_A > k_B$ Fwggj $U_B > U_A$ MFk. vdNt A– it tpl B - ,d kJ mjf Ntiy nraaggl NtzLk.

m epiwAss xU nghUs RUstyYld ,izffgglL› nraygLjjggLk tpiradhy mJ eLepiyay ,UeJ 25 cm mstwF elrailfwJ.

a. RUstyy - epiw mikggy NrkffggLl epiy Mwwiyf fzffLf.

b. ,ej elrapy RUstyy tpirahy nraaggll Ntiy ahJ?

c. RUstyyhdJ mNj 25 cm mstwF mKffggllhy NrkffggLk epiy Mwwy kwWk mKffjjpdNghJ RUstyy tpirahy nraaggll Ntiy Mfpatwiwf fzffLf. (RUstyy khwyp k = 0.1 n m^{-1})

jhT:

RUstyy khwyp k = 0.1 N m^{-1}

,lgngahrr x = 25 cm = 0.25 m

a. RUstyyy NrkffggLl epiy Mwwy

$$U = \frac{1}{2}kx^2 = \frac{1}{2}\acute{}\ 0.1\acute{}\ (0.25)^2 = 0.0031J$$

b. RUstyy tpir $\vec{F}$ My nraaggll Ntiy Wskjpg G

$$Ws = \int_0^x \vec{F}_s.d\vec{r} = \int_0^x (-kx\hat{i}).(dx\hat{i})$$

RUstpy $\vec{F}_s$ tpir vjphfFwp x mrrpd jpirapy nraygLfpwJ. mNjrkak elrpahdJ NehfFwp x mrrpd jpirapy nraygLfpwJ.

$$W_s = \int_0^x (-kx)\,dx = -\frac{1}{2}kx^2$$

$$W_s = -\frac{1}{2} \times 0.1 \times (0.25)^2 = -0.0031J$$

ntspgGw mikgghy nraaggll Ntiyapd %yk epiy Mwwiy tiuaWffyhk. epiy Mwwypy css NehfFwp> MwwyhdJ mikggpypUeJ nghUSfF khwwggLtijf FwpffpwJ. Mdhy ,eNehtpy ks tpirahy nraaggll Ntiy vjphfFwp kjpgGilaJ. Vnddwhy kstpirahdJ ,lgngahrrpapd jpirfF vjphjjpirapy nraygLfpwJ.

c. mKffjjpd NghJk nghUspy mNj msT epiy Mwwy NrkpffggLfpwJ.

$$U = \frac{1}{2}kx^2 = 0.0031J$$

mKff ggLk NghJ RUstpy ks tpirahy nraaggll Ntiy

$$W_s = \int_o^x \vec{F}_s.\vec{d}_r = \int_o^x (kx\hat{i}).\left(-dx\hat{i}\right)$$

mKffggLk Nehtpy RUstpy kstpir NehfFwp x mrir Nehffp nraygLfpwJ kwWk ,lgngahrrpahdJ vjphfFwp x mrrpd jpirapy cssJ.

Mwpwy; khwpwh kwpWk; Mwpwy; khwpWk; tpirfs; (Conservative force and Non conservative force)

Mwpwy; khwpwh tpir (Conservative Force):

xU nghUis efhjJk NghJ tpirapdhy myyJ tpirfnfjpuhf nraaggll Ntiy nghUspd njhlff kwWk ,Wjp epiyfis klLk rhheJk> nghUspd njhlff kwWk ,Wjp epiyfSffpilNa nrdw ghijapd ,ayigr rhuhkYk ,Ugg;d; mttpir> Mwwy khwwh tpir vdggLk.

Gtpapy A vdw Gsspapy css xU nghUisf fUJNthk. ,jid h caujjpy css B vdw kwnwhU Gsspfs %dW ghijfspy vLjJr nryyyhk.

ghij vtthW ,Ugg;Dk njhlff kwWk ,Wjp epiyfs khwhky ,UfFk tiu Gtpahgg tpirfnfjpuhf nraaggll Ntiy khwhJ. ,JNt Gtpahgg tpirahdJ Mwwy khwwh tpirahf ,UggjwF fhuzkhFk. Mwwy khwwh tpir epiy Mwwypd vjphfFwp rhaTfF rkkhFk.

xU ghpkhz Nehtpy

$$F_x = \frac{dU}{dx}$$

klrp RUstpy tpir> epiykpddpay tpir> fhejtpir> Gtpahgg tpir Nghdwit Mwwy khwwh tpirfSfF cjhuzqfs MFk.

Mwpwy; khwpWk; tpir (Non-Conservative Force)

xU nghUis tpirapdhy myyJ tpirfnfjpuhf efhjjr nraaggll Ntiy njhlff kwWk ,Wjp epiyfSffpilNa css ghijiar rhhejpUgg;d mttpir Mwwy khwWk tpir vdggLk. ,jd nghUs nttNtW ghijfspy nraaggll Ntiyapd kjpgG khWgLk vdgjhFk.

1. cuhaT tpirfs Mwwy khwWk tpirfs MFk. Vnddwhy cuhaTfF vjpuhf nraaggll Ntiy nghUs efhej ghijapd njhiyitr rhhejJ.

2. fhwWjjilahy VwgLk tpir> ghfpay tpir MfpaitAk Mwwy khwWk tpirfs MFk. ,ttpirahy myyJ

Mwwy; khwwh kwWk; Mwwy; khwWk; tpirfis xggpLjy:

t.vz;	Mwwy; khwwh tpirfs;	Mwwy; khwWk; tpirfs;
1.	nraaggll Ntiy ghijiar rhhejjyy	nraaggll Ntiy ghijiar rhhejJ
2.	xU Rwwpy nraaggll Ntiy RopahFk	xU Rwwpy nraaggll Ntiy Ropayy
3.	nkhjj Mwwy khwhJ	Mwwyhd J ntgg Mwwy> xspMwwyhf ntspggLfpwJ
4.	nraaggll Ntiy KOtJk klfgglf $baJ	nraaggll Ntiy KOtJk klfgglf $baJ myy.
5.	tpirahdJ epiy Mwwypd vjphfFwp rhaTfF rkkhFk	mJ Nghdw njhlhG ,yiy

tpirfnfjpuhf nraaggll Ntiy ,affjjpd jpirNtfjijr rhhejJ.

Mwwy khwwh kwWk Mwwy khwWk tpirfspd gzGfs njhFffgglLssd.

vLj;Jf;fhl;L:
fofzl NehTfspy Gtpahg G tpirapdhy nraaggll Ntiyiaf fzffpLf.

jhT:

tpir $\vec{F} = mg\left(-\hat{j}\right) = -mg\hat{j}$

,lgngahrrp ntflh $d\vec{r} = dx\hat{i} + dy\hat{j}$

(,lgngahrrp ,U ghpkhzjjpy cssjhy myF ntflhfs $\hat{i}$kwWk $\hat{j}$ gadgLjjggLfpwJ)

(a) ,affkhdJ nrqFjjhf klLk cssjhy> ,lgngahrrpapd fpiljjsf$W dx RopahFk. vdNt ghij 1 ,d topNa tpirapdhy nraaggll Ntiy (h njhiytpwF)

$$W_{ghij1} = \int_A^B \vec{F}.d\vec{r} = \int_A^B \left(-mg\hat{j}\right).\left(dy\hat{j}\right)$$

$$= -mg\int_0^h dy = -mgh$$

ghij 2 ,y nraaggll nkhjj Ntiy

$$W_{ghij2} = \int_A^B \vec{F}.d\vec{r} = \int_A^C \vec{F}.d\vec{r} + \int_C^D \vec{F}.d\vec{r} + \int_D^B \vec{F}.d\vec{r}$$

Mdhy

$$\int_A^C \vec{F}.d\vec{r} = \int_A^C \left(-mg\hat{j}\right).\left(dx\hat{i}\right) = 0$$

$$\int_C^D \vec{F}.d\vec{r} = \int_C^D \left(-mg\hat{j}\right).\left(dy\hat{j}\right)$$

$$= mg\int_{0}^{h} dy = mgh$$

$$\int_{D}^{B} \vec{F}.d\vec{r} = \int_{D}^{B} \left(-mg\hat{j}\right).\left(-dx\hat{i}\right) = 0$$

vdNt ghij 2 ,d toþNa t¡ira¡dhy nraaggll nkhjj Ntiy

$$W_{ghij2} = \int_{A}^{B} \vec{F}.d\vec{r} = -mgh$$

Mwwy khwwh t¡ira¡dhy nraaggll Ntiy ghijiar rhhejjyy vdgij mw¡aTk.

vLjJffhlL

2 kg e¡iwAss xU nghUs ,aff cuhaTf Fzfk 0.9 nfhzLss xU guggþy 20 N Gwt¡ira¡dhy 10 m njhiyt¡wF efhjjggLtjhff fUJf. Gwt¡ir kwWk ,aff cuhat¡dhy nraaggll Ntiy vdd? Kbitg gwwþa fUjijf $Wf. ($g = 10\ m\ s^{-2}$ vdf nfhsf)

jhT:

$m = 2\ kg,\ d = 10\ m,\ F_{ext} = 20\ N,\ = \mu_k = 0.9$

xU nghUs f¡ilklI guggþy ,aqFk NghJ mJ ,U t¡irfisg ngWf¡wJ.

a. Gw t¡ir $F_{ext} = 20\ N$

b. ,aff cuhaT t¡ir

$f_k = \mu_k mg = 0.9 \times (2) \times 10 = 18\ N$

Gwt¡ira¡dhy nraaggll Ntiy

$W_{ext} = F_d = 20 \times 10 = 200\ J$

,aff cuhaT t¡ira¡dhy nraaggll Ntiy

$W_k = f_k d = (-18) \times 10 = -180\ J$

,qF vj¡hfFw¡ahdJ ,aff cuhaT t¡ir› ,lgngahrr¡a¡d j¡irfF vj¡uhf cssijf Fw¡ff¡wJ.

nghUs¡d kJ nraaggll nkhjj Ntiy

$W_{total} = W_{ext} + W_k = 200 - 180 = 20\ J$

cuhaT t¡ir xU Mwwy khwWk t¡ir vdgjhy Gwt¡irahy nfhLffggll 200 J ,y 190 J ,offggllJ kwWk ,jid klnlLff ,ayhJ.

Mw¡wy; khwh t¡j¡ (Law of Conservation of energy):

xU nghUis ehk NkyNehff¡ vw¡ejhy mjd ,aff Mwwy FiweJ nfhzNl nryf¡wJ kwWk mjd e¡iy Mwwy mj¡fh¡jJf nfhzNl nryf¡wJ (fhwWj jilia Gwffz¡fFkNghJ) nghUshdJ ngUk cauijij milAkNghJ Mwwy KOtJk e¡iy MwwyhFk. mJNghdW nghUshdJ ngUk cauj¡y ,UeJ tOejhy mjd ,aff Mwwy mj¡fh¡fFk kwWk e¡iy Mwwy FiwAk. jiuiaj njhLkNghJ mjd Mwwy KOtJk ,aff MwwyhFk. ,ilggll Gss¡fs¡y MwwyhdJ ,aff MwwyhfTk e¡iy MwwyhfTk ,UfFk. nghUshdJ jiuia milAk NghJ ,aff

,ej cjhuzjj¡y xtnthU Gss¡a¡Yk e¡iyahwwy kwWk ,aff Mwwy khWk. vd¡Dk› ,aff Mwwy kwWk e¡iy Mwwy¡d $Ljy mjhtJ nkhjj ,aej¡u Mwwy vgNghJk khwhJ. ,J nkhjj Mwwy khwhJ vdgijf Fw¡ff¡wJ. ,JNt Mwwy khwh t¡j¡ahFk.

Mwwy khwh t¡j¡a¡dgb Mwwiy MffNth mo¡ffNth ,ayhJ. MwwyhdJ xU tifa¡y¡UeJ kwnwhU tifahf khwf$baJ. Mdhy xU jd¡jj mikgg¡d nkhjj Mwwy khw¡y¡ahf ,UfFk.

tsfFtJ ahnjdy>h caujjy xatpy css xU nghUspd nkhjj Mwwy KotJk epiy Mwwy (U = mgh) klLNk. NkYk h caujjy mjd ,aff Mwwy (KE) RoahFk. nghUs fNo tpOkNghJ 'y' njhiytpy mjd epiyahwwy kwWk ,aff Mwwy RoahfhJ. mNjrkak h caujjy ,Uej mNj mstpy nkhjj Mwwy khwhky ,UfFk. nghUs jiuiaj njhl neUqFk NghJ epiy Mwwy RoahFk kwWk nkhjj Mwwy ,aff Mwwyhf klLNk ,UfFk.

vLj;Jf;fhl;L

1 kg epiwAss xU nghUs h = 10 m caujjypUeJ tpOfwJ.

(a) h = 10 m caujjpy nghUspd nkhjj Mwwy
(b) h = 4 m caujjpy nghUspd epiy Mwwy
(c) h = 4 m caujjpy nghUspd ,aff Mwwy

(d)nghUs jiuapy NkhJk Ntfk Mfpatwiwf fzffpLf.
(g = 10 ms^{-2}vdf nfhsf)

jhq;T:

(a) Gtpahgg tpir Mwwy khwwh tpirahFk. vdNt ,affk KOtJk nkhjj Mwwy khwhky ,UfFk.

h = 10 m caujjpy nkhjj Mwwy (E) KOtJk epiy Mwwyhf ,UfFk.
E = U = mgh = 1 × 10 × 10 = 100 J

(b) h = 4 m caujjpy epiy Mwwy
U = mgh = 1 × 10 × 4 = 40 J

(c) ,affk KOtJk nkhjj Mwwy khwpy vdgjhy h = 4 m caujjpy ,aff MwwyhdJ
KE = E – U = 100 – 40 = 60J

khwhf 4 m caujjpy nghUspd jpirNtfjjpy ,UeJk ,aff Mwwiyf fhzyhk. 6 m toej gpwF css jpirNtfjij ,affr rkdghlbypUeJ fzffplyhk.

$$v = \sqrt{2gh} = \sqrt{2 \acute{} 10 \acute{} 6} = \sqrt{120}\, ms^{-1}$$

$$v^2 = 120$$

,aff Mwwy $KE = \frac{1}{2}mv^2 = \frac{1}{2} \acute{} 1 \acute{} 120 = 60J$

d. nghUs jiuapy NkhJk epiyapy nkhjj Mwwy KOtJk ,aff MwwyhFk. NkYk epiy Mwwy U = O

E = KE = $\frac{1}{2}mv^2 = 100\,J$

v = $\sqrt{\frac{2}{m}KE} = \sqrt{\frac{2}{1} \acute{} 100} = \sqrt{200} \approx 14.12\, ms^{-1}$

vLj;Jf;fhl;L

gljjpy fhlbAssthW 100 kg epiwAss xU nghUs jiuapypUeJ 10 m caujjpwF ,U khWgll topfspy J}ffggLfpwJ. ,U NehTfspYk Gtpahgghy nraaggl Ntiy vdd? rhajsjjpd topahf nghUis vLjJr nrytJ vspjhf cssJ Vd?

jhtT:

m = 100 kg, h = 10 m

ghij (1) ,d toNa:

nghUis 10 m caujpwFj J}ffj Njitahd rpWk tpir F_1 tpir Gtpahgg tpirfFr rkkhf ,Uff Ntz Lk.

$F_1 = mg = 100 \times 10 = 1000$ N

ghij (1) ,d toNa efhej njhiyT h = 10 m

ghij (1) ,d toNa nghUspd kJ nraaggll Ntiy

$W = Fh = 1000 \times 10 = 10{,}000$ J

ghij (2) ,d toNa:

rhajsjjpd toNa nghUisf nfhzL nryy nghUspd kJ ehk nrYjJk rpWk tpir F_2MdJ mg– fF rkkhf ,yiy› khwhf mg sinθ-fF rkkhFk. mg sinθ< mg)

vdNt (mg sin θ< mg)

rhajsg ghijapd eskhdJ

$$l = \frac{h}{\sin 30^\circ} = \frac{10}{0.5} = 20m$$

ghij (2) ,d toNa nghUspd kJ nraaggll

Ntiy $W = F_2 l = 500 \times 20 = 10{,}000$ J

Gtpahgg tpirahdJ Mwwy khwwh tpir vdgjhy Gtpahggghy nghUspd kJ nraaggll Ntiy mjid nfhzL nrdw ghijiar rhhejjyy.

,U ghijfspYk Gtpahgg tpirahy nraaggll Ntiy 10›000 J MFk.

ghij (1) ,d toNa: Fiwthd njhiyT efhjj Gtpahggfff vjpuhf mjpfkhd tpir nrYjj NtzbAssJ.

ghij (2) ,d toNa: mjpfkhd njhiyT efhjj Gtpahggfff vjpuhf Fiwthd tpir nrYjj NtzbAssJ.

rhajsjjpd toNa nrYjjggl Ntzba tpir Fiwthf cssjhy rhajsjjpd toahf nghUis vLjJr nrytJ vspjhf cssJ.

vLj;Jf;fhl;L:

m epiwAss xU nghUs jiuapypUeJ $v_0$vdw njhlff NtfjJld VwpaggLfpwJ. h caujpy mjd Ntfjijf fhzf.

jhtT:

Gtpahgg tpir Mwwy khwwh tpir vdgjhy ,affk KOtJk nkhjj Mwwy khwhJ.

Mwpwy;	njhlf;fj;jpy;	,Wjapy;
,aff Mwwy	$\frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2$
epiy Mwwy	0	mgh
nkhjj Mwwy	$\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}mv_0^2$	$\frac{1}{2}mv^2 + mgh$

h caujpy epiy Mwwy› ,aff Mwwy kwWk nkhjj Mwwy Mfpatwwpd ,Wjp kjpgGfs fzffplggllLssd.

Mwwy khwh tpjpapd gb njhlff kwWk ,Wjp nkhjj Mwwyfs rkkhFk.

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + mgh$$

$$v_0^2 = v^2 + 2gh$$

$$v = \sqrt{v_0^2 - 2gh}$$

ghlggFjp ,y ,afftpay rkdghlilg gadgLjjp Ezfzpj Kiwggb ,J Nghdw KbT ngwgglljj ftdpffTk. vdpDk Mwwy khwh tpjpapd Kiwggb fzffpLtJ Ezfzpj Kiwiatpl kpfTk vspjhf cssJ.

xU RUstpyYld ,izffggll 2kg epiwTss xU nghUs mjd rkepiyapypUeJ x = 10 m vdw njhiyTfF efhjjggLfpwJ. RUstpy khwpy; k = 1 N m^{-1}kwWk gugG cuhatwwfhff fUJf.

a. nghUshdJ rkepiyiaf flfFkNghJ mjd Ntfk vdd?

b. nghUshdJ rkepiyiaf flfFk NghJk›x = ± 10 m vdw tpspkG epiyia flfFk NghJk nghUspd kJ nraygLk tpir ahJ?

jhT:

a. RUstpy tpir xU Mwwy khwwh tpir Mifahy nkhjj Mwwy khwpy; MFk. x = 10m vDkNghJ nkhjj Mwwy KOtJk epiy Mwwyhf klLNk ,UfFk.

$$E = U = \frac{1}{2}kx^2 = \frac{1}{2}\acute{}\ (1)\acute{}\ (10)^2 = 50J$$

nghUs rkepiyiaf flfFk NghJ (x = 0), epiy Mwwyhdj

$$U = \frac{1}{2}\acute{}\ 1\acute{}\ (O) = OJ$$

,eepiyapy KO MwwYk ,aff Mwwyhf klLNk cssJ.

$$E = KE = \frac{1}{2}mv^2 = 50J$$

Ntfk

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2\acute{}\ 50}{2}} = \sqrt{50}ms^{-1} \gg 7.07\,ms^{-1}$$

RUstpyypd kstpir F = – kx vdgjhy nghUshdJ eLepiyiaf flfFk NghJ mJ vttpiriaAk czuhJ. eLepiyapy nghUshdJ kpf Ntfkhf efUfpwJ vdgij mwpaTk. nghUshdJx = +10 m (elr) vdw epiyapy cssNghJ tpir F = -kx

F =-(1) (10) = - 10N ,qF vjphFwpahdJ tpir eLepiyia Nehffp mjhtJ vjph mrir Nehffp cssijf Fwpffpwj. NkYk nghUshdJ

x = ± 10 m (mKffk) vdw epiyapy cssNghJ mJ czUk tpir

F = -(1) (10) = - 10N ,qF NehfFwpahdJ tpir Neh x - mrir Nehffp cssijf Fwpffpwj.

vdw epiyapy nghUshdJ ,ej ,U tspkG Gspspfspyk ngUk tpiria czhejhYk fzNeu xaT epiyfF tUfpwJ.

nrqFjJ tl;l ,af;fk; (Motion in a vertical circle):

m epiwAss xU nghUs epiwaww› elrj jdikaww E}yd xU Kidapy ,izffggLfpwJ. NkYk› E}yd kWKidahdJ epiyahf ,UfFkhW nghUjjgglLssJ. mejgnghUs nrqFjJj jsjjpy mikej tll ,affjij Nkwnfhstjhff gwwp mwpa jdpjj nghUspd tpirgglk (Free body dagram) xdiwf fUJNthk. ,qF epiyntflh $\left(r\right)$ MdJ nrqFjjhd foNehffpa jpirAld Nfhzjij θVwgLjjp gljjpy cssthW cldb jpirNtfjijf nfhzLssJ.

1. fo Nehffp nraygLk Gtpahgg tpir
2. E}ypd topNa nraygLk ,Otpir

nghUspd kJ epA+lldpd ,uzlhk tjpiag gadgLjj› njhLNfhlLj jpirapy›

$$mg\sin\theta = ma_t$$

$$mg\sin\theta = -m\left(\frac{dv}{dt}\right)$$

,qF $a_t = \frac{dv}{dt}$ vdgJ njhLNfhlLj jpirapy vjph KLffk MFk.

Mujjpirapy›

$$T - mg\cos\theta = m\,a_r$$

$$T - mg\cos\theta = \frac{mv^2}{r}$$

,qF $a_r = \frac{v^2}{r}$ vdgJ ikaNehfF KLffk MFk.

,affjij edF GHpeJ nfhsSktifapy tlljij A, B, C, D vdw ehdF gFjpfshfg gphpffyhk. Nkwfzl ,U rkdghLfspy ,UeJ foffzlthW ehdF Kffpa fUjJfis GHpeJ nfhssyhk.

1. nghUshdJ midjJ θ kjpgGfSfFk (θ= 0° jtpu) njhLNfhlLj jpirapy KLffjij (g sin θ) nfhzbUffpwJ. ,ej nrqFjJ tll ,affk xU ruhd tll ,affk myy vdgJ njspthfpwJ.

2. rkdghLfs kwWk ,UeJ mwpeJ nfhstJ vddntdpy ,affjjpd NghJ jpirNtfjjpd vz kjpgG khWtjhy› E}ypd ,Otpirak khWfpdwJ.

3. rkdghL $T = mg\cos q + \frac{mv^2}{r}$ RlbffhlLtJ tlljjpd A kwWk D gFjpfspy (- $\frac{p}{2} < 0 < \frac{p}{2}$ kwWk cos θNehfFwp) mg cosθvgNghJk Ropiatpl mjpfkhFk. vdNt jpirNtfk RopahdhYk ,Otpir RopahfhJ.

4. rkdghL $\frac{mv^2}{r} = T - mg\cos q$ NkYk RlbffhlLtJ tlljjpd B kwWk C gFjpfspy ($\frac{p}{2} < q < \frac{3p}{2}$ kwWk cos θvjphfFwp)› rkdghlbd ,uzhtJ gFjp (- mg cos θ) vgNghJk Ropia tpl mjpfkhFk. vdNt ,Otpir RopahdhYk jpirNtfk RopahfhJ.

nrqFjJ tll ,affk njhlhghd fzfFfis jhTfhzkNghJ Nkwfzl fUjJfis kdjpy nfhs Ntz Lk.

mbggff Gsspl 1 kwWk Nkwgff Gsspl 2 Mfpa ,U epiyfis klLk fUjjpy nfhzL NkYk gFgghaT nraNthk. nghUspd jpirNtfkhdJ mbggff Gsspl 1 ,y v_1 vdTk. Nkwgff Gsspl 2 ,y v_2 vdTk NtW vej Gsspapyk v vdTk nfhsf. jpirNtfjjpd jpir midjJg Gsspfspyk tllgghijapd njhLNfhlLj jpirapy cssJ. mbggffg Gsspapypl;UeJ E}ypd ,Otpirahd J T_1 vdTk› Nkwgff Gsspapypl;UeJ ,Otpir T_2 vdTk NtW vej Gsspapyk ,Otpir T vdTk nfhsf. xtnthU Gsspapyk ,Otpirikag Gsspia Nehffp nraygLfpwJ. Mwwy khwh tpjpiag gadgLjjp ,ej ,U Gsspfspyk ,Otpirfs kwWk jpirNtfqfis fzffplyhk.

mbggf;f Gs;sp (1):

nghUshdJ mbggff Gsspl 1 ,y cssNgh Gtpahg G tpir mg nghUspd kJ nrqFjjhf foNehffp nraygLfpwJ kwWk ,Otpir T_1 nrqFjjhf NkyNehffp mjhtJ ikag Gsspia Nehffp nraygLfpwJ. rkdghL ,UeJ ehk ngWtJ

$$T_1 - mg = \frac{mv_1^2}{r}$$

$$T_1 = \frac{mv_1^2}{r} + mg$$

Nkwgf;f Gs;sp (2):

Nkwgff Gsspl 2 ,y nghUspd kjhd Gtpahg G tpir mg kwWk ,Otpir T_2 Mfpa ,uzLk foNehffp mjhtJ ikag Gsspia Nehffp nraygLfpwJ.

$$T_2 + mg = \frac{mv_2^2}{r}$$

$$T_2 = \frac{m_2^2}{r} - mg$$

rkdghLfs kwWk T_1> T_2 vd mwpayhk. ,Otpirapd NtWghL $T_1 - T_2$ MdJ rkdghL rkdghL ,UeJ fopggjd %yk ngwggLfpwJ.

$$T_1 - T_2 = \frac{mv_1^2}{r} + mg - \left(\frac{mv_2^2}{r} - mg\right)$$

$$= = \frac{mv_1^2}{r} + mg - \frac{mv_2^2}{r} + mg$$

$$T_1 - T_2 = \frac{m}{r}\left(v_1^2 - v_2^2\right) + 2mg$$

Gsspl 1 kwWk 2 ,y Mwwy khwh tpjpiag gadgLjjp $\left(v_1^2 - v_2^2\right)$ kjpgig vspjhff fzffplyhk.

,Otpirak nghUs nryYk jpirak vgNghJk xdWfnfhdW nrqFjjhf cssjhy ,Otpirahd J nghUspd kJ vttpj Ntiyak nraahJ. Gtpahg G tpirahd J nghUspd kJ Ntiy nrafpwJ. NkYk mJ Mwwy khwwh tpir vdgjhy ,affk KOtJk nghUspd nkhjj Mwwy khwhJ.

Gsspl 1 ,y css nkhjj Mwwy (E_1) Gsspl 2 ,y css nkhjj Mwwy (E_2) fF rkkhFk.

$E_1 = E_2$

Gsspl 1 ,y epiy Mwwy $U_1 = 0$ (Gsspl 1 I FwpGg Gsspahf vLjJfnfhstjd %yk)

Gss‌ 1 ,y ,aff Mwwy $KE_1 = \frac{1}{2}mv_1^2$

Gss‌ 1 ,y nkhjj Mwwy $E_1 = U_1 + KE_1 = 0 + \frac{1}{2}mv_1^2 = \frac{1}{2}mv_1^2$

,JNghdNw Gss‌ 2 ,y e‌iy Mwwy $U_2 = mg(2r)$
(Gss‌ 1 ,y ,UeJ hkj‌gG 2r MFk)

Gss‌ 2 ,y ,aff Mwwy $KE_2 = \frac{1}{2}mv_2^2$

Gss‌ 2 ,y nkhjj Mwwy

$$E_2 = U_2 + KE_2 = 2mgr + \frac{1}{2}mv_2^2$$

rkdghL csthW Mwwy khwh t‌j‌ggb

$$\frac{1}{2}mv_1^2 = 2mgr + \frac{1}{2}mv_2^2$$

khww‌aikff

$$\frac{1}{2}m(v_1^2 - v_2^2) = 2mgr$$

$$v_1^2 - v_2^2 = 4gr$$

rkdghL rkdghL g‌uj‌a‌l

$$T_1 - T_2 = \frac{m}{r}[4gr] + 2mg$$

vdNt ,Ot‌ira‌y khWghlhdJ

$$T_1 - T_2 = 6mg$$

Nkwgf;f Gs;s‌ (2) ,y; r‌Wk Ntfk;
nghUshdJ Gss‌ 2 ,y xU r‌Wk Ntfjijf nfhzbUff Ntzlk› ,yiynad‌y Gss‌ 2 l milAk Kdghf E}yhdj jshTwW mjdhy nghUs tllgghijia e‌iwT nraahJ. ,ej r‌Wk Ntfjijf fzff‌l rkdghL ,y ,Ot‌ir $T_2 = 0$ vdf nfhsNthk.

$$0 = \frac{mv_2^2}{r} - mg$$

$$\frac{mv_2^2}{r} = mg$$

$$v_2^2 = rg$$

$$v_2 = \sqrt{gr}$$

nghUshdJ tllgghija‌y njhlhej ,aqf Gss‌ 2 ,y v_2 ³ $\sqrt{gr}$ vdw Ntfjijf nfhzbUff Ntzlk.

mbgGss‌ (1) ,y r‌Wk Ntfk:
Gss‌ 2 ,y ,ej r‌Wk Ntfjijg $\left(v_2 = \sqrt{gr}\right)$ ngw nghUshdJ Gss‌ 1 Yk xU r‌Wk Ntfjijf nfhzbUff Ntzlk.
rkdghL lg gadgLjj‌ Gss‌ 1 ,y r‌Wk Ntfjij ehk fhzyhk.

$$v_1^2 - v_2^2 = 4gr$$

rkdghL g‌uj‌a‌l

$$v_1^2 - gr = 4gr$$

$$v_1^2 = 5gr$$

$$v_1 = \sqrt{5gr}$$

nghUshdJ tllgghijaiy njhlheJ ,aqf Gss 1 ,y $(v_1 = \sqrt{5gr})$ vdw Ntfjijf nfhzbUff Ntz Lk.

rkdghLfs ,UeJ mwtJ vddntdiy nghUs tllgghijia tlL tyfhky eiwT nraa mbgGss 1 ,y rWk Ntfkhd J Nkwgff Gss 2 ,y css rWk Ntfjij tl $\sqrt{5}$ klqF ,Uff Ntz Lk.

vLj;Jf;fhl;L:

faiwWld fllggll xU thsiay css eh 0.5 m MuKss nrqFjJ tlljij Rwwi RowwggLfiwJ. ,affjjid NghJ euhd J thsiay ,UeJ riejhky ,Uff mbgGssiay ,Uff Ntzba rWk jirNtfjijf fzffiLf. ($g = 10\ ms^{-2}$)

jhT

tlljjid Muk $r = 0.5\ m$

Nkwgff Gssiay Njitahd Ntfk $v_2 = \sqrt{gr} = \sqrt{10 \acute{} 0.5} = \sqrt{5} m s^{-1}$

mbggff Gssiay Ntfk $v_1 = \sqrt{5gr} = \sqrt{5} \acute{} \sqrt{gr} = \sqrt{5} \acute{} \sqrt{5} = 5 m s^{-1}$

jiwd; (Power):

jiwdid; tiuaiw:

jiwd vdgJ vttsT Ntfkhf myyJ nkJthf xU Ntiy nraaggLfiwJ vdgjd msthFk. Ntiy nraaggLk tjk myyJ Mwwy ntsiggLk tjk› jiwd vd tiuaWffggLfiwJ.

$$\text{jiwd } (P) = \frac{\text{nraaggll Ntiy}(W)}{\text{vLj Jfnfhzl Neuk } (t)}$$

$$P = \frac{W}{t}$$

ruhrhij; jiwd;:

nraaggll nkhjj Ntiyffk vLjJf nfhzl nkhjj Neujjiwfk ,ilNa css tifjk ruhrhijjiwd (P_{ruhrhi}) vd tiuaWffggLfiwJ.

$$(P_{ruhrhi}) = \frac{\text{nraaggll nkhjj Ntiy}}{\text{vLj Jfnfhzl nkhjj Neuk}}$$

cldibj; jiwd;:

xU fz Neujjiy (Neu ,ilntsi Roiia neUqFk NghJ) ntsiggLk jiwd cldbj jiwd (P_{cldb}) vd tiuaWffggLfiwJ.

$$(P_{cldb}) = \frac{dw}{dt}$$

jiwdid; myF:

jiwd xU]Nfyh msthFk. mjd ghikhzk (ML^2T^{-3}) jiwdid SI myF thl (W) vdW euhti ,aejujijf fzLgibjj N[k] thl ngauhy mioffggLfiwJ.

xU tidhbaiy xU [y Ntiy nraaggllhy jiwd xU thl vd tiuaWffggLfiwJ. ($1W = 1Js^{-1}$) fiNyhthl (KW), nkfhthl (MW) kwWk [ifhthl (GW) Mfiait jiwdid cah myFfs MFk.

$1\ KW = 1000\ W = 10^3$ thl

1 MW = 10^6 thl

1 GW = 10^9 thl

Nkhllhhfs› ,aejpuqfs kwWk rpy jhdpaqfp thfdqfSfF Fjpiujjpwd (horse – power) (hp) vdwioffggLk jpwdpd gioa myfhdJ tzpfhjpahf ,dDk gadghlby cssJ. Fjpiujjpwid (hp) thl (W) vdw myfpy khww

1hp = 746 W

midjJ kpd rhjdqfspd kJk xU Fwpggpll jpwdpd msT mrrpIggIL toqfggLfpdwd. xU 100 thl tpsfF (bulb) xU tpdhbapy 100 [y kpd Mwwiy Efhfpwj. [{y vdw myfhy msffggLk Mwwypd jpwid thl vdw myfpYk Neujij tpdhb vdw myfpYk Fwpggpltjhy 1J = 1 Ws vd vOjyhk. kpd cgfuzqfs gy kzp Neujjpwf gadghlby cssNghJ mit mjpf mstpyhd Mwwiy EfUfpdwd. kpd Mwwiy thl tpdhb (Ws) vdw rpwpa myfpy mstpLkNghJ nghpa vz kjpgGfisf ifahs NtzLk. vdNt kpd MwwyhdJ fpNyhthl kzp (kilowatt hour – kwh) vdw myfhy mstpIggLfpwJ.

1 kpd myF (1 Apdpl) = 1 KWh = 1 (10^3W) × 3600 s)

1 kpd myF = 3600 ×10^3 Ws

1 kpd myF = 3.6 ×10^6 J

1 KWh = 3.6 10^6 J

kpd Mwwy EfhTfF KWh vdw myfpy kpdfllz glbayfs jahhpffggLfpdwd. 1 myF kpd Mwwy vdgJ 1 KWh MFk.

(FwpgG: KWh vdgJ Mwwypd myF; jpwdpd myF myy)

vLj¡Jf¡fhl¡L:

xU 75 W kpd tprpw jpdKk 8 kzp Neuk xU khjjjpwF (30 ehlfs) gadgLjjggllhy Efuggll Mwwiy kpd myfpy fzffpLf.

jhT:

jpwd P = 75 W

gadghlL Neuk t = 8 kzp ×30 ehlfs = 240 kzp. Efuggll kpd MwwyhdJ jpwd kwWk gadghlL Neuk Mfpatwwpd ngUffy gyd MFk.

kpd Mwwy = jpwd ×gadghlL Neuk = P × t

= 75 thl ×240 kzp

= 18000 thl kzp

= 18 fpNyh thl kzp = 18 KWh

1 kpd myF = 1 KWh

kpd Mwwy = 18 myF

kpddpio tpsfFfs 1000 kzp Neuk xsptRk. CFL tpsfFfs 6000 kzp Neuk xsptRk. Mdhy LED tpsfFfs 50000 kzpNeuk xsptRk (Vwjjho 25 MzLfs› ehnshdWfF 5.5 kzp Neuk)

jpwd¡ kwWk¡ jpirNtfk¡ Mfpatwwpf¡F ,ilNa cs¡s njhlhG:

$\vec{F}$ vdw tpirapdhy dr vdw ,lngahrrpfF nraaggll Ntiy

$$W = \int \vec{F}.d\vec{r}$$

rkdghL ,lJ gffjjpy cssij ,tthW vOjyhk.

$$W = \int dW = \int \frac{dW}{dt} dt$$

(dt - ,y ngUffTk tFffTk nraa)

jpirNtfk $\vec{v}=\frac{d\vec{r}}{dt}$ vdgjhy $d\vec{r}=\vec{v}dt$

rkdghL tyJ gfffjpy cssij ,tthW vOjyhk

$$\int \vec{F}.d\vec{r}=\int\left(\vec{F}.\frac{d\vec{r}}{dt}\right)dt=\int\left(\vec{F}.\vec{v}\right)dt \quad \because \vec{v}=\frac{d\vec{r}}{dt}$$

rkdghL rkdghL ,y gujpapl

$$\int\frac{dW}{dt}dt=\left(\vec{F}.\vec{v}\right)dt$$

$$\int\left(\frac{dW}{dt}-\vec{F}.\vec{v}\right)dt=0$$

,ej njhlhghdJ dt ,d vej xU jddpriradhd kjpggpwFk rhpahf cssJ. milgGfFwpfFs css kjpgG Ropahf ,Uff Ntzlk vdgij ,J Fwpffpwj. mjhtJ

$$\frac{dW}{dt}=-\vec{F}.\vec{v}=0 \text{ myyJ } \frac{dW}{dt}=\vec{F}.\vec{v}$$

vLj;Jf;fhl;L:

1250 kg epiwAss xU thfdk xU rkkhd Neh rhiyapy 0.2 ms^{-2} KLffjJld 500 N vdw vjphfFk Gwtpirfnfjpuhf ,affggLfpwJ. thfdjjpd jpirNtfk 30 ms^{-1} vdpy thfdjjpd ,aejpuk ntspggLjJk jpwidf fzffpLf.

jhT:

thfdjjpd ,aejpuk› vjphfFk tpirfnfjpuhf Ntiy nraJ thfdjij xU KLffjJld ,aff Ntzlk. vdNt thfdjjpd ,aejpuk ntspggLjJk jpwd.

P = (vjphfFk tpir + (epiw ×Kffk) (jpirNtfk)

$$P=\vec{F}_{tot}.\vec{V}=(F_{resistive}+F)V$$

$$P=\vec{F}_{tot}.\vec{V}=(F_{resistive}+ma)V$$

= (500 + (1250 ×0.2)) (30) = 22.5 kW

Nkhjy;fs; (Collisions):

Nkhjy vdgJ ekikr Rwwp mttgNghJ eilngwf$ba xU nghJthd epfoT MFk. cjhuzkhf Nfuk› gpyypahl]› Nfhypfffzl Nghdw tpisahllfs ,U nghUlfSffpilNa Nkhjyfshdj njhljYld myyJ njhljypdwp Vwglyhk.

midjJ Nkhjy nrayKiwfspYk NehfNfhlL cejk khwhj. ,U nghUlfs Nkhjywwhy mtwwpwfpilNa nraygLk rkkhd fzjjhfF tpirfs Dtvdw Nkhjywk Neujjpy mtwwpd cejqfspy khwwjij VwgLjJfpwJ. mjhtJ Kjy nghUs $\vec{F}_{12}$ vdw tpiria ,uzlhtJ nghUspd kJ nrYjJfpwJ. mNjNghy epAlldpd %dwhk tpjpggb› ,uzlhtJ nghUshdj Kjy nghUspd kJ $\vec{F}_{21}$ vdw tpiria nrYjJfpwJ. ,it Kjy kwWk ,uzlhtJ nghUlfspd cejjjpy KiwNa $D\vec{P}_1$ kwWk $D\vec{P}_2$ vdw khwwjij VwgLjJfpwJ. jwNghJ ,jd njhlhGfis foffzlthW vOjyhk.

$$D\vec{p}_1=\vec{F}_{12}Dt$$

$$D\vec{p}_2=\vec{F}_{21}Dt$$

rkdghL ,uzilAk $ll

$$\Delta\vec{P}_1 + \Delta\vec{P}_2 = \vec{F}_{12}\,\Delta t + \vec{F}_{21}\Delta t = \left(\vec{F}_{12} + \vec{F}_{21}\right)\Delta t$$

eilA+lldid %dwhk tijggb $\vec{F}_{12} = -\vec{F}_{21}$

$$\Delta\vec{P}_1 + \Delta\vec{P}_2 = 0$$

$$\Delta(\vec{P}_1 + \vec{P}_2) = 0$$

,UGwKk Δt - My tFff› kwWk vy i y $\Delta t \to 0$ vdf nfhss ehk ngWtJ

$$\lim \Delta t \to 0 \frac{\Delta(\vec{p}_1 + \vec{p}_2)}{\Delta t} = \frac{d(\vec{p}_1 + \vec{p}_2)}{dt} = 0$$

Nkwfzl rkdghL nkhjj NehfNfhlL cejk xU khwh msT vdgijf Fwiffiwj.

FwigG: cejk xU ntflh msthFk. vdNt Nkhjyid NghJ jdijjdi nghUlfsid cejjijf fhz ntflh $Ljy gidgwwggl NtzLk.

Nkhjy;fsid; tiffs;
vej xU Nkhjy nrayKiwaiYk nkhjj NehfNfhlL cejKk› nkhjj MwwYk vgNghJk khwhJ. mNjrkak nkhjj ,aff MwwyhdJ vgNghJk khwhky ,Uffj Njitaiyiy. njhlff ,aff Mwwyid xU gFji NtW tifahd Mwwyhf khwwkilfiwJ. Vnddwhy Nkhjyfs kwWk Nkhjyfshy VwgLk cUfFiyT Mfiatwwid jhffk nghJthf ntggk› xyi xsi Nghdwtwiw cUthfFfiwJ. ,ej tiisTfis fzffiy nfhzL Nkhjyfis ehk foffzlthW tifggLjjyhkl.

a. klri Nkhjy
b. klriaww Nkhjy

klri Nkhjy; (Elastic Collision):
xU Nkhjyiy nghUlfsid njhlff nkhjj ,aff MwwyhdJ (NkhjYfF Kd) nghUlfsid ,Wji nkhjj ,aff MwwYfF (NkhjYfFg gid) rkkhf ,Uejhy mJ klriNkhjy vdggLk. mjhtJ
NkhjYfF Kd nkhjj ,aff Mwwy = NkhjYfFg gid nkhjj ,aff Mwwy

klriaww Nkhjy; (Inelastic collision):
xU Nkhjyiy nghUlfsid njhlff nkhjj ,aff MwwyhdJ (NkhjYfF Kd) nghUlfsid ,Wji nkhjj ,aff MwwYfF (NkhjYfFg gid) rkkhf ,yiynadiy mJ klriaww Nkhjy vdggLk. mjhtJ
NkhjYfF Kd nkhjj ,aff Mwwy ¹ NkhjYfFg gid nkhjj ,aff Mwwy
NkhjYfF Kd NkhjYfFg gid
nkhjj ,aff Mwwy - nkhjj ,aff Mwwy
= (Nkhjyid NghJ Mwwy ,ogG) = ΔQ

,aff Mwwy khWk vdiDk nkhjj Mwwy khwhJ. vndwhy nkhjj MwwyhdJ ,lff Mwwyid rkdghL kwWk Nkhjyid NghJ Vwgll midjJ ,ogGfisAk csslffia rkdghL (ΔQ) Mfiatwiwf nfhzLssJ. Nkhjyid NghJ ,aff Mwwyiy VwgLk ,ogG xyi ntggk Nghdw NtW tifahd Mwwyhf khwwkilfiwJ vdgij mwiaTk. NkYk NkhjYWk ,U nghUsfSk NkhjYfFg gid xdWld xdW xlbfnfhzlhy mttif Nkhjyfs KO klriawwNkhjy myyJ klriaww Nkhjy vdggLk. mttifahd Nkhjiy mbffb fhzyhk. cjhuzkhf><ukhd› xU fsikz cUzil (myyJ ggisfk) xU ,aqFk thfdjjid kJ vwiaggllhy› mJ ,aqFk thfdjJld xlbf nfhsfiwJ kwWk mit rk jiirNtfjJld ,aqFfidwd.

xU ghikhz klri Nkhjy;fs;
m_1 kwWk m_2 eiwAss ,U klrig nghUsfs fhlbAssthW xU cuhatww fiiljjsg gugguy NehfNfhlby (Neh x-mrrid jiiraiy) ,aqFtjhff fUJf.

kl;rp kwWk; kl;rpaww Nkhjy;fis xggLjy;:

t.vz	**kl;rp Nkhjy;**	**kl;rpaww cejk; khwhJ**
1.	nkhjj cejk khwhJ	nkhjj cejk khwhJ
2.	nkhjj ,aff Mwwy khwhJ	nkhjj ,aff Mwwy khWk
3.	njhlhGila tpirfs Mwwy khwwh tpirfs	njhlhGila tpirfs Mwwy khwWk tpirfs
4.	,aejpu Mwwy rpijtilahJ	,aejpu MwwyhdJ ntggk> xsp xyp Nghdwitahf ntspggLfpwJ.

epiw	**njhlf;f jpirNtfk;**	**,Wjp jpirNtfk;**
epiw m_1	u_1	v_1
epiw m_2	u_2	v_2

Nkhjy epfo epiw m_1 epiw m_2 I tpl Ntfkhf ,aqFtjhff fUJf. mjhtJ u_1> $u_2$klrp NkhjYfF ,U nghUsfspd nkhjj NehfNfhlL cejk kwWk ,aff Mwwyfs NkhjYfF KdGk NkhjYfFg gpdGk khwhky xNu msthf ,Uff Ntz Lk.

	epiw m_1,d; cejk;	**epiw m_2,d; cejk;**	**nkhj;j NehfNfhlL cejk;**
NkhjYfF Kd	$P_{i1} = m_1u_1$	$P_{i2} = m_2u_2$	$P_i = P_{il} + P_{i2}$ $P_i = m_1u_1 + m_2u_2$
NkhjYfF gpd	$P_{f1} = m_1v_1$	$P_{f2} = m_2v_2$	$P_f = P_{f1} + P_{f2}$ $P_f = m_1v_1 + m_2v_2$

NehfNfhlL cej khwh tpjpay ,UeJ NkhjYfF Kd nkhjj cejk (P_i) = NkhjYfFg gpd nkhjj cejk (P_f)

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

myyJ

$m1(u_1 - v_1) = m_2 (v_2 - u_2)$

NkYk

	epiw m_1,d; ,af;f Mwwy;	**epiw m_2,d; ,af;f Mwwy;**	**nkhj;j ,af;f Mwwy;**
NkhjYfF Kd	$KE_{i1} = \frac{1}{2}m_1u_1^2$	$KE_{i2} = \frac{1}{2}m_2u_2^2$	$KE_i = KE_{i1} + KE_{i2}$ $KE_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$
NkhjYfFg gpd	$KE_{f1} = \frac{1}{2}m_1v_1^2$	$KE_{f2} = \frac{1}{2}m_2v_2^2$	$KE_f = KE_{f1} + KE_{f2}$ $KE_f = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

klrp NkhjYfF

NkhjYfF Kd nkhjj ,aff Mwwy KE_i = NkhjYfFg gpd nkhjj ,aff Mwwy Ke_f

RUffpa gpwF khwwpaikff $m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2)$

Nkwfzl rkdghlil $a^2 - b^2 = (a + b)(a - b)$

vdw thagghlilg gadgLjjp kzLk vOj

$m_1(u_1+v_1)(u_1-v_1) = m_2(v_2+u_2)(v_2 - u_2)$

rkdghL tFff fpilggJ

$$\frac{m_1(u_1+v_1)(u_1-v_1)}{m_1(u_1-v_1)}=\frac{m_2(v_2+u_2)(v_2-u_2)}{m_2(v_2-u_2)}$$

$u_1 + v_1 = v_2 + u_2$

khwwpa i k f f

$u_1 – u_2 = v_2 – v_1$

rkdghL , t thW vOjyhk.

$u_1 – u_2 = -(v_1 – v_2)$

,jd nghUshdJ vej xU Neub klrp Nkhjypyk› NkhjYfFggpd ,U klrpg nghUsfspd xgGik Ntfk NkhjYfF Kd ,Uej mNj vz kjpgigf nfhzLk Mdhy vjphjjpiraYk ,UfFk vdgjhFk. NkYk ,ej KbT epiyiar rhhejjyy vdgij mwpaTk.

Nkwfzl rkdghlbypUeJ $v_1$kwWk $v_2$kjpgGfisf fhz

$v_1 = v_2 + u_2 – u_1$

myyJ

$v_2 = u_1 + v_1 – u_2$

,Wjp jpirNtfqfs $v_1$kwWk $v_2$fzlwpjy:

rkdghL gupjapLtjd %yk m_1 ,d jpirNtfkhdJ

$m_1(u_1 – v_1) = m_2(u_1 + v_1 – u_2 – u_2)$

$m_1 (u_1 – v_1) = m_2 (u_1 + v_1 – 2u_2)$

$m_1u_1 – m_1v_1 = m_2u_1 + m_2v_1 – 2m_2u_2$

$m_1u_1 – m_2u_1 + 2m_2u_2 = m_1v_1 + m_2v_1$

$(m_1 – m_2)u_1 + 2m_2u_2 = (m_1 + m_2)v_1$

myyJ $v_1=\left(\frac{m_1-m_2}{m_1+m_2}\right)u_1+\left(\frac{2m_2}{m_1+m_2}\right)u_2$

,J NghdNw rkdghL gupjapl myyJ rkdghL gupjapl m_2 ,d ,Wjp jpirNtfkhdJ

$$v2=\left(\frac{2m_1}{m_1+m_2}\right)u_1+\left(\frac{m_2-m_1}{m_1-m_2}\right)u_2$$

nghUsfs xNu epiwiaf nfhzbUejhy mjhtJ $m_1 = m_2$

rkdghL $v_1=(0)u_1+\left(\frac{2m_2}{2m_2}\right)u_2$

$v_1 = u_2$

rkdghL Þ $v_2=\left(\frac{2m_1}{2m_1}\right)u_1+(0)u_2$

$v_2 = u_1$

rkdghLfs kwWk njhptpggJ vddntdpy xU ghpkhz klrp Nkhjypy rk epiwAss ,U nghUsfs NkhjpfnfhzlhY NkhjYfFg gpd mtwwpd jpirNtfqfs ghpkhwpf nfhssggLfpdwd.

nghUsfs xNu epiwiaf nfhzbUejhy› mjhtJ $m_1 = m_2$ kwWk ,uzlhtJ nghUs (toffkhf ,yfF vd mioffggLtJ) xaT epiyapy css NghJ ($u^2 = 0$) $m_1 = m_2$kwWk ($u_2 = 0$) vdw kjpgGfis rkdghLfs ,y gupjapl

rkdghL Þ $v_1 = 0$

rkdghL Þ $v_2 = u_1$

rkdghL kwWk njhtggJ vddntdy Kjy nghUs NkhjYfFg gd xaT eiyfF tUkNghJ ,uzlhtJ nghUs Kjy nghUsd njhlff jirNtfjjy ,aqFfwJ.

Kjy nghUshdJ ,uzlhtJ nghUsd eiwia tl Fiwthf ,Uejhy› $\left(m_1 << m_2, \frac{m_1}{m_2} << 1\right)$ gwF tfjk $\frac{m_1}{m_2} \to 0$ kwWk ,yfF xaT eiyay cssNghJ ($u_2 = 0$) rkdghL ,d njhFj kwWk gFjia m_2My tFfff

$$v_1 = \frac{\left(\frac{m_1}{m_2} - 1\right)}{\left(\frac{m_1}{m_2} + 1\right)} u_1 + \frac{2}{\left(\frac{m_1}{m_2} + 1\right)} (o)$$

$$v_1 = \frac{(0 - 1)}{(0 + 1)} u_1$$

$$v_1 = u_1$$

,J Nghdnw›

rkdghL njhFj kwWk gFjia m_2 – Mytfff

$$v_2 = \frac{2\frac{m_1}{m_2}}{\left(\frac{m_1}{m_2} + 1\right)} u_1 + \frac{\left(1 - \frac{m_1}{m_2}\right)}{\left(\frac{m_1}{m_2} + 1\right)}$$

$$v_2 = (O) u_1 + \frac{\left(1 - \frac{m_1}{m_2}\right)}{\left(\frac{m_1}{m_2} + 1\right)}$$

eiw Fiwthf css Kjy nghUshdJ mNj njhlff jirNtfjJld vjhjjiray jUkGfwJ (kznlOfwJ) vdgijr rkdghL css vjhfFw Fwffwj. mjf eiwAss ,uzlhtJ nghUshdJ NkhjYfFg gwFk xaT eiyaNyNa njhlheJ ,Uffwj vdgijr rkdghL Fwffwj. vLjJffhllhf› geJ xdW eiyahd Rthd kJ vwaggllhy gejhdJ vwaggll mNj jirNTfjjNyNa vjhjjiray Rthy ,UeJ jUkg tUk.

NehT 4: ,uzlhtJ nghUshdJ Kjy nghUistl eiw Fiwthf cssNghJ›

$$\left(m_2 << m_1, \frac{m_2}{m_1} << 1\right) \text{ gwF tfjk } \frac{m_2}{m_1} \to 0$$

kwWk ,yfF xaT eiyay cssNghJ ($u_2 = 0$) rkdghL ,d njhFj kwWk gFjia m_1 - My tFfff

$$v_1 = \left(\frac{1 - \frac{m_2}{m_1}}{1 + \frac{m_2}{m_1}}\right)u_1 + \left(\frac{2\frac{m_2}{m_1}}{1 + \frac{m_2}{m_1}}\right)(O)$$

$$v_1 = \left(\frac{1 - 0}{1 + 0}\right)u_1 + \left(\frac{0}{1 + 0}\right)(0)$$

$$v_1 = u_1$$

,J Nghd Nw› njhFjp kwWk gFjpia m_1 - My tFff

$$v_2 = \left(\frac{2}{1 + \frac{m_2}{m_1}}\right)u_1 + \left(\frac{\frac{m_2}{m_1} - 1}{\frac{m_2}{m_1}}\right)(O)$$

$$v_2 = \left(\frac{2}{1 + 0}\right)u_1$$

$$v_2 = 2u_1$$

fdkhf css Kjy nghUshdJ NkhjYfFg gpwF mNj jpirNtfjJld njhlheJ ,aqFfpwJ vdgijr rkdghL Fwpffpwj. epiw Fiwthf css ,uzlhtJ nghUs Kjy nghUspd njhlff jpirNtfjijg Nghy ,U klqF jpirNtfjJld ,aqFfpwJ vdgijr rkdghL Fwpffpwj. epiw Fiwthf css nghUs NkhjYWk Gsspaypueh Ntfkhfr nryfpwJ.

vLj;Jf;fhl;L:

10 ms^{-1} Ntfjjpy ,aqFk xU epiw Fiwthd nghUs mjd epiwiag NghdW ,U klqF kwWk mjd Ntfjjpy ghjpasT nfhzl mNj jpiraypy ,aqFk kwnwhU nghUspd kJ NkhJfpwJ. Nkhjyhd J xU ghpkhz klrp Nkhjy vdf fUJf. NkhjYfFg gpwF ,U nghUsfspd Ntfk vdd?

jhhT:

Kjy nghUspd epiw m vdf› kwWk mjd njhlff jpirNtfk u_1 = 10 ms^{-1}, vdNt ,uzlhtJ nghUspd epiw 2m kwWk mjd njhlff jpirNtfk

$$u_2 = \frac{1}{2}u_1 = \frac{1}{2}(10ms^{-1})$$

rkdghLfs kwWk ,U nghUsfspd ,Wjp jpirNtfqfisf fzffplyhk.

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \left(\frac{2m_2}{m_1 + m_2}\right)u_2$$

$$v_1 = \left(\frac{m - 2m}{m + 2m}\right)10 + \left(\frac{2 \times 2m}{m + 2m}\right)5$$

$$v_1 = \left(\frac{1}{3}\right)10 + \left(\frac{4}{3}\right)5 = \frac{-10 + 20}{3} = \frac{10}{3}$$

$$v_1 = 3.33\ ms^{-1}$$

$$v_2 = \left(\frac{2m_1}{m_1+m_2}\right)u_1 + \left(\frac{m_2-m_1}{m_1+m_2}\right)u_2$$

$$v_2 = \left(\frac{2m}{m+2m}\right)10 + \left(\frac{2m-m}{m+2m}\right)5$$

$$v_2 = \left(\frac{2}{3}\right)10 + \left(\frac{1}{3}\right)5 = \frac{20+5}{3} = \frac{25}{3}$$

$v^2 = 8.33\ ms^{-1}$

v_1 kwWk v_2 Mfpa ,U Ntfqf Sk NehfFwpahf cssjhy mit ,uzLk KiwNa 3.33 m s^{-1} kwWk 8.33 ms^{-1} vdw jpirNtfqfSld NkhjYfF Kd ,aqfpa jpiranyNa ,aqFfpdwd.

KO klr;raww Nkhjy; (Perfect Inelastic Collision):

KO klrpaww Nkhjypy nghUsfs NkhjYfFggpwF xU nghJthd jpirNtfjjpy ,aqFk tifapy xdWld xdW epuejukhf xlbfnfhsfpdwd. $m_1$kwWk $m_2$epiw nfhzl xU nghUsfs NkhjYfF Kd KiwNa $u_1$kwWk $u_2$vdw njhlff jpirNtfqfSld ,aqFtjhff nfhsf. KO klrpaww NkhjYfFg gpwF nghUlfs v vdw nghJthd jpirNtfjJld xdwhf ,aqFfpdwd.
Nkhjypd NghJ NehfNfhlL cejk khwwgglhky cssjhy

nghUs;	jpirNtfk;		NehfNfhlL cejk;	
	njhlf;fk;	,Wjp	njhlf;fk;	,Wjp
epiw m_1	u_1	v	m_1u_1	m_1v
epiw m_2	u_2	v	m_2u_2	m_2v
	nkhjjk		$m_1u_1 + m_2u_2$	$(m_1+m_2)\ v$

nghJthf jpirNtfjij foffzlthW fzffplyhk.

$$v = \frac{m_1u_1 + m_2u_2}{(m_1+m_2)}$$

vLj;Jf;fhl;L:
50 g epiwAss xU Jgghffp FzL 450 g epiwAss xU njhqftplggll nghUspd mbggFjapypUeJ RlggLfpwJ. Jgghffp FzL nghUspDs nghjpeJ nghUshdJ 1.8 m caujpwF NkyNehffpr nryfpwJ. Jgghffp Fzbd Ntfjijf fzffpLf.

$g = 10\ ms^{-2}$vdf nfhsf.

jhT:

$m_1 = 50\ g = 0.05\ kg$; $m_2 = 450\ g = 0.45\ kg$

Jgghffp Fzbd Ntfk u_1MFk. ,uzlhtJ nghUs XaT epiyapy cssJ ($u_2 = 0$) Jgghffp FzL nghUspDs nghjpej gpwF Jgghffp FzL kwWk nghUs Mfpatwpd nghJthd jpirNtfk v vdf.

$$v = \frac{m_1u_1 + m_2u_2}{(m_1 + m_2)}$$

$$v = \frac{0.05u_1 + (0.45 \times 0)}{(0.05 + 0.45)} = \frac{0.05}{0.50}u_1$$

nghJthd j¡irNtfkhdJ Jgghff¡ FzL kwWk nghUs Mf¡a xUqf¡i zej mikgg¡d NkyNehff¡a nrqFjJ ,affjj¡wfhd njhlff j¡irNtfk MFk. ,uzlhtJ ,affr rkdghlby¡UeJ

$$v = \sqrt{2gh}$$

$$v = \sqrt{2 \times 10 \times 1.8} = \sqrt{36}$$

$$v = 6\ ms^{-1}$$

,jid Nkwfzl rkdghlby g¡uj¡a¡lL U_1 kj¡giggngw

$$6 = \frac{0.05}{0.50}u_1 \quad \text{myyJ} \quad u_1 = \frac{0.50}{0.05} \times 6 = 10 \times 6$$

$$u_1 = 60ms^{-1}$$

KO kl;r¡aww Nkhjy¡y; VwgLk; ,af;f Mwwy; ,ogG:

KO klr¡aww Nkhjy¡d NghJ ,aff Mwwy¡d ,ogghdJ xy¡ ntggk› xs¡ Nghdw NtW tifahd Mwwyhf khwwggLf¡wJ. NkhjYfF Kd nkhjj ,aff Mwwy KE¡kwWk NkhjYfFgg¡d nkhjj ,aff Mwwy EK¡fvdf nfhsf.

$$KE_i = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$$

NkhjYfFg g¡d nkhjj ,aff Mwwy

$$KE_f = \frac{1}{2}(m_1 + m_2)v^2$$

vdNt ,aff Mwwy¡y VwgLk ,ogG

$$\Delta Q = KE_i - KE_f$$

$$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)v^2$$

rkdghL rkdghL ,y g¡uj¡a¡lL $(a + b)^2 = a^2 + b^2 + 2ab$ vdw ,awfz¡j rkdghlilg gadgLjj› RUff ehk ngWtJ.

kl;r¡asgG Fzfk; (e)(Coefficient of restitution):

,U ,uggh geJ kwWk xU g¡sh]bf geJ ,uzilAk xNu jsjj¡y t¡ornratjhff nfhsNthk. ,uggh gejhdJ g¡sh]bf geijt¡l mj¡f caujj¡wF NknyOkGk. Vnddwhy xU klr¡g gzGss ,uggh gej¡wF ,aff Mwwy¡d ,ogG g¡sh]bf gej¡wF ,aff Mwwy¡d ,ogG g¡sh]bf gej¡wfhd ,ogigt¡l k¡f FiwthFk. nghJthf NkhjYfFg g¡wF ,U nghUsfs¡d ,aff Mwwy kj¡gg¡id klr¡asgG Fzfk(Coefficient of Restitution – COR) vdggLk xU gh¡khzkww vz %ykhf msejw¡ayhk.

NkhjYfFg g¡d css t¡yFk j¡irNtfjj¡wFk (rhhGj j¡irNtfk) NkhjYfF Kd css neUqFk j¡irNtfjj¡wFk (rhhGj j¡irNtfk) ,ilNa css t¡fjk klr¡asgG Fzfk vd tiuaWffggLf¡wJ.

mjhtJ

$$e = \frac{\text{tpyFk jpirNtfk (NkhjYf Fg gpd)}}{\text{neUqFk jpirNtfk (NkhjYf F gpd)}}$$

$$= = \frac{(v_2 - v_1)}{(u_1 - u_2)}$$

klrp Nkhjypy tpyFk jpirNtfkhdJ neUqFk jpirNtfjjpwF rkk vd fpilffg ngwNwhk.

mjhtJ

$$(u_1 - u_2) = (v_2 - v_1) \Rightarrow \frac{(v_2 - v_1)}{(u_1 - u_2)} = 1 = e$$

klrp NkhjYfF klrpaspgG Fzfk e = 1 vdgij ,J Fwpffpwj. ,ayghf› NkhjYfFg gpwF ,aff Mwwypy ,ogG VJkpyiy vdgNj ,jd nghUshFk. vdNt nghUshdJ mNj ,aff MwwYld NknyOkGfpwJ. ,J toffkhf KO klrp vd mioffggLfpwJ.

vttpj czikahd Nkhjy epfoTfspYk Nkhjypdhy ,aff Mwwypy VjhtJ ,ogG VwgLk. ,jd nghUs e ,d kjpgG vgnghOJk 1 – l tplf Fiwthf ,UfFk. KOikahd gpshjbf gejhf ,Uejhy mJ kzLk NknyOkghJ. Mifahy NkhjYfFg gpwF mtwwpd tpyFk jpirNtfk Ropahfk. vdNt klrpaspgG Fzfjjpd kjpgG e = 0. nghJthf› xU nghUspd klrpaspgG Fzfk 0 < e < 1 vd ,UfFk.

vLj;Jf;fhl;L:

xU klrpaww Nkhjypy xU nghUs epiyahf cssNghJ rkepiwfs nfhzl nghUsfspd jpirNtfqfspd tpfpjk $\frac{v_1}{v_2} = \frac{1-e}{1+e}$ vdf fhlLf.

jhhT:

$$e = \frac{\text{tpyFk jpirNtfk (NkhjYf Fg gpd)}}{\text{neUqFk jpirNtfk (NkhjYf F gpd)}}$$

$$= = \frac{(v_2 - v_1)}{(u_1 - u_2)} = \frac{(v_2 - v_1)}{(u_1 - 0)} = \frac{(v_2 - v_1)}{u_1}$$

$$\therefore v_2 - v_1 = eu_1$$

NehfNfhlL cejk khwh tpjpapypUeJ

$$mu_1 = mv_1 + mv_2 \therefore u_1 = v_1 + v_2$$

rkdghL (2) ,y css u_1,d kjpgig rkdghL (1) ,y gpujpapl

$$v_2 - v_1 = e(v_1 + v_2)$$

,jidr RUff

$$\frac{v_1}{v_2} = \frac{1-e}{1+e}$$