KvR, kw³ I ¶gZv

f~wgKv

mvaviYfv‡e ˆ`bw›`b Rxe‡b †Kvb wKQy Kiv‡KB KvR e‡j| wKšÍ c`v_ weÁv‡bi fvlvq ïagvÎ †Kvb wKQy Ki‡jB KvR nq bv| GLv‡b ej c‡qvM Kivi mv‡_ mv‡_ e¯‘i miY n‡j Z‡eB Zv‡K KvR ejv nq| †hgbÑ GKRb gvbyl mvivw`b a‡i hw` †mv‡Zi wecix‡Z †bŠKv Pvjvq Ges w`b †k‡l †`‡Lb Zxi‡i mv‡c‡¶ wZwb GKB Ae¯’v‡b Av‡Qb, Z‡e c`v_ weÁv‡bi fvlvq wZwb †Kvb KvR Ki‡jb bv| †Kbbv, ej c‡qvM Kivi d‡j Zvi †bŠKvi †Kvb miY nqwb| wKšÍ ˆ`bw›`b Rxe‡bi avivYv Abyhvqx wZwb cPyi KvwqK cwikg Ki‡jb|

cvVÑ1
KvR

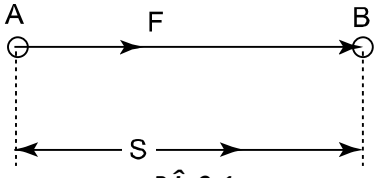
D‡Ïk¨
G cvV †k‡l Avcwb

- Kv‡Ri msÁv wjL‡Z cvi‡eb,
- Kv‡Ri GKK mg‡ni eYbv w`‡Z cvi‡eb,
- Kv‡Ri GKK mg‡ni g‡a¨ cvi¯úwiK m¤úK wjL‡Z cvi‡eb|

6.1.1. KvR (Work)

KvR t †Kvb e¯‘i Dci ej c‡qvM Kiv n‡j hw` e‡ji Awfgy³ e¯‘wU miY N‡U, Z‡e chy³ ej KvR K‡i‡Q e‡j aiv nq| chy³ ej I H e‡ji Awfgy³ e¯‘i †h miY N‡U, Zv‡`i ¸Ydj‡K KvR e‡j|

awi, A we›`y‡Z Ae¯Z GKwU e¯‘i Dci AB eivei F ej c‡qvM Kiv n‡jv| ej c‡qv‡Mi d‡j e¯‘wU AB eivei B we›`y‡Z m‡i †M‡jv| G‡¶‡Î awi, e¯‘wUi miY n‡jv S|



wPÎ 6.1

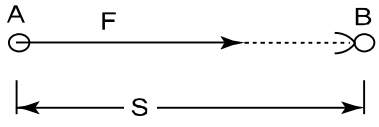
∴ ej‡ji Øviv m¤úb KvR, W = FS ..... (6.1)

ej `y‡ivt‡e KvR Ki‡Z cv‡i, c_gwU nj e‡ji Øviv KvR| wØZxqwU n‡jv e‡ji wei“‡× KvR|

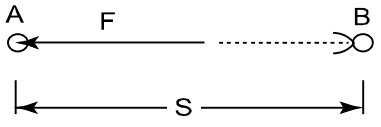
e‡ji Øviv KvR t ej c‡qv‡Mi d‡j e¯‘wU hw` e‡ji wµqvi Awfgy³ m‡i hvq (wPÎ 6.2) Z‡e e‡ji Øviv KvR n‡q‡Q e‡j|

(K) GKwU eB †Uwe‡ji Dci †_‡K †g‡S‡Z †dj‡jv n‡jv| eBwU AwfKl e‡ji cfv‡e wb‡P co‡e| G‡¶‡Î AwfKl e‡ji Øviv KvR n‡q‡Q e‡j|

(L) GKwU dz‘ej Pjš Ae¯vq Av‡Q| dz‘ejwU‡K ej c‡qvM Kivi d‡j hw` GUv e‡ji wµqvi w`‡KB m‡i hvq| Z‡e e‡ji Øviv KvR n‡q‡Q e‡j|



wPÎ 6.2



wPÎ 6.3

e‡ji wei“‡× KvR t ej c‡qv‡Mi d‡j e¯‘wU hw` e‡ji wµqvi wecixZ w`‡K m‡i hvq (wPÎ 6-3) Z‡e e‡ji wei“‡× KvR n‡q‡Q e‡j|

(K) GKwU eB †g‡S †_‡K †Uwe‡j IVv‡bv nj| eBwU AwfKl e‡ji wei“‡× Ic‡i IV‡e| G‡¶‡Î AwfKl e‡ji wei“‡× KvR n‡q‡Q e‡j|

(L) `yU wecixZagx PvR ev Avavb ci¯úi‡K AvKlY K‡i| G `yU Avavb‡K ci¯úi n‡Z `‡i miv‡j e‡ji wei“‡× KvR n‡q‡Q e‡j|

6.1.2. Kv‡Ri GKK (Unit of Work)

Avgiv Rwb, KvR, W = FS

GLv‡b, ej = F Ges miY = S

hw` F = 1 Ges S =1 nq Z‡e W=1 nq| A_vr †Kvb e¯‘z Dci GKK ej c‡qv‡Mi d‡j e‡ji wµqv †iLv eivei hw` e¯‘z GKK miY nq, Z‡e m¤úb Kv‡Ri cwigvY‡K GKK KvR e‡j| Kv‡Ri AvšRwZK GKK n‡jv Rý| †Kvb e¯‘z Dci GK wbDUb ej c‡qvM Ki‡j hw` e‡ji w`‡K Dnvi miY 1 wgt nq, Zvn‡j m¤úwZK Kv‡Ri cwigvY n‡e 1 Rý|

6.1.3. Kv‡Ri gvÎv (Dimension of work)

Avgiv Rwb,

$$KvR = ej \times miY = fi \times ZiY \times miY$$

$$= fi \times \frac{miY^2}{mgq^2}$$

$$\therefore [W] = \left[M \frac{L^2}{T^2} \right] = [ML^2T^{-2}]$$

mvimsL¨c

KvR t chy³ ej I e‡ji AwfgyL e¯‘z mi‡Yi ¸Ydj‡K KvR e‡j|

e‡ji Øviv KvR t ej c‡qv‡Mi d‡j e¯‘‡Z hw` e‡ji wµqvi AwfgyL m‡i hvq, Z‡e e‡ji Øviv KvR n‡q‡Q ejSvq|

e‡ji wei“‡× KvR t ej c‡qv‡Mi d‡j e¯‘‡Z hw` e‡ji wµqvi wecixZ w`‡K m‡i hvq, Z‡e e‡ji wei“‡× KvR n‡q‡Q ejSvq|

c‡qvRbxq mgxKiY

KvR t W = **F. S**

cv‡VvËi gj¨vqb

K. mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1| c`v_ we`¨vq KvR ej‡Z ejSvqÑ

(K) ‡Kvb e¯‘z †e‡Mi cwieZb (L) †Kvb e¯‘z Dci ej c‡qvM

(M) †Kvb KwqK cwikg (N) chy³ e‡ji AwfgyL ev wecixZ w`‡K e¯‘z miY|

2| AvšRwZK c×wZ‡Z Kv‡Ri GKKÑ

(K) Mvg-†m.wg. (L) dz-cvDÛvj

(M) Rý (N) wK‡jvMvg-wgUvi|

L. msw¶ß ck

1| Kv‡Ri msÁv wjLyb|

2| Kv‡Ri GKK I gvÎv wjLyb|

cvV-2
wewfbœ cKvi ej KZ…K K…Z Kvh©

D‡Ïk¨
G cvV †k‡l Avcwb

- AwfKl©q e‡ji cÖfv‡e m¤úvw`Z Kv‡Ri eYbv w`‡Z cvi‡eb;
- a“e ej KZ…K K…Z m¤úvw`Z Kv‡Ri eYbv w`‡Z cvi‡eb;
- cwieZbkxj ej KZ…K K…Z m¤úvw`Z Kv‡Ri eYbv w`‡Z cvi‡eb;
- w¯úÖs cmvi‡Y m¤úvw`Z Kv‡Ri †¶‡Î, ej ∝ |mibl cgvY Ki‡Z cvi‡eb|

6.2.1. AwfKl©q KvR

(i) AwfKl©q e‡ji cÖfv‡e cZ‡bi Rb¨ KvR t

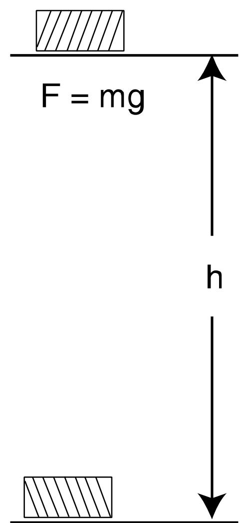
g‡bKwi, m f‡ii GKwU e¯‘‡K h D”PZv n‡Z gvwU‡Z †dj‡v n‡jv (wPÎ 6.4)|

m¤úvw`Z KvR = ej × miY

ev, W = F × h

= mg × h

GLv‡b mg e¯‘i Dci cÖhy³ AwfKl©q ej|



wPÎ 6.4

∴ H ej Øviv m¤úvw`Z KvR t

W = mgh .... (6.2)

∴ m¤úvw`Z KvR = fi × AwfKl©q ZiY × D”PZv|

D`vniY-1

500 wK‡jvMÖvg f‡ii GKwU e¯‘ 50 wgUvi D”PZv n‡Z co‡j| e¯‘wUi Dci AwfKl©q ej Øviv m¤úvw`Z KvR KZ?

mgvavb t GLv‡b †h‡nZz e¯‘wU Dci n‡Z wb‡P co‡e, myZivs Gi Dci AwfKl©q ej wµqv Ki‡e|

∴ AwfKl©q ej Øviv m¤úvw`Z KvRÑ

W = mgh

= 500 × 9.8 × 50 Ryj

= 2.45 × 10^5 Ryj|

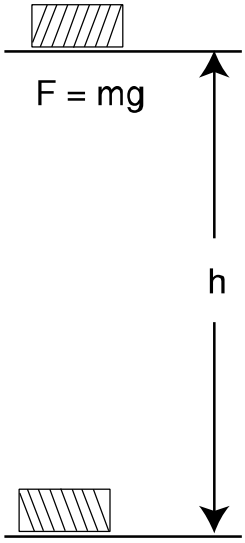
(ii) *AwfKlxq e‡ji wei“‡× Dc‡i DVv‡bvi Rb¨ KvR t-*

g‡b Kwi, m *f‡ii GKwU e¯‘‡K* h *D”PZvq DVv‡bv n‡jv (wPÎ 6.5)|*

m¤úvw`Z KvR = m ×(−g)×h

[GLv‡b e‡ji wei“‡× KvR msNwUZ n‡”Q e‡j g *Gi gvb FYvZK]*

∴ W = −mgh ..... *(6.3)*



wPÎ 6.5

wKšzhLb G KvRwU gvby‡l ev ewB‡ii †Kvb Drm Øviv m¤úvw`Z nq, ZLb e¯‘i IR‡bi* (mg) *mgcwigvY ej Dci w`‡K c‡qvM K‡i e¯‘wU‡K DVv‡Z nq|

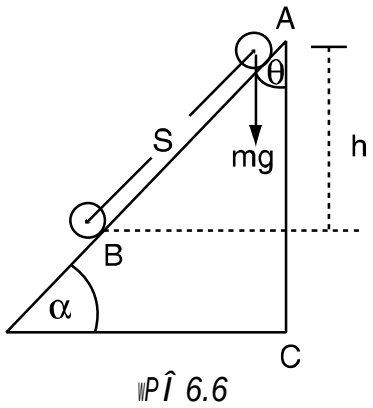
∴ *gvby‡l ev Drm KZK.m¤úvw`Z KvR* = mg × h

ev, W = mgh

(iii) *†njvb Zj eivei AwfKlxq e‡ji cfv‡e cZ‡bi Rb¨ KvR t*

awi, m *f‡ii GKwU e¯‘GKwU gm¤Y AvbZ Zj* AB *†e‡q* A *Ae¯‘vb n‡Z* B *Ae¯‘v‡b Avm‡Z e¯‘wU* h *D”PZv AwZµg K‡i| AwfKl ej* mg *e¯‘wU‡K Lvovfv‡e wb‡Pi w`‡K Uvb‡e|*

g‡bKwi, mi‡Yi AwfgyL I AwfKl e‡ji AwfgyLi ga¨eZx† KvY θ *Ges* AB = s



wPÎ 6.6

∴ *AwfKl ej* mg*-Gi w`‡K mi‡Yi Ask* = Scosθ,

wPÎ n‡Z, h = scosθ

∴ *AwfKl ej Øviv m¤úvw`Z KvR -*

W = mg scosθ

= mgh

hw` Zjwu Aby‡fwgK Z‡ji mv‡_ α *†KvY Drcb K‡i, Zvn‡jÑ*

θ = (90° - α)

∴ W = mgscosθ = mgcos (90°-α)

= mgs sinα .... *(6.4)*

D`vniY-2

150 cvDÛ f‡ii GK e¨w³ 50 cvDÛ f‡ii GKwU †evSv wb‡q 40 dzU `xN GKwU wmuo †e‡q bvgj | hw` wmuowU †` Iqv‡j ii mnZ 60° †Kv‡Y _v‡K, Z‡e †m KZ KvR Kij †ei Ki"b|

mgvavb t

awi, KvR = W

Avgiv cvB, W = mgh

Avevi h = fvi‡K‡›` i উল্লম্ব miY = Scosθ

∴ W = mgS cosθ

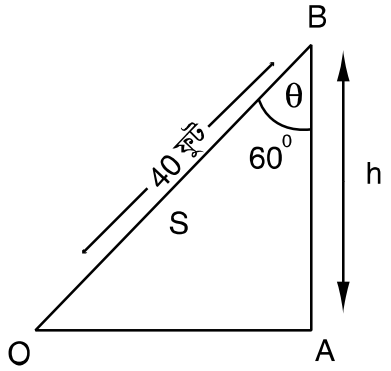
GLv‡b,

m = (150+50) cvDÛ = 200 cvDÛ, g = 32 dzU/†m2

∴ W = 200 × 32 × 40 × cos60°

= 200 × 1280 × $\frac{1}{2}$

= 128000 dzU-cvDÛvj |



wPÎ 6.7

6.2.2. Kv‡Ri cwigvc (a"e e‡ji †¶‡Î)

chy³ ej Ges e‡ji Awfgy³L e¯‘z mi‡Yi ¸Ydj Øviv Kv‡Ri cwigvc Kiv nq|

A_vr KvR = ej × e‡ji wµqv †iLv eivei mi‡Yi gvb|

ev, w = F × S

GLv‡b, F = chy³ ej

S = e‡ji wµqv †iLv eivei e¯‘z miY|

g‡b Kwi, A we›`y‡Z Ae¯Z GKwU e¯‘z Dci AB eivei F ej chy³ n‡jv| ej chy³ nIqvq e¯‘wU A we›`y n‡Z C we›`y‡Z wM‡q AC=S `i‡Z AwZµg Kij [wPÎ 6-8]| C we›`y n‡Z AB Gi Dci CD j¤ Uvbv n‡jv| Zvn‡j AB eivei mi‡Yi Dcvsk = AD|

∴ F ej Øviv m¤úwË`Z KvR,

W = ej × e‡ji wµqv‡iLv eivei mi‡Yi gvb

= F × AD

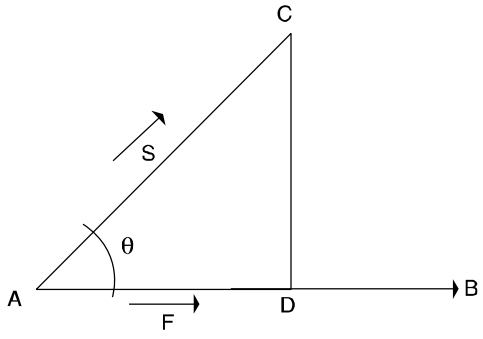
ADC mg‡KvYx wÎf‡ZR,

cosθ = $\frac{AD}{AC}$

ev, AD = ACCOSθ = SCOSθ

∴ W = F × SCOSθ.....(1)

= S × F COSθ..... (2)



wPÎ 6.8

(1) n‡Z, W = e‡ji gvb × e‡ji w`‡K mi‡Yi Dcvs‡ki gvb|

(2) n‡Z, W = mi‡Yi gvb × mi‡Yi w`‡K e‡ji Dcvs‡ki gvb|

(1) I (2) n‡Z, W = **F. S = S . F**.... .... (6.5)

A_vr KvR‡K ej I mi‡Yi WU ev †¯‹vi ¸Ydj (Dot ev Scalar Products) wn‡m‡e cKvk Kiv hvq| †h‡nZz KvR (W), `y‡U †f±‡ii ¸Ydj, AZGe KvR GKwU †¯‹vi iwk|

(6.5) mgvKiY n‡Z cvBÑ

W = **F.S** = FScosθ; GLv‡b, θ, FGes SGi ga¨eZx† KvY|

(K) $\theta = 0°$ *n‡j*

$W = F.S = FS\cos\theta$

$= FS$

KvR abvZK n‡j e‡j i Øviv KvR eySvq|

(L) $\theta = 90°$ *n‡j*

$W = FS\cos\theta = FS\cos 90° = 0$

A_vr ej Øviv KvR kbv¨ n‡e|

(M) $\theta = 180°$ *n‡j*

$W = FS\cos 180° = -FS$

KvR FYvZK n‡j e‡j i wei“‡× KvR eySvq|

D`vniY-3

200 *WvB‡bi GKwU ej wb`ó f‡ii Dci wµqv Kivq e¯‘wU ej c‡qv‡Mi w`‡Ki mv‡_* 60° *†KvY Drcb K‡i* 50 *†m.wg. `i“Z m‡i †Mj| Kv‡Ri cwigvY †ei Ki“b|*

mgvavb t

awi, KvR = W

Avgiv cvB, W = FS cosθ

= 200×50×COS60°

$= 200 \times 50 \times \frac{1}{2}$

= 5000 *AvM|*

GLv‡b,

F = 200 *WvBb*

S = 50 *†m.wg Ges*

θ = 60°

6.2.3. cwieZbkxj ej KZK.m¤úvw`Z KvR (Work done by variable force)

g‡bKwi, GKwU cwieZbkxj ej F, X *A¶ eivei e¯‘wU Dci wµqv Ki‡Q| d‡j e¯‘wU* x_1 *Ae¯v‡b n‡Z* x_2 *Ae¯v‡b m‡i †Mj| ej* F,x *Gi A‡c¶K| GLb* x_1 *t_‡K* x_2 *chš† gvU miY‡K A‡bK¸wj ¶z ¶z ^`N¨* dx *Gi mgvó wn‡m‡e MY¨ Kiv nj| d‡j, cwZwU ¶z mi‡Yi ïi“‡Z e¯‘wU Dci ej †h wµqv K‡i Zv Øvi‡B H miY m¤úb nq|*

∴ dx *¶z mi‡Yi Rb¨ ej KZK.KZ.KvR,*

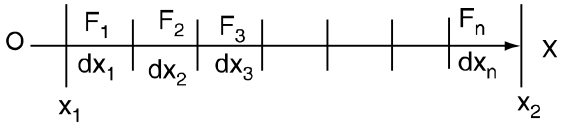
$dw = Fdx$

x_1 *n‡Z* x_2 *†Z mi‡Yi Rb¨ †gvU KvR n‡e mg¯— ¶z ¶z* dx *Ask mi‡Yi Rb¨ Kv‡Ri mgvói mgvb|*

∴ *m¤úvw`Z KvR,* $W = \int dw = \int_{x_1}^{x_2} Fdx$

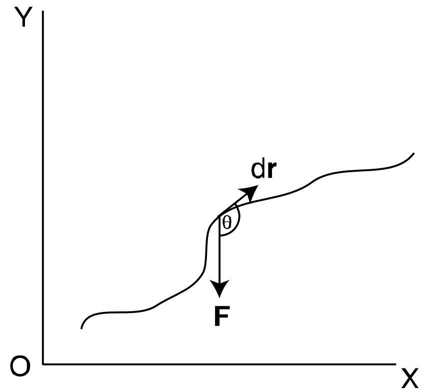
hw` e‡ji Awfgy³ I mi‡Yi Awfgy³Li ga¨eZx †KvY θ *nq (wPÎ 6.6)*

$W = \mathbf{F}.\mathbf{dr} = \int_{r_1}^{r_2} FCos\theta dr$ .....{*6.9(L)*}



wPÎ 6-9 (K)

ej, gv‡b I AwfgyL cwieZbkxj n‡j H e‡ji wµqvi Rb¨ e¯‘GKwU wbw`ó †iLvq MwZkxj n‡e| G‡¶‡Î wbw`ó †iLwUi †Kvb we›`y‡Z AswKZ ¯úkK Øviv Hwe›`y‡Z e¯‘ MwZ AwfgyL wbw`ó n‡e|



wPÎ 6-9(L)

Kv‡RB GB cwieZbkxj e‡ji KZKvR wbYq Ki‡Z mgM MwZc_‡K AwZ ¶z ¶z miY dr Gi mgwói mgvb wn‡m‡e aiv nq|

awi, cwZwU ¶z mi‡Yi ïi“‡Z e¯‘ Dci †h ej wµqv K‡i †mB ej †m ¶z mi‡Yi Rb¨ AcwieZbkxj| GLb, GKwU ¶z miY dr Ges H mi‡Yi Rb¨ wµqviZ ej F-Gi ga¨eZx †KvY θ n‡j ejwU dr eivei GKwU As‡k Ges Zvi j¤ w`‡K Aci GKwU As‡k wef³ n‡e| AvswkK `yU h_vµ‡g, n‡eÑ

FCosθ Ges FSinθ

H ¶z mi‡Yi Rb¨ e‡ji FSinθ AskK Øviv m¤úbœ KvR kb¨| †Kbbv, dr I FSinθ Gi ga¨eZx †KvY 90°|

Zvn‡j dr mi‡Yi Rb¨ KZKvR

$$dw = FdrCos\theta = \mathbf{F}.d\mathbf{r}$$

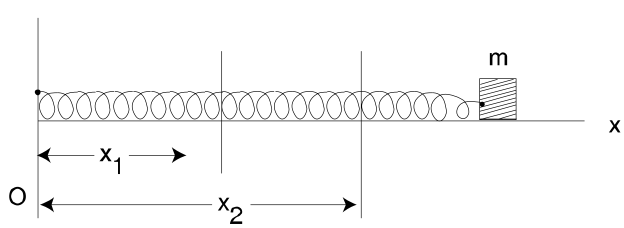
∴ r_o Ae¯'vb n‡Z r Ae¯'v‡b mi‡Yi Rb¨ m¤úbœ KvR,

$$W = \int_{r_o}^{r} (FCos\theta)\ dr$$

$$W = \int_{r_o}^{r} \mathbf{F}.d\mathbf{r} \quad .... (6.7)$$

6.2.3. w¯ús cmvi‡Y m¤úvw`Z KvR (ej ∝ x)

awi GKwU gm„Y Z‡ji Dci m f‡ii GKwU e¯‘ i‡q‡Q| GKwU w¯ús S Gi GK cvš— e¯‘wUi m‡_ Ges Aci cvš— GKwU wbw`ó ¯'v‡b AvUKv‡bv Av‡Q| GLb, e¯‘wU‡K †U‡b w¯ús Gi ˆ`N¨ evov‡j, w¯ús Gi g‡a¨ w¯'wZ¯'vcK a‡gi `i“b GKwU Af¨šixb ej m„wó n‡e|



wPÎ 6-10

∴ w¯'wZ¯'vcK mxgv AwZµg bv Ki‡j, Af¨šÍixb e‡ji gvb û‡Ki m¤ú¨mvi‡Yi ˆ`N©¨ cwieZ©‡bi mgvbycvwZK I wecixZgyLx|

g‡b Kwi w¯úªs Gi x cwigvY ˆ`N©¨ e„w×i d‡j D™¢‚Z Af¨šÍixb ej F

AZGe û‡Ki m¤ú¨mvi‡Yi,

$F = -kx$, GLv‡b k mgvbycvwZK a"eK GB e‡ji w`K w¯úªs m¤úªmviY Ki‡Z n‡j evB‡i †_‡K ej cÖ‡qvM Ki‡Z n‡e|

g‡b Kwi GB chÖy³ ej $F^/$

myZivs w¯úªs m¤úªmvi‡Yi Rb¨ $F^/ = -F = Kx$

∴ w¯úªswU‡K x_1 Ae¯'vb n‡Z x_2 Ae¯'v‡b cÖmviY Ki‡Z evB‡i †_‡K cÖ‡qvMK…Z ej Øviv m¤úbœ KvR,

$$W = \int_{x_1}^{x_2} F^/ .dx = \int_{x_1}^{x_2} F^/ dx = \int_{x_1}^{x_2} kxdx \qquad [F^/ \text{ I } dx \text{ Gi g‡a¨ †KvY k~b¨}]$$

$$= k\int_{x_1}^{x_2} xdx = k\left[\frac{x^2}{2}\right]_{x_1}^{x_2} = \frac{1}{2}k\,[x^2]_{x_1}^{x_2} = \frac{1}{2}k\,(x_2{}^2 - x_1{}^2)$$

$$\therefore W = \frac{1}{2}kx_2^2 - \frac{1}{2}kx_1^2 \text{ ---- ----- ----- --- --- } (6.10)$$

G KvR abvZ¥K| G Kv‡Ri mgcwigvY kw³ w¯úªs-Gi g‡a¨ w¯'wZkw³ iƒ‡c mwÂZ _v‡K|

hLb $x_1 = 0$ Ges $x_2 = x$, ZLb

$$W = \frac{1}{2}kx^2 \text{ ... . } (6.11)$$

BnvB w¯'wZ¯'vcK mxgvi g‡a¨ GKwU w¯úªs Gi x cwigvY m¤úªmvi‡Y mwÂZ kw³|

mvims‡¶c

c‡kœvËi gš¿vqb

K. mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1| w¯úªs cÖmvi‡Y m¤úbœ`Z Kv‡Ri †¶‡Î ej w¯úªs-Gi ˆ`N©¨ e„w×iÑ

(K) mgvbycvwZK (L) e¨v¯ÍvbycvwZK

(M) e‡Mi mgvbycvwZK (N) e‡Mi e¨v¯ÍvbycvwZK|

L. mswr¶ß cÖk

1| AwfKlxq e‡ji cÖfv‡e coš— e¯'i Kv‡Ri mgxKiYwU wjLyb|

2| †njv‡bv Z‡j AwfKlxq e‡ji cÖfv‡e cZ‡bi Rb¨ †h KvR m¤úbœ nq| Zvi Qwe G‡K mgxKiYwU wjLyb|

3| GKwU w¯úªs m¤úªmvi‡Y Kv‡Ri cwigvY KZ ewY©Z Ki"b|

cvV-3
gnvKlxq †¶‡Î m¤úvw`Z KvR I kw³

D‡Ïk¨

G cvV †k‡l Avcwb

- gnvKlxq †¶‡Î m¤úvw`Z Kv‡Ri eYbv w`‡Z cvi‡eb;
- kw³ i msÁv w`‡Z cvi‡eb;
- kw³ i cKvi‡f` Ki‡Z cvi‡eb;
- MwZkw³ i msÁv wjL‡Z cvi‡eb;
- MwZkw³ cwigv‡ci c×wZmg‡ni eYbv w`‡Z cvi‡eb|

6.3.1. gnvKlxq †¶‡Î m¤úvw`Z KvR $\left(ej \propto \frac{1}{r^2}\right)$

gnvKl t b‡fvgÛ‡j Aew¯Z †h †Kvb `yB e¯‘ ga¨Kvi cvi¯úwiK AvKlY ej‡K gnvKl e‡j|

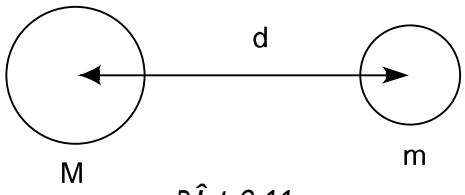
wbDU‡bi gnvKl m¤ú

wbDU‡bi gnvKl m¤úwU wb‡¤ †`qv njÑ

Ògnvwe‡ki c‡Z¨KwU e¯‘ev e¯‘KYv G‡K Aci‡K AvKlY K‡i Ges G AvKlY e‡ji gvb e¯‘ev e¯‘z KYvØ‡qi f‡ii ¸Yd‡ji mgvbycwZK Ges G‡`i ga¨Kvi `¤‡Zi e‡Mi e¨v¯—vbycwZK|Ó

$\therefore F \propto -\frac{Mm}{d^2}$ ..... *(6.15)*

ev, $F = -G\frac{Mm}{d^2}$

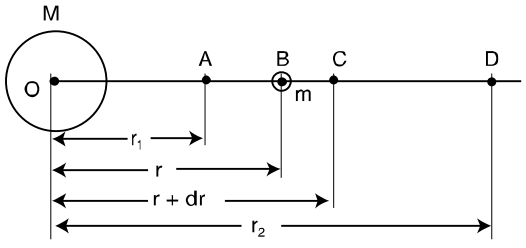


wP¤Î t 6.11

GLv‡b, M I m e¯‘ev e¯‘KYvØ‡qi fi|
d n‡jv M I m e¯‘ev e¯‘KYvØ‡qi ga¨eZx© `¤Z| Ges G GKwU mgvbycwZK a“eK (Gravitational Constant)|

awi, GKwU ¸i“fvi e¯‘i fi M| Gi fvi‡K›` O| B we›`yZ m f‡ii GKwU e¯‘ cvcb Kwi Ges OB= r *(wP¤Î 6.11)*|
gnvKlxq m¤ú n‡Z e¯‘yBi g‡a¨ gnvKlxq ejÑ

$F = -G\frac{Mm}{r^2}$ ..... *(6.16)*



wP¤Î 6.12

gnvKlxq ejwU BO eivei wµqv Ki‡e| B n‡Z dr `¤‡Z C GKwU we›`ybB| AZGe, OC = r+dr| C we›`yB we›`y Lye KvQvKwQ e‡j BC `¤‡Zi g‡a¨ F a“e aiv nq| †QvU e¯‘‡K B n‡Z C we›`yZ wb‡Z n‡j evBi n‡Z ej c‡qvM Ki‡Z n‡e| G e‡ji gvb F Gi mgcwigvY Ges wecixZ w`‡K n‡Z n‡e|

awi, cÖhy³ ej = $F^{/}$

$\therefore F^{/} = G\frac{Mm}{r^2}$ .... (6.17)

Ges $F^{/}$ Gi w`K BC eivei
†QvU e¯'‡K B n‡Z C we›`y‡Z wb‡Z evB‡i n‡Z cÖ‡qvMK…Z ej Øviv m¤úvw`Z KvRÑ

$dw = F^{/}.\, dr = F^{/}\, dr$ [∵ $F^{/}$ I dr Gi ga¨eZx© †KvY k~b¨]

ev, $dw = G.\frac{Mm}{r^2}\, dr$. .... (6.18)

‡QvU e¯'‡K A n‡Z D we›`y‡Z wb‡Z m¤úvw`Z KvR,

$$W = \int dw = \int_{r_1}^{r_2} G\frac{Mm}{r^2}dr \quad [\text{GLv‡b } OA = r_1, OD = r_2]$$

$$= GMm\int_{r_1}^{r_2}\frac{1}{r^2}dr$$

$$= GMm\int_{r_1}^{r_2} r^{-2}dr$$

$$= GMm\left[\frac{r^{-2+1}}{-2+1}\right]_{r_1}^{r_2}$$

$$= GMm\left[\frac{r^{-1}}{-1}\right]_{r_1}^{r_2}$$

$$= GMm\left[-\frac{1}{r}\right]_{r_1}^{r_2}$$

$$= -GMm\left[\frac{1}{r}\right]_{r_1}^{r_2}$$

$$= -GMm\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$$

$$= GMm\left(\frac{1}{r_1}-\frac{1}{r_2}\right) \text{ ---- ---- --- --- --(6.19)}$$

D³ mgxKiY n‡Z †`Lv hv‡"Q †h, evB‡i n‡Z cÖ‡qvMK…Z ej Øviv m¤úvw`Z KvR abvZK|

AD `~i‡Zi g‡a¨ F ev $F^{/}$ ej cwieZ©bkxj| A_©vr ej `~i‡Zi mv‡_ cwieZ©bkxj Ges Zv `~i‡Z¡i e‡M©i e¨v¯ÍvbycvZ m~Î †g‡b P‡j

$\therefore$ ej $\alpha \frac{1}{r^2}$ .... (6.20)

6.3.2 kw³ (Energy)

†Kvb e¯‘i Dr‡mi KvR Kivi mvg_©‡K kw³ e‡j|
†Kvb e¯‘ KvR Ki‡Z mg_© n‡j Zvi kw³ Av‡Q ejv nq| †Kvb e¯‘i Drm †gvU †h cwigvY KvR Ki‡Z cv‡i Zv w`‡q Gi kw³i cwigvc Kiv nq|
kw³ Ges Kv‡Ri GKK Ryj| kw³ GKwU †¯‹jvi ivwk|

kw³‡K †gvUvgywU AvU fv‡M fvM Kiv hvq| h_vÑ
(1) hvwšÍK kw³ (Mechanical Energy)
(2) Zvc kw³ (Heat Energy)
(3) kã kw³ (Sound Energy)
(4) Av‡jvK kw³ (Light Energy)
(5) PŠ¤^K kw³ (Magnetic Energy)
(6) we`y¨r kw³ (Electrical Energy)
(7) ivmvqwbK kw³ (Chemical Energy)
(8) cvigvYweK kw³ (Atomic Energy)

G BDwb‡U ïay hvwšÍK kw³ m¤ú‡K Av‡jvPbv Kiv n‡e| G kw³ `yÕcKvi| h_vÑ
(1) MwZkw³ (Kinetic Energy), G‡K ms‡¶‡c K.E. †jLv nq|
(2) w¯'wZkw³ ev wefe kw³ (Potential Energy), G‡K ms‡¶‡c P.E. †jLv nq|

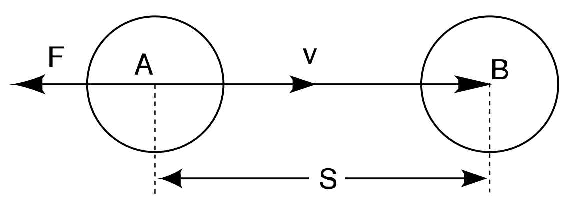
6.3.3. MwZkw³ (Kinetic Energy)

e¯‘ MwZkxj _vKvq KvR Kivi Rb¨ †h mvg_¨ A_©vr kw³ ARb K‡i Zv‡K MwZkw³ e‡j| †hgbÑ †Lv‡jvqvoMY jvwV †`qvi Av‡M wKQyUv †ŠŠ‡o Av‡mb| KviY †`Šo‡q wb‡Ri kix‡i MwZkw³ ARb K‡ib, hv jvwV w`‡Z mvnvh¨ K‡i|

MwZkw³i cwigvc

1g cÖ×wZ t MwZkxj e¯‘ MwZ‡Z _vKvKvjxb A_©vr w¯'wZ‡Z Avmvi c~e© gyn~Z© chš— †h cwigvY KvR m¤úbœ K‡i Zv Øviv Gi MwZkw³ cwigvc Kiv nq|

awi, m f‡ii GKwU e¯‘ AB eivei V †e‡M Pj‡Q| e¯‘wUi MwZi wecixZ w`‡K BA eivei Zvi Dci F cwigvY a"e ej c‡qvM Kiv nj| G wei"× e‡ji Rb¨ g›`b mylg n‡e| awi, g›`b =a| GLb g›`‡bi Rb¨ e¯‘wU A n‡Z s `~iZ¡ AwZµg K‡i B we›`y‡Z G‡m †_‡g hv‡e|



wPÎ t 6.13

∴ MwZkw³ = ej × w¯'wZ‡Z Avmvi c~e© gyn~Z© chš— AwZµvš— `~iZ¡
$= F \times s$ .... (6.21)

wbDU‡bi MwZi 2q m~Î n‡Z cvB

ej = fi × ZiY ev g›`b

$\therefore F = ma$

Avevi, GLv‡b e¯‘wZi cv_©gK †eM = v

Pewš† eM = 0

g›`b = a

∴ $0^2 = v^2 - 2as$

ev, $2as = v^2$

ev, $s = \frac{u^2}{2a}$

mgxKiY (6.21) G F I S Gi gvb ewm‡q cvBÑ

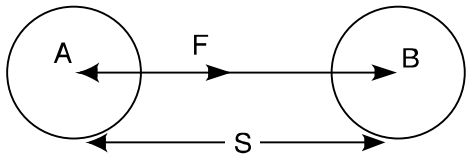
MwZkw³ = $ma \times \frac{v^2}{2a} = \frac{1}{2} mv^2$

∴ K.E. = $\frac{1}{2} mv^2$

A_vr MwZkw³ = $\frac{1}{2} \times fi \times †eM2$

2q c×wZ

awi, m f‡ii GKwU w¯‘i e¯‘vi Dci F ej c‡qvM Kiv nj| ej c‡qvM Kivi d‡j e¯‘wU AB eivei a mgZi‡Y P‡j S `~iZ AwZµg Kij|



wPÎ t 6.14

chy³ ej Øviv KZ.KvR e¯‘wZi MwZkw³ i|‡c Awefz‡Z n‡e|

GLb, KZ.KvR = ej × miY

= Fs

= mas .... (6.22)

GLv‡b e¯‘vi fi = m

Aw`‡eM, u = 0

†kl †eM, v

Avgiv Rwb, $v^2 = u^2 + 2as = 2as$ (∵ u =0)

ev, $s = \frac{u^2}{2a}$

GLb (6.22)†Z s Gi gvb ewm‡q cvBÑ

∴ KZKvR = ma. $\frac{u^2}{2a} = \frac{1}{2} mv^2$

ev, MwZkw³, K.E.= $\frac{1}{2} mv^2$ .... (6.23)

∴ MwZkw³ = $\frac{1}{2} \times fi \times †eM^2$

D`vniYÑ1

0.1kg f‡ii GKwU e¯‘z †eM 20m/s n‡j, Gi MwZkw³ KZ?

mgvavb t Avgiv Rwb,

GLv‡b,

$m = 0.1$ †KwR

$\upsilon = 20$ wgt/†mt|

MwZkw³, $KE = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 0.1 \times (20)^2$ Rvÿ

$= 20$ Rvÿ|

mvims‡¶c

†Kvb e¯‘evi Dr‡mi KvR Kivi mvg_¨‡K kw³ e‡j|

hwšK kw³ `ycKvi| h_vÑ

(1) MwZkw³ I

(2) w¯wZkw³ ev wefe kw³|

e¯‘MwZkxj _vKvq KvR Kivi Rb¨ †h mvg_¨ A_vr kw³ ARb K‡i Zv‡K MwZkw³ e‡j|

c‡qvRbxq mgxKiYmgm¨

gnvKIxq †¶‡Î m¤úvw`Z KvR t $W = GMm\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

MwZkw³ t $K.E. = \frac{1}{2} mv^2$

cv‡VvËi gvjv‡qb

K. mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1| kw³ ‡K ‡gvUvgywU wef³ Kiv hvqÑ

(K) `yBwU fv‡M (L) Qq fv‡M

(M) AvU fv‡M (N) wZb fv‡M|

2| MwZkw³i GK‡Ki bvgÑ

(K) Ak¶gZv (L) Rvÿ

(M) IqvU (N) †m.wg/†m‡KÛ|

L. msw¶ß ck

1| kw³ Kv‡K e‡j? kw³ ‡K KZfv‡M fvM Kiv hvq?

2| wewfb cKvi kw³i bvg wjLyb|

3| hwšK kw³ ‡K KZ fv‡M fvM Kiv hvq I wK wK?

cvV-4
KvR kw³ Dccv`¨, w¯’wZ kw³ I kw³i wbZ¨Zvi m~Î

D‡Ïk¨
G cvV †k‡l Avcwb-

- KvR kw³ Dccv`¨wU cgvY Ki‡Z cvi‡eb,
- w¯’wZ kw³i eYbv Ki‡Z cvi‡eb,
- kw³i wbZ¨Zvi m~ÎwU wjL‡Z I eYbv Ki‡Z cvi‡eb|

6.4.1. KvR–kw³ Dccv`¨ (Work-Energy Theorem)

weeÄZ t †Kvb e¯‘i Dci cÖhy³ ej ØvivK…Z.KvR e¯‘wUi MwZ-kw³i cwieZ©‡bi mgvb|

Avgiv `yÕ †¶‡Î KvR-kw³ Dccv`¨ cgvY Ki‡Z cvwi|

(K) e¯‘i kw³ e„w× Ges

(L) e¯‘i kw³ nvm|

(K) e¯‘i kw³ e„w× t awi, GKwU MwZkxj e¯‘i fi m Ges †eM u wPÎ 6-15 (K)| GLb hw` e¯‘wUi †e‡Mi w`‡K GKwU a"e ZiY Kvix ej F c‡qvM Kiv nq| Z‡e e¯‘wU ZwiZ n‡e|

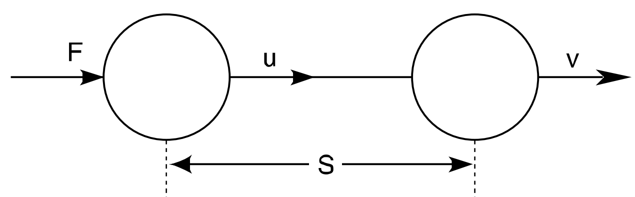
awi, ZiY = a

AwZµvš— `~iZ = s

s `~iZ AwZµg †k‡l †eM = v

ej Øviv m¤úvw`Z KvR,

W = Fs



wPÎ t 6.15

Avevi, Avgiv Rwb,

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

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

$$\therefore W = Fs = mas = m \times \left(\frac{v^2-u^2}{2s}\right) \times s \quad [ej, F = ma]$$

$$= \frac{1}{2} m (v^2 - u^2)$$

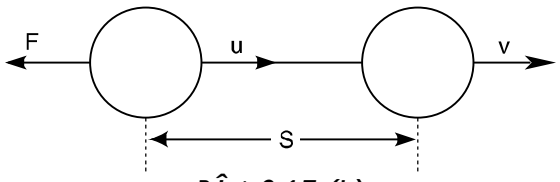
$$= \frac{1}{2} mv^2 - \frac{1}{2} mu^2 \quad ....\ (6.24)$$

$\therefore$ ej Øviv m¤úvw`Z KvR = e¯‘i †kl MwZkw³ – e¯‘i Avw` MwZkw³

= e¯‘i MwZkw³i e„w×|

(L) e¯‘i kw³ nvm t awi, GKwU MwZkxj e¯‘i fi m Ges †eM u wPÎ 6-15 (L)| GLb hw` e¯‘wUi †e‡Mi wecixZ w`‡K GKwU a"e g›`bKvix ej F c‡qvM Kiv nq, Z‡e e¯‘wUi †eM K‡g _vK‡e|

awi, g›`b a Ges s `i‡Z AwZµg †k‡l †eM v AZGe ej Øviv m¤úwK`Z KvR
W = Fs



wPÎ t 6.15 (L)

Avgiv Rwb, $v^2 = u^2 - 2as$

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

$\therefore W = Fs = mas$

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

$= \frac{1}{2} m (u^2-v^2)$

$\therefore W = \frac{1}{2} mu^2 - \frac{1}{2} mv^2$ .... (6.26)

∴ e¯‘Øviv m¤úwK`Z KvR = e¯‘i Aw` MwZkw³ Ñ e¯‘i †kl MwZkw³
= e¯‘i kw³ nvm
= e¨wqZ kw³ i cwigvc|

D`vniY-1

25 Mvg f‡ii GKwU ivB‡d‡ji ¸wj 500 wgUvi/†m: †e‡M P‡j GKwU j¶¨ e¯‘‡f` Kiv‡i ci 100wg:/†m: †e‡M †ei n‡q †Mj| j¶e¯‘‡f` Ki‡Z KZ kw³ e¨wqZ n‡e?

mgvavb

¸wji Aw` MwZkw³ $= \frac{1}{2} mu^2$

Ges †kl MwZkw³ $= \frac{1}{2} mv^2$

∴ e¨wqZ kw³ i cwigvY Ñ

$= \frac{1}{2} mu^2 - \frac{1}{2} mv^2 = \frac{1}{2} m (u^2 - v^2)$

$= \frac{1}{2} \times 25 \{(5\times10^4)^2 - (1\times10^4)^2\}$

$= \frac{1}{2} \times 25 \times 10^8 \times (25-1)$

$= 3000 \times 10^7$ AvM = 3000 Rvÿ|

∴ ej Øviv m¤úwK`Z KvR = e¯‘wZi MwZkw³ i cwieZb|
= 3000 Rvÿ|

GLv‡b,
m = 25 Mvg
u = 500 wg:/†m: = 5×10^4 ‡m:wg:/†m:|
v = 100 wg:/†m: = 1×10^4 ‡m:wg:/†m:|

6.4.2. w¯wZkw³ ev wefe kw³ (Potential Energy)

w¯wZkw³ A_ w¯wZRwbZ kw³ A_vr wb`ó Ae¯v‡b ev Ae¯vq _vKvi Rb¨ e¯‘th kw³ cvß nq Zv‡K w¯wZkw³ e‡j|

†Kvb e¯zAe¯vi cwieZ‡bi Rb¨ †h kw³ ARb K‡i Zv Øviv e¯‘i w¯wZkw³ cwigvc Kiv nq|

gwU n‡Z GK UvKvi cv_i‡K wKQyDc‡i DVv‡j cv_iwU GK cKvi kw³ jvf K‡i| d‡j cv_iwU †Kvb e¯i Dci co‡j e¯‘wU †m ¯vb n‡Z m‡i hvq| wKšze¯‘i Dci w¯ifv‡e cv_iwU‡K ivL‡j e¯‘wUi Ae¯v‡bi †Kvb cwieZb n‡e bv| mgZiv cv_iwU‡K Dc‡i DVv‡bvi d‡jB cv_iwU kw³ jvf K‡i| GB kw³B w¯wZ kw³|

6.4.2 : wewfbœ cKvi w¯wZ kw³

Avgiv GLv‡b `ywU cKv‡ii w¯wZ kw³ Av‡jvPbv Kie|

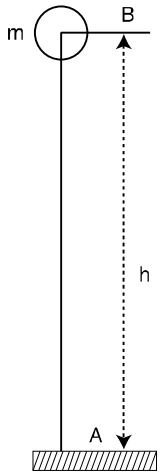
(K) AwfKlxq w¯wZ kw³ ev AwfKlxq wefe kw³ (Gravitational Potential Energy) Ges

(L) w¯wZ¯vcK wefe kw³ (Elastic Potential Energy)

(K) AwfKlxq wefe kw³

†Kvb e¯‘wK AwfK‡li wei“‡× Dc‡i Zzj‡Z evB‡ii Dr‡mi AwfKl e‡ji wei“‡× KvR Ki‡Z nq| G KvR w¯wZkw³ wn‡m‡e mwÂZ _v‡K| G‡K e¯‘i AwfKlxq wefe kw³ ev w¯wZkw³ ejv nq| G‡¶‡Î f¡cô‡K cvgvY¨ Zj (reference level) wn‡m‡e aiv nq|

AwfKlxq wefe kw³i cwigvc t g‡bKwi, m f‡ii GKwU e¯z f¡cô A we›`y‡Z Ae¯Z| GLb e¯wU‡K A we›`y n‡Z h D”PZvq B we›`y‡Z ¯vcb Kiv nj| e¯‘wU‡K h D”PZvq DVv‡Z AwfKlxq e‡ji wei“‡× †h cwigvY KvR m¤úb n‡e, ZvB w¯wZ kw³i i¡‡c mwÂZ _vK‡e| hw` AwfKlxq Zi‡Y g nq Z‡e e¯‘i Dci chy³ AwfKlxq ej F=mg, e¯‘i IR‡bi mgvb n‡e|



wPÎ t 6.16

∴ w¯wZ kw³ ev wefe kw³ (P.E) = e¯‘wK AwfK‡li wei“‡× Dc‡i Zzj‡Z m¤úwK` KvR = ej × Ae¯vb `ywUi g‡a¨ `i“Z = F × h = mgh

ev, P.E. = mgh ..... (6.26)

Dc‡ii mgxKiY n‡Z †`Lv hvq †h, D”PZvi (h) Dci wefe kw³ wbfi K‡i| D”PZv (h) hZ †ewk n‡e wefe kw³ ZZ †ewk n‡e| D”PZv Kg n‡j wefe kw³ I Kg n‡e| †hgb f¡cô h = 0 nIqvq †mLv‡b wefe kw³ kZ¨|

(L) w¯wZ¯vcK wefe kw³

GKwU w¯wZ¯vcK e¯‘i Dci evBi n‡Z ej c‡qvM Kiv n‡j e¯‘wUi AvKvi ev AvKwZi cwieZb nq| d‡j, e¯‘wUi AvKvi ev AvKwZi cwieZb NUv‡Z e¯‘i Dci KvR Ki‡Z nq| G KvR e¯‘wU‡Z w¯wZkw³ wn‡m‡e mwÂZ _v‡K| Avi G kw³i bvgB w¯wZ¯vcK wefe kw³| †hgb GKwU w¯wZ¯vcK w¯ús Gi ms‡KvPb ev m¤úmvi‡Y KZ.KvR, w¯ús-G w¯wZ¯vcK wefe kw³i i¡‡c mwÂZ _v‡K|

6.4.3. kw³i wbZ¨Zvi m~Î (Principle of conservation Energy)

ÒKw³ Awebkki| Gi aŸsm ev m„wó †bB| kw³ †Kejgvl GK iƒc n‡Z Aci GK ev GKvwaK iƒ‡c cwiewZZ n‡Z cv‡i| gnwe‡k †gvU kw³i cwigvY wbw`ó I AcwieZbxq|Ó

†hgbÑ b`x‡Z Avovorwo fv‡e DPyeua w`‡j, cwbi †j‡fj Dc‡i D‡V hvq, d‡j DPZvi d‡j G‡Z w¯wZ kw³ mwÂZ nq| cwb hLb DPy n‡Z DcwP‡q c‡o ZLb G w¯wZ kw³ MwZ kw³‡Z cwiewZZ nq| G kw³i mvnv‡h¨ UvievBb Nyiv‡q we`y¨r kw³ Drcb Kiv nq| Gfv‡e hvwšK kw³ we`y¨r kw³‡Z cwiewZZ nq| ˆe`y¨ZK cvLv †Nvivi mgq we`y¨r kw³ hvwšK kw³‡Z cwiewZZ nq|

ˆe`y¨ZK Bw¯‡Z we`y¨r kw³ Zvc kw³‡Z cwiewZZ nq|

ev®úxq BwÄ‡b Kqjv cyo‡q †h Zvc cvIqv hvq †m Zvc w`‡q cwb‡K ev‡®ú cwiYZ K‡i BwÄb Pvjv‡bv nq| G‡¶‡Î Zvc kw³ hvwšK kw³‡Z cwiewZZ nq|

myZivs উল্লিখিত NUbv n‡Z †`Lv hvq †h, kw³ †Kejgvl GK iƒc n‡Z Aci iƒ‡c cwiewZZ nq| Gi aŸsm ev m„wó †bB|

(K) cošš e¯ii †¶‡Î kw³i wbZ¨Zvi m‡Îi cgvY

g‡b Kwi, m f‡ii GKwU e¯‡K f~-cô n‡Z h D”PZvq A we›`y‡Z DVv‡bv n‡jv| A we›`y‡Z e¯ii mg¯ kw³B w¯wZkw³|

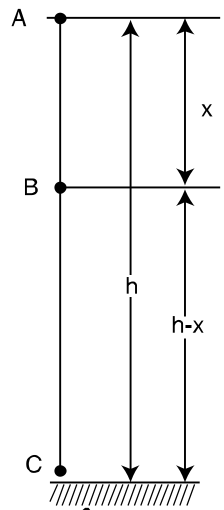
A we›`y‡Z e¯ii w¯wZ kw³ = mgh

A we›`y‡Z e¯ii MwZkw³ = 0

∴ A we›`y‡Z e¯ii †gvU kw³ = w¯wZkw³+MwZkw³

= mgh + 0

= mgh..... (6.27)



wPÎ t 6.17

GLb, A we›`y n‡Z e¯wU‡K †Q‡o w`‡j e¯wU AwfK‡li cf‡e x `~iZ AwZµg K‡i B we›`y‡Z Avm‡j e¯wU MwZcvß n‡e A_vr w¯wZ kw³ nvi‡e Ges MwZ kw³ jvf Ki‡e|

awi, B we›`y‡Z e¯ii †eM = v . Ges AB = x

AZGe, B we›`y‡Z e¯ii w¯wZ kw³ = mg (h-x)

Ges B we›`y‡Z e¯ii MwZ kw³ $=\frac{1}{2}mv^2$

GLb, $v^2 = u^2 + 2gx = 0+2gx=2gx$

∴ B we›`y‡Z e¯ii MwZ kw³ $=\frac{1}{2}m.2gx=mgx$

∴ B we›`y‡Z e¯ii †gvU kw³ = w¯wZkw³ + MwZkw³

= mg(h-x) +mgx

= mgh ....(6.28)

awi, f~-cô‡K ¯úk Kivi cƒe gyn~‡Z e¯wUi †eM v/ |

Avevi, GLv‡b, $v^2 = u^2 + 2gh = 2gh$ [∵ Avw`‡eM $u = 0$ Ges `~iZ¡ = h] f~-c„‡ô ¯úk Kivi wVK c~e© gyn~‡Z© e¯‘wU¯'wZ kw³ = mg×0 = 0 [∵ h = 0]

∴ f~-c„‡ô ¯úk Kivi wVK c~e© gyn~‡Z© e¯‘i MwZ kw³ $= \frac{1}{2} mv'^2$

$= \frac{1}{2} m.2gh$

$= mgh$

∴ f~-c„‡ô ¯úk Kivi wVK c~e© gyn~‡Z© e¯‘wUi †gvU kw³ = w¯'wZ kw³ + MwZ kw³

$= 0 + mgh$

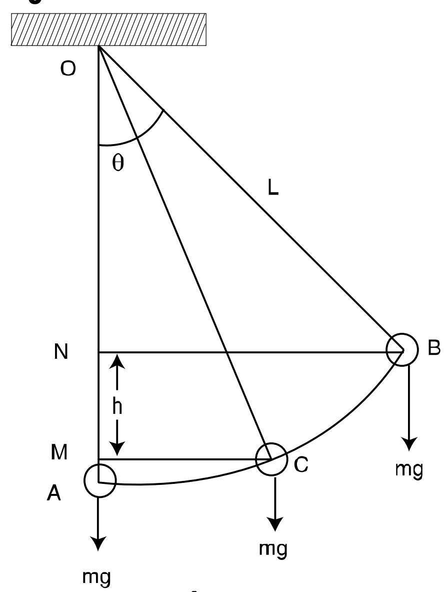
$= mgh$ .... (6.29)

AZGe, mgxKiY (6.27), (6.28) Ges (6.29) n‡Z ejv hvq †h, e¯‘ co‡Z _vK‡j Gi †gvU kw³i †Kvb cwieZ©b nq bv| A_©vr cošš e¯‘i †¶‡Î kw³i wbZ¨Zvi m~Î cÖgvwYZ n‡jv|

(L) Av‡›`vjZ mij †`vj‡Ki †¶‡Î kw³i wbZ¨Zvi m~‡Îi cÖgvY t

cÖgvY t

6.18 bs wP‡Î GKwU mij †`vjK †`Lv‡bv n‡q‡Q| A we›`y †`vj‡Ki MwZc‡_i meeb¤ Ges B we›`y m‡ev©”P we›`y| e‡ei fi m, B we›`y‡Z †cŠQv‡j †`vjKwU gyn~‡Zi Rb¨ w¯'i Ae¯'vq _vK‡e| AZGe, B we›`y‡Z mg¯— kw³B w¯'wZkw³| Avevi B we›`yA we›`yn‡Z AN D”PZvq Aew¯'Z| awi A we›`y‡Z w¯'wZ kw³ kb¨|



wPÎ t 6.18

∴ B we›`y‡Z w¯'wZ kw³ $= mg \times AN$

Ges B we›`y‡Z MwZ kw³ $= 0$

B we›`y‡Z †gvU kw³ $= mg \times AN + 0$

$= mg \times AN$................(6.30)

AZtci †`vjKwU †Kvb GK mgq C we›`y‡Z Avm‡e| C we›`y‡Z e‡ei w¯'wZ kw³ I MwZ kw³ DfqB _vK‡e|

∴ C we›`y‡Z w¯'wZ kw³ $= mg \times AM$

Ges C we›`y‡Z MwZ kw³ $= \frac{1}{2} mv^2 = \frac{1}{2} m \times 2gh$

[∵ $v^2 = u^2 + 2gh = 0 + 2gh = 2gh$]

$= mgh = mgNM = mg \times (AN-AM)$

∴ C we›`y‡Z †gvU kw³ $= mg \times AM + mg\,(AN-AM)$

$= mg \times AM + mgAN - mgAM$

$= mgAN$................................ (6.31)

mgxKiY (6.30) Ges (6.31) n‡Z †`Lv hvq †h, B I C we›`y‡Z †gvU kw³ mgvb| Av‡›`vjZ mij †`vj‡Ki †¶‡Î kw³i wbZ¨Zvi m~Î cÖgvwYZ n‡jv|

cv‡VvËi g~j¨vqb

K. mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1| wb‡Pi †Kvb evK¨wU mwVK?
(K) gnvwe‡k¦i †gvU k³i cwigvY e¨× nIqv cv‡i
(L) gnvwe‡k¦i †gvU k³i cwigvY nvm †c‡Z cv‡i
(M) gnvwe‡k¦i †gvU k³i cwigvY wbw`©ó I AcwieZ©bxq

L. msw¶ß cÖk

1| KvR k³ Dccv`¨ wee„Z Ki“b|
2| w¯’wZ k³ ev wefe k³ Kv‡K e‡j?
3| k³i wbZ¨Zvi m~ÎwU wjLyb|

cvV-5
e‡ji cKvi‡f`, kw³i AcPq I ¶gZv

D‡Ïk¨
G cvV †k‡l Avcwb

- msi¶Ykxj I Amsi¶Ykxj e‡ji msÁv I D`vniY wjL‡Z cvi‡eb;
- msi¶Ykxj I Amsi¶Ykxj e‡ji g‡a¨ cv_K¨ wbYq Ki‡Z cvi‡eb;
- kw³i AcPq m¤ú‡K wjL‡Z cvi‡eb;
- Kg`¶Zvi msÁv wjL‡Z cvi‡eb;
- ¶gZvi msÁv wjL‡Z cvi‡eb;
- ¶gZvi gvÎv mgxKiY I GKK wjL‡Z cvi‡eb|

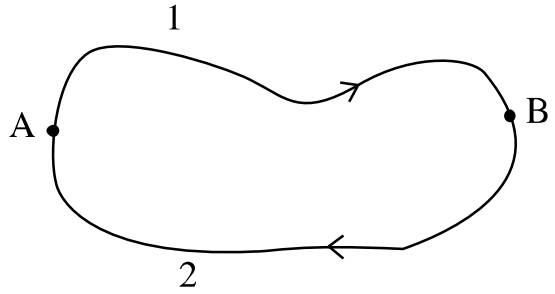
6.4.1. msi¶Ykxj ej I Amsi¶Ykxj ej (Conservative Force & Non conservative Force)

ej `vB cKvi| h_vÑ msi¶Ykxj ej I Amsi¶Ykxj ej|

msi¶Ykxj ej t GKwU ej‡K msi¶Ykxj ej ejv nq ZLb, hLb †Kvb KYv‡K †h †Kvb c_ Nyi‡q cv_wgK Ae¯v‡b Avb‡j KYwUi Dci H ej Øviv m¤úwK`Z Kv‡Ri cwigvY kb¨ nq| †hgbÑ AwfKlxq ej, ˆe`ïZK ej, Av`k©¯ús-Gi weKwZ.cwZ‡ivaKvix ej BZ¨vw`|

GKwU ej‡K Amsi¶Ykxj ejv ejv nq ZLb, hLb †Kvb KYv‡K †h †Kvb c_ Nyi‡q cv_wgK Ae¯v‡b Avb‡j KYwUi Dci H ej Øviv m¤úwK`Z Kv‡Ri cwigvY kb¨ nq bv| †hgbÑ NlY ej, mv›` ej BZ¨vw`|

awi, GKwU e¯. A we›`y n‡Z 1 bs c‡_ B we›`y‡Z Av‡m| Avevi B we›`y n‡Z 2bs c‡_ cybivq A we›`y‡Z wd‡i Av‡m| GLb e¯‘i Dci wµqviZ ej hw` msi¶Ykxj nq, Z‡eÑ



wPÎ t 6.19

$W_{AB_1} + W_{BA_2} = 0$

ev, $W_{AB_1} = -W_{BA_2}$ ..... (6.32)

ev, $W_{AB_1} = W_{AB_2}$ ..... (6.33)

GLv‡b, W_{AB_1} = 1 bs c‡_ e¯‘wU A n‡Z B-†Z Avm‡Z m¤úwK`Z Kv‡Ri cwigvY

W_{BA_2} = 2 bs c‡_ e¯‘wU B n‡Z A-†Z †h‡Z m¤úwK`Z Kv‡Ri cwigvY

W_{AB_2} = 2 bs c‡_ e¯‘wU A n‡Z B-†Z †h‡Z m¤úwK`Z Kv‡Ri cwigvY

mgxKiY (6.33) n‡Z †`Lv hvq †h,

1 bs c‡_ A n‡Z B †Z †h‡Z m¤úwK`Z Kv‡Ri cwigvY = 2 bs c‡_ A n‡Z B †Z †h‡Z m¤úwK`Z Kv‡Ri cwigvY|

AZGe, GKwU KYv‡K GK we›`y n‡Z Ab¨ we›`y‡Z wb‡q †h‡Z KYwUi Dci ej Øviv m¤úwK`Z Kv‡Ri cwigvY hw` c‡_i Dci wbfi bv K‡i ïaywe›`y y`wUi Ae¯v‡bi Dci wbfi K‡i, Z‡e Zv‡K msi¶Ykxj ej e‡j|

Amsi¶Ykxj ej *t Avgiv Rwb, NlYej me`v MwZi we‡ivwaZv K‡i| GKwU e¯‧K Agm„Y †Uwe‡ji Dci w`‡q †U‡b wb‡j, NlY e‡ji wei“‡× KvR K‡i| Avevi hw` e¯‧wU‡K †U‡b ce©Ae¯'v‡b wb‡q Avmv nq Z‡e cÖvq NlY e‡ji wei“‡× KvR nq| d‡j c_g †¶‡Î m¤úbœ KvR wd‡i cvIqv hvq bv| mÂwiZ e¯‧K †h †Kvb c‡_ Nyi‡q ce©Ae¯'v‡b Avb‡j NlY ej KZ©K m¤úvw`Z Kv‡Ri cwigvY k~b¨ nq bv| ZvB, NlY ej Amsi¶Yklj ej|*

6.5.2. msi¶Ykxj ej I Amsi¶Ykxj e‡ji g‡a¨ cv_©K¨

msi¶Ykxj ej	Amsi¶Ykxj ej
1. GKwU ej‡K msi¶Ykxj ej ejv nq ZLb, hLb †Kvb KYv‡K †h †Kvb c‡_ Nyi‡q cv_wgK Ae¯'v‡b Avb‡j KYwUi Dci H ej Øviv m¤úvw`Z Kv‡Ri cwigvY k~b¨ nq|	1. GKwU ej‡K Amsi¶Ykxj ej ejv nq ZLb, hLb †Kvb KYv‡K †h †Kvb c‡_ Nyi‡q cv_wgK Ae¯'v‡b Avb‡j KYwUi Dci H ej Øviv m¤úvw`Z Kv‡Ri cwigvY k~b¨ nq bv|
2. msi¶Ykxj ej KZ©K m¤úvw`Z KvR m¤ú~Y©fv‡e cybi“×vi Kiv m¤¢e|	2. Amsi¶Ykxj ej KZ©K m¤úvw`Z KvR m¤ú~Y©fv‡e cybi“×vi Kiv m¤¢e bq|
3. e¯‧i Dci msi¶Ykxj ej Øviv m¤úvw`Z MwZ c‡_i cv_wgK I †kl we›`yi Dci wbf©ikxj|	3. e¯‧i Dci Amsi¶Ykxj ej Øviv m¤úvw`Z KvR ïaygvÎ c‡_i cv_wgK I †kl we›`yi Dci wbf©ikxj bq|
4. msi¶Ykxj e‡ji wµqvq hvwšÎK kw³i wbZ¨Zvi m~Î cÖ‡hvR¨ nq|	4. Amsi¶Ykxj e‡ji wµqvq hvwšÎK kw³i wbZ¨Zvi m~Î cÖ‡hvR¨ nq bv|

6.5.3. kw³i AcPq (Dissipation of Energy)

Avgiv Rwb, kw³ Awebk¦i| kw³ ïaygvÎ GKiƒc †_‡K Ab¨ iƒ‡c iƒcvšÍwiZ n‡Z cv‡i| iƒcvšÍ‡ii c‡e I c‡i †gvU kw³i cwigvY AcwiewZ©Z _v‡K| jW© †Kjwfb (Lord Kelvin) *c_g j¶¨ K‡ib †h, kw³ Awebk¦i n‡jI c‡Z¨K iƒcvšÍ‡i c`Ë kw³ I cvß kw³ mgvb nq bv| iƒcvšÍ‡ii c‡i cvß kw³i cwigvY, c`Ë kw³i cwigvY A‡c¶v wKQyUv Kg nq| GLv‡b, wKQyUv kw³ Ggbfv‡e AvZcKvk K‡i †h, Zv Avgv‡`i †Kvb Kv‡R Av‡m bv| kw³i G AKvh©Ki iƒcvšÍi‡K kw³i AcPq e‡j|*

GLv‡b D‡jøL¨ Kiv c‡qvRb †h, gnwe‡k¦ cwiZ¨³ kw³ GKiƒc n‡Z Ab¨iƒ‡c iƒcvšÍwiZ n‡”Q| c‡Z¨K iƒcvšÍ‡i wKQyUv kw³ AKvh©Ki iƒ‡c iƒcvšÍwiZ n‡”Q| d‡j, KvR Kivi Dc‡hvMx kw³i cwigvY w`b w`b K‡g hv‡”Q|

6.5.4. Kg©`¶Zv (Efficiency)

†Kvb h‡š¿i Kg©`¶Zv ej‡Z †mB hš¿ Øviv Kv‡R iƒcvšÍwiZ kw³ I M„nxZ †gvU kw³i AbycvZ‡K eySvq| G‡K mvaviYZ* $\eta$ *(BUv) Øviv cKvk Kiv nq Ges ms‡¶‡c `¶Zv ejv nq|

$$\therefore \text{ msÁvbymv‡i, `¶Zv } \eta = \frac{\text{Kv‡R iƒcvšÍwiZ kw³}}{\text{M„nxZ †gvU kw³}}$$

Kg©`¶Zv mvaviYZ kZKiv wn‡m‡e cKvk Kiv nqÑ

$$\therefore \text{ Kg©`¶Zv } \eta = \frac{\text{Kv‡R iƒcvšÍwiZ kw³}}{\text{M„nxZ †gvU kw³}} \times 100\%$$

6.5.5. ¶gZv (Power)

†Kvb hš¿ ev Dr‡mi KvR Kivi nvi‡K ¶gZv e‡j | GKK mg‡q m¤úvw`Z KvR Øviv ¶gZvi cwigvc Kiv nq, t mg‡q w cwigvY KvR m¤úvw`Z n‡j ¶gZv,

$$P = \frac{w}{t}$$

$$\therefore\ ¶gZv = \frac{KZ.KvR}{mgq} \quad \text{.... .... (6.34)}$$

KvR Kivi nvi memgq mgvb bv n‡j (6-34) mgxKiY w`‡q Mo ¶gZv cvIqv hvq|

Zvr¶wYK ¶gZv, $P = \frac{dw}{dt}$ ... . (6.35)

6.5.6. ¶gZvi gvÎv

$$¶gZv = \frac{KvR}{mgq}$$

$$ev,\ ¶gZv = \frac{ej \times miY}{mgq}$$

$$= \frac{fi \times ZiY \times miY}{mgq}$$

$$= \frac{fi \times ‡eM \times miY}{mgq^2}$$

$$= \frac{fi \times miY \times miY}{mgq^3}$$

$$= \frac{fi \times miY^2}{mgq^3}$$

$$= \frac{ML^2}{T^3} = ML^2\ T^{-3}$$

6.5.7. ¶gZvi GKK

AvšRwZK c×wZ‡Z ¶gZvi GKK Rvgv/†m ev IqvU cwZ †m‡K‡Û GK Rvgv KvR Kivi ¶gZv‡K GK IqvU e‡j | $1W = 1JS^{-1}$

cv‡VvËi g~j¨vqb

K mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1| wb‡Pi †KvbwU Amsi¶Ykxj e‡ji cKó.D`vniYÑ
(K) ˆe`ÿwZK ej (L) NlY ej
(M) AwfKlxq ej|

2| ej mvavi iYZ
(K) `yB cKvi (L) GK cKvi
(M) AvU cKvi (N) cuvP cKvi|

3| ¶gZvi gvÎvÑ
(K) $[ML^2T^2]$ (L) $[MLT^{-2}]$
(M) $[ML^2T^{-3}]$ (N) $[ML^3T^{-3}]$

L. msw¶ß ck

1| msi¶Ykxj ej Kv‡K e‡j?
2| msi¶Ykxj I Amsi¶Ykxj e‡ji D`vniY wjLyb|
3| NlY ej msi¶Ykxj bq †Kb?
4| kw³i AcPq ej‡Z wK eySb?
5| Kg`¶Zv Kv‡K e‡j?

iPbvg~jK ck

1| KvR ej‡Z wK eySb? D`vniYmn e¨vL¨v Ki"b|
2| D`vniYmn e‡ji Øviv KvR I e‡ji wei"‡× KvR Av‡jvPbv Ki"b|
3| wewfb †¶‡Î AwfKlxq Kv‡Ri eYbv Ki"b|
4| †`Lvb †h, a"e ej KZK.m¤úvw`Z KvR= **F.S**|
5| †`Lvb †h, cwieZbkxj e‡ji †¶‡Î Kv‡Ri $W = \int_{r_o}^{r} (F\cos\theta)\, dr$ i|‡c cKvk Kiv hvq|
6| w¯ús cmvi‡Y m¤úvw`Z Kv‡Ri iwkgvjv wbYq Ki"b|
8| gnvKlxq †¶‡Î m¤úvw`Z Kv‡Ri iwkgvjv wbYq Ki"b|
9| MwZkw³ ej‡Z wK eySb? †`Lvb †h, m f‡ii GKwU e¯'i †eM v n‡j Gi MwZkw³ $= \frac{1}{2}mv^2$|
10| KvR kw³ Dccv`¨ cgvY Ki"b|
11| wefe kw³ KZ cKvi I wK wK? AwfKlxq wefe kw³i iwkgvjv wbYq Ki"b|
12| kw³i wbZ¨Zv m~ÎwU wjLyb| coš e¯'i †¶‡Î kw³i wbZ¨Zvi m~Î cgvY Ki"b|
13| mij †`vj‡Ki †¶‡Î kw³i wbZ¨Zvi m~ÎwU cgvY Ki"b|
14| msi¶Ykxj I Amsi¶Ykxj ej Kv‡K e‡j? D`vniY mn eYbv Ki"b|
15| ¶gZv ej‡Z wK eySb? ¶gZvi GKK m¤ú‡K e¨vL¨v Ki"b|