w¯wZ¯vcKZv

fwgKv

†Kvb e¯‘ Dci ej c‡qvM Ki‡j e¯‘wU hw` MwZkxj bv nq, Z‡e H e¯‘i AYy‡jvi ga¨eZx` i‡Zi cwieZb N‡U, hv e¯‘wUi AvKvi I AvKwZi cwieZb NUvq| e¯‘i AYy‡jvi ga¨Kvi Avš:AvYweK ej chy³ e‡j i wei“‡× wµqv K‡i| d‡j chy³ ej mwi‡q wb‡j e¯‘wU c‡ei Ae¯vq wd‡i hvq|

w¯wZ¯vcKZv c`v‡_i Ggb GKwU ag hvi Rb¨ †Kvb e¯‘evB‡i †_‡K chy³ e‡j i wµqvi d‡j Gi AvKvi ev AvqZb Df‡qiB cwieZ‡bi c‡Póv‡K evav †`q Ges chy³ ej Acmwiw Z n‡j c‡ei AvKvi ev AvqZb wd‡i cvq, †h me e¯‘wZ w¯wZ¯vcKZv ag we`¨gvb Zv‡`i‡K w¯wZ¯vcK e¯‘ (Elastic body) e‡j|

cvV-1
Avš: AvYweK ej I w¯wZ¯vcKZv m¤úKxq K‡qKwU msÁv

D‡Ïk¨
G cvV †k‡l Avcwb

- Avš:AvYweK ej m¤ú‡K e¨vL¨v w`‡Z cvi‡eb,
- Avš:AvYweK ej I w¯wZ¯vcK ag eYbv Ki‡Z cvi‡eb,
- w¯wZ¯vcKZv m¤ú‡K K‡qKwU msÁv wjL‡Z cvi‡eb|

9.1.1 AvštAvYweK ej (Intermolecular Forces)

Abyt c`v‡_i ¶žZg Kbv hvi g‡a¨ c`v‡_i ¸bv¸Y m¤úY¨f~v‡e we`¨vgvb Ges hv gy³ Ae¯vq ¯vaxbf~v‡e Ae¯vb Ki‡Z cv‡i, Zv‡K Abye‡j|

cigvYyt c`v‡_i ¶žZg KYv hvi ¯vaxb mËv bvB Ges hv gy³ Ae¯vq Ae¯vb Ki‡Z cv‡i bv wKšz ivmvqwbK wµqvq AskMnY Ki‡Z cv‡i, Zv‡K cigvbye‡j|

Avš:AvYweK ej : c`v_ AmsL¨ AYyi mgb‡q MwVZ| Avi G AYyfgn~ Lye Aí RvqMv Rxeb Ae¯vb K‡i| d‡j `yU AYyi g‡a¨ AwZ ¶z`ª cwigvY dukv ¯vb i‡q‡Q| G dukv ¯vb‡K Avš:AvYweK ¯vb (Intermolecular Space) e‡j|

Avevi c`v‡_i AYyfg‡ni g‡a¨ GKwU AvKlY ej Av‡Q e‡jB AYyfg‡ni g‡a¨ Avš:AvYweK ¯vb _vKv m‡Ë| Giv ci¯úi n‡Z we"Qb n‡q c‡o bv| G AvKlY ejB Avš:AvYweK ej bv‡g cwiwPZ|

ej c‡qv‡M †Kvb c`v_‡K cmwiZ Ki‡Z PvB‡j, AYyx‡jvi g‡a¨ dukv ¯vb A_vr Avš:AvYweK ¯vb †e‡o hvq| wbDU‡bi ZZxq mî Abyfv‡i AYyx‡jv cwZwµqv ej c‡qvM K‡i c‡ei Ae¯vq wd‡i Avmvi †Póv K‡i| Avevi ej c‡qvM K‡i †Kvb e¯‡K msKwZPZ Ki‡Z PvB‡j AYyx‡jvi g‡a¨ dukv ¯vb A_vr Avš:AvYweK ¯vb K‡g hvq| wbDU‡bi ZZxq mî Abyfv‡i AYyx‡jv Gev‡i cwZwµqv ej c‡qvM K‡i| Zv‡`i Aww` Ae¯v‡b wd‡i Avmvi †Póv K‡i| Gf~v‡e Avšt AvYweK e‡j i c`v‡_i w¯wZ¯vcKZv a‡gi mwó nq|

**c`v‡_i Ae¯v** : c`v_ mvaviYZ wZb Ae¯vq we`¨vgvb, h_v- KwVb, Zij I evqexq|

AZ¨waK Zvcgv‡Îvq evqexq c`v_ AvqwbZ nq| G‡¶‡Î mgvb msL¨K ab I FY Avqb mwó nq, c`v‡_i G Ae¯v‡K প্লাজমা Ae¯v (Plasma State) e‡j| G‡K c`v‡_i PZz_ Ae¯v I e‡j|

KwVb c`v‡_i AYyx‡jvi g‡a¨ Avš:AvYweK ej AZ¨š cej| d‡j KwVb c`v‡_i AYyx‡jv `p eÜ‡b Ave× _v‡K| ZvB KwVb c`v‡_i wbw`ó AvKvi I AvqZb Av‡Q| KwVb c`v_ `ycKvi, h_v:- ùwUKvKvi ev †KjvwmZ (Crystalline) Ges A‡KjvwmZ (Non-crystalline or amorphous).

†KjvwmZ : KwVb c`v‡_i g‡a¨ hLb cigvYyfgn~ mye¨¯— Ae¯vq weivR K‡i ZLb Zv‡K †KjvwmZ e‡j| cigvYyx‡jv mxp eÜ‡bi mv‡_ mkxjZ Ae¯v‡b we¨¯— _v‡K|

A‡KjvwmZ: KwVb c`v‡_i g‡a¨ hLb cigvYyfgn~ Awe¨¯— Ae¯vq _v‡K ZLb Zv‡K A‡KjvwmZ e‡j| A‡KjvwmZ Ae¯vq c`v_ KwVb _vK‡j I cigvYyfgn~ Zi‡ji gZ Awe¨¯— i‡q hvq|

Zij c`v_ (Liquid)

Zij c`v‡_i ZvcgvÎv KwVb c`v‡_i †P‡q †ewk _v‡K| AYy‡jv Zvc †_‡K kw³ Mnb K‡i mÂqYkxj nq| Ges Zi‡ji wfZi BZ¨Z wew¶ßfv‡e †Nviv‡div K‡i| d‡j, AY~‡jvi g‡a¨ Avš:AvYweK ej `ej n‡q c‡o| AYy‡jv KwVb c`v‡_i b¨vq wbw`ó ¯v‡b Ave× _v‡K bv| Z‡e ci¯úi KvQvKwQ _v‡K| G Kvi‡Y Zij c`v‡_i wbw`ó AvKvi †bB ïaygvÎ AvqZb Av‡Q|

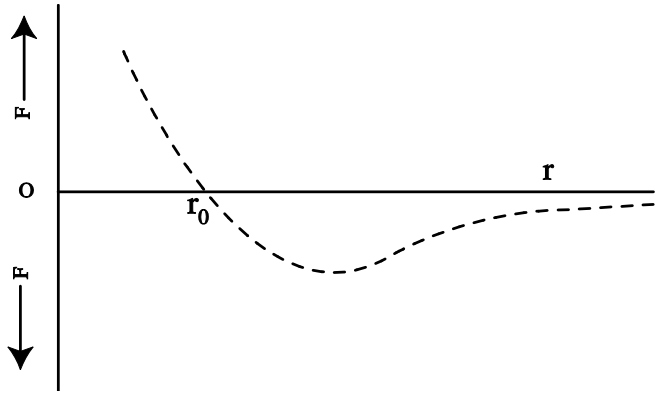
evqexq c`v_ (Gas)

evqexq c`v‡_i ZvcZgvÎv Zij c`v‡_i †P‡q I †ewk _v‡K| AYy‡jv Zvc †_‡K Zij c`v‡_i †P‡q Av‡iv AwaK kw³ MnY K‡i| AwaK gvÎvq mÂibkxj nq| d‡j AYy‡jvi g‡a¨ Avšt AvYweK `iZ A‡bK †e‡o hvq| AYy‡jv ¯vaxbfv‡e Pviw`‡K Qwo‡q c‡o| G Kvi‡Y evqexq c`v‡_i wbw`ó AvKvi I AvqZb †bB|

9.1.2 Avšt AvYweK ej I w¯wZ¯vcK ag

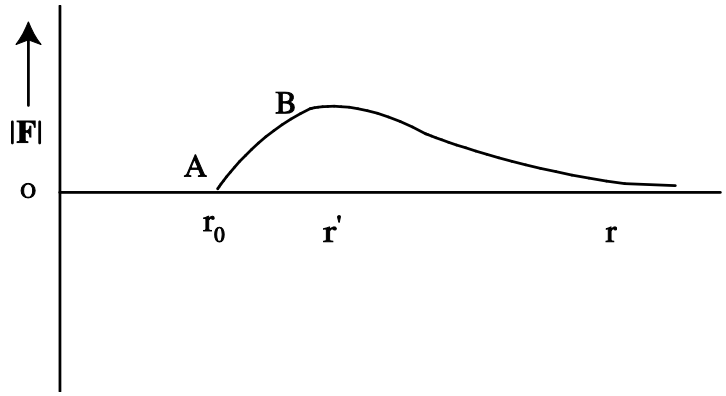
awi, `ywU AYy g‡a¨ Avš:AvYweK ej, F Ges Avš:AvYweK `iZ, r| F Gi gvb r Gi Dci wbfikxj| Avš:AvYweK `iZ A_vr r Gi gvb hZ Kg n‡e Avš:AvYweK ej ZZ †ewk weKIYagx n‡e| r Gi gvb hZ †ewk n‡e Avš:AvYweK ej ZZ †ewk AvKIYagx n‡e| ¯vfweK Ae¯vq AvKIY I weKIY e‡ji gvb mgvb| awi, G Ae¯vq $r=r_0$ KwVb c`v‡_i AYy‡jv mvg¨ve¯v‡bi mv‡c‡¶ ¯ú›`bkxj| †Kbbv, $r>r_0$ n‡j AvKIYagx ej AYyK mvg¨ve¯v‡bi w`‡K †U‡b wb‡q hvq| MwZ RoZvi Rb¨ AYyv mvg¨ve¯vb AwZµg K‡i $r<r_0$ Ae¯v‡b P‡j hv‡e| Avevi $r<r_0$ n‡j AvKIYagx ej AYyv‡K mvg¨ve¯vq wb‡q hvq| Gfv‡e AYy‡jv mvg¨ve¯v‡b ¯úw›`Z n‡Z _v‡K|

F ebvg r Gi †jLwPÎ 9-1 wP‡Î †`Lv‡bv n‡jv| G wPÎ n‡Z †`Lv hvq †h, $r<r_0$ n‡j weKIYagx ej KvR K‡i| G †¶‡Î, r Kg‡j F ev‡o| $r>r_0$ n‡j weKIYagx ej KvR K‡i| G‡¶‡Î, r wKQyi evo‡j F ev‡o, Zvici, r evo‡j F Kg‡Z _v‡K|



wPÎ t 9-1

Avevi wPÎ 9-2 n‡Z †`Lv hvq †h, AB Ask †gvUvgyv mij, A_vr w¯wZ¯vcK ej weKwZi mgvbycwZK, GwU û‡Ki m‡Ë| chy³ ej mwi‡q wb‡j e¯‘U c‡ei Ae¯vq wd‡i hv‡e| e¯‘i G agB w¯wZ¯vcKZv| Avš:AvYweK `iZ r-Gi †ewk n‡j |F| K‡g †h‡Z _v‡K| e¯‘U c‡ei Ae¯vq wd‡i †h‡Z cv‡i bv| AZGe chy³ e‡ji GKwU wbw`ó mxgv Av‡Q hv AwZµg Ki‡j e¯‘U cwei Ae¯vq wd‡i Av‡m bv A_vr w¯wZ¯vcK _v‡K bv| chy³ e‡ji G mxgv‡K w¯wZ¯vcK mxgv e‡j|



wPÎ t 9-2

9.1.3 w¯wZ¯vcKZv (Elasticity)

†Kvb e¯‘vi Dci evB‡i †_‡K ej c‡qvM Ki‡j Gi wewfb As‡ki g‡a¨ Av‡cw¶K miY nq Ges e¯‘wU AvKvi ev AvqZb ev Df‡qiB cwieZb N‡U| G Ae¯vq e¯‘vi ga¨Kvi AvštAvYweK ej cwieZb‡K evav w`‡Z _v‡K hvi d‡j ej c‡qvM eÜ n‡j e¯‘wU c‡ei Ae¯vq wd‡i hvq|

msÁv t evB‡i †_‡K ej c‡qv‡Mi d‡j hw` †Kvb e¯‘vi AvKvi ev AvqZb ev Df‡qi cwieZb N‡U Ges chy³ ej mwi‡q wb‡j †h a‡gi cfv‡e e¯‘wU cybe©vei AvKvi I AvqZb wd‡i cvq Zv‡K w¯wZ¯vcKZv e‡j|

K. c¥ô w¯wZ¯vcK e¯‘(Perfectly elastic body) t chy³ ej Acmvib Ki‡j hw` weKZ.e¯‘ m¤úv¥fv‡e Zv‡`i ceve¯vq wd‡i Av‡m, Z‡e †m e¯‘wU c¥ô w¯wZ¯vcK e¯‘(Perfectly elastic body) e‡j| ev¯‘e †Kvb e¯‘B c¥ô w¯wZ¯vcK bq|

L. bgbxq e¯‘(Plastic body) t †h me e¯‘ n‡Z chy³ ej AcmviY Ki‡j Giv weKZ.Ae¯v ‡_‡K c‡ei Ae¯vq wd‡i Av‡m bv Zv‡`i bgbxq e¯‘(Plastic body) e‡j| e¯‘vi G ag‡K bgbxqZv e‡j| ev¯‘e m¤úv¥ bgbxq e¯‘wcvIqv hvq bv| AvUvi `jv, gwUi `jv BZ¨w`‡K bgbxq ev প্লাস্টিক e¯‘ wn‡m‡e aiv nq|

M. c¥ô `p e¯‘(Perfectly rigid body) t †h me e¯‘vi Dci evB‡i ‡_‡K †h †Kvb cwigvY ej c‡qv‡Mi d‡j I G‡`i AvKvi ev AvKwZi †Kvb cwieZY N‡U bv Zv‡`i c¥ô `p e¯‘(Perfectly rigid body) e‡j| ev¯‘e c¥ô `p e¯‘wcvIqv hvq bv| KvP, B¯úvZ BZ¨w`‡K wKQywKQy¶‡Î c¥ô `p e¯‘ n‡m‡e aiv hvq|

N. w¯wZ¯vcK mxgv (Elastic limit) t Avgiv Rwb, e¯‘vi Dci ej c‡qvM Ki‡j Gi AvKvi Ges AvKwZi cwieZb nq| ej mwi‡q wb‡j e¯‘wU w¯wZ¯vcK a‡gi Rb¨ cÖvi‡q c‡ei Ae¯vq wd‡i Av‡m| chy³ e‡j i gvb hZ †ewk nq, e¯‘vi AvKvi ev AvKwZi cwieZbI ZZ †ewk nq| chy³ ej ax‡i ax‡i evov‡Z _vK‡j Ggb GK Ae¯v Av‡m hLb e¯‘wU Avi w¯wZ¯vcK e¯‘vi g‡Zv AvPiY K‡i bv A_vr chy³ ej mwi‡q wb‡j I c‡ei Ae¯vq wd‡i Avm‡Z cv‡i bv| Kv‡RB, c‡Z¨K e¯‘vi AvKvi ev AvKwZ. cwieZ‡bi GKwU wbw`ó mxgv i‡q‡Q| e¯‘vG wbw`ó mxgvi g‡a¨ _vK‡jB Zv w¯wZ¯vcK e¯‘vi b¨vq AvPiY K‡i| AvKvi ev AvKwZ. cwieZ‡bi G wbw`ó mxgv chš †cŠQv‡Z e¯‘wZ †h cwigvY ej c‡qvM Ki‡Z nq Zv‡K w¯wZ¯vcK mxgv e‡j|

AZGe, evB‡i †_‡K chy³ e‡j i GKwU m‡ev”P gvb chš e¯‘ w¯wZ¯vcK e¯‘vi b¨vq AvPiY K‡i, e‡j i G m‡ev”P gvb‡K w¯wZ¯vcK mxgv e‡j|

O. Amn fvi (Breaking weight) t w¯wZ¯vcK mxgv chš GKwU e¯zm¤úY¨ w¯wZ¯vcK _v‡K| chy³ ej G mxgv AwZµg Ki‡j e¯z w¯wZ¯vcK _vK‡e bv| A_v‡r ej Acmv‡iY Ki‡j I wKQyUv eKwZ. †_‡K hv‡e| chy³ ej µgk evov‡Z _vK‡j Ggb Ae¯v Av‡m, hLb e¯‡U fvi mn¨ Ki‡Z bv †c‡i wQ‡o ev †f‡½ hv‡e| mev‡c¶v Kg †h fv‡iiv ev IR‡bi wµqvi d‡j †Kvb e¯zQ‡o ev †f‡½ hvq, Zv‡K H e¯‡ Amn fvi ev Amn IRb ev Amn ej e‡j|

P. Amn cxob (Breaking Stress) t †Kvb GKwU e¯‡ GKK †¶Îd‡ji Dci chy³ Amnfvi‡K Amn cxob e‡j|

$$\therefore \text{Amn cxob} = \frac{\text{Amn ej}}{\text{†¶Îdj}}$$

Q. w¯wZ¯vcK Kwš (Elastic fatigue) w¯wZ¯vcK mxgvi g‡a¨ †Kvb e¯‡Z ev Zv‡i A‡bK¶Y hver cxob c‡qvM Ki‡j wKsev cxo‡bi nvm-ewn× Ki‡j e¯‡ w¯wZ¯vcK a‡gi Aebwl N‡U| ZLb Amnfvi A‡c¶v Kg fv‡iB H e¯zQ‡o ev †f‡½ hv‡e, e¯‡ev Zv‡ii G Ae¯v‡K w¯wZ¯vcK Kwš e‡j|

mvi-ms‡¶c

w¯wZ¯vcKZv : w¯wZ¯vcKZv c`v‡_i GKwU ag hvi Rb¨ †Kvb e¯zchy³ e‡ji wµqvq Gi AvKvi ev AvqZb ev Df‡qiB cwieZ‡bi c‡Póv‡K evav †`q Ges chy³ ej Acmvwi‡Z n‡j c‡ei AvKvi ev AvqZb wd‡i cvq|

c¥w¯wZ¯vcK e¯z chy³ ej Acmv‡iY Ki‡j hw` wewKZ.e¯zm¤úY¨fv‡e Zv‡`i ceve¯vq wd‡i Av‡m, Z‡e †m e¯‡K c¥w¯wZ¯vcK e¯‡ej|

w¯wZ¯vcK mxgv t evB‡i †_‡K chy³ e‡jiv GKwU m‡ev"P gvb chš e¯zGKwU w¯wZ¯vcK e¯‡ b¨vq AvPiY K‡i, e‡jiv G m‡ev"P gvb‡K w¯wZ¯vcK mxgv e‡j|

Amn fvi t mev‡c¶v Kg †h fv‡iiv ev IR‡bi wµqvi d‡j †Kvb e¯zQ‡o ev †f‡½ hvq, Zv‡K H e¯‡ Amn fvi e‡j|

c‡kvËi gj¨vqb

K. mwVK DË‡ii cv‡k wUK (√) wPý w`b|

1. chy³ ej Acmv‡iY Ki‡j hw` †Kvb weKZ.e¯‘zm¤úv`¨fv‡e ce©e¯‘vq wd‡i Av‡m, Z‡e e¯‘wU wK cKwZi?
   K. bgbxq L. c¥`p
   M. c¥w¯‘wZ¯‘vcK N. mgw`K agx|
2. evB‡i †_‡K chy³ e‡j‡i GKwU m‡ev"P gvb chš e¯‘zi¯‘wZ¯‘vcK e¯‘iz b¨vq AvPiY K‡i, G m‡ev"P gvb‡K wK e‡j?
   K. Amn fvi L. w¯‘wZ¯‘vcK Kwš
   M. Amn cxob N. w¯‘wZ¯‘vcK mxgv|
3. mev‡c¶v Kg †h fv‡ii ev IR‡bi wµqvi d‡j †Kvb e¯‘zQtio ev †f‡½ hvq, Zv‡K H e¯‘iz wK e‡j?
   K. Amn cxob L. Amn fvi
   M. w¯‘wZ¯‘vcK Kwš N. AvqZb weKwZ.|

L. msw¶ß ck

1. c`v_ wK wK Ae¯‘vq _vK‡Z cv‡e?
2. KwVb c`v_ KZ cKvi I wK wK?
3. Avš: AvYweK ej wK?
4. Avš: AvYweK e‡j‡i AvKlY I weKlY KLb ew× cvq?
5. c¥w¯‘wZ¯‘vcK e¯‘zKv‡K e‡j?
6. bgbxq e¯‘zI c¥`p e¯‘zKv‡K e‡j?
7. w¯‘wZ¯‘vcK mxgv ej‡Z wK e‡Sb?
8. Amn fvi ej‡Z wK e‡Sb?
9. Amn cxob I w¯‘wZ¯‘vcK mxgvi msÁv wjLb|

cvV-2
wewKwZ, cxob I û‡Ki mÂ‡q

D‡Ïk¨

G cvV †k‡l Avcwb

- wewfbœ cKvi wewKwZ.eYbv Ki‡Z cvi‡eb,
- wewfbœ cKvi cxob eYbv Ki‡Z cvi‡eb,
- û‡Ki mÂ‡qU wjL‡Z I eYbv Ki‡Z cvi‡eb|

9.2.1 wewfbœ cKvi wewKwZ. I cxob

wewKwZ. (Strain) t Avgiv Rwb, ‡Kvb w¯wZ¯cK e¯‘z Dci ej c‡qvM Ki‡j Gi ^`N¨, AvKvi ev AvKwZ, AvqZb BZ¨vw`i cwieZb N‡U| evB‡i †_‡K ej c‡qv‡Mi d‡j †Kvb e¯‘z GKK gvÎvq †h cwieZb nq Zv‡K wewKwZ.e‡j |

awi, †Kvb e¯‘z Aw`gvÎv = x, ej chy³ nevi ci gvÎv = y

∴ gvÎvi cwieZb = x~y

∴ GKK gvÎvi cwieZb A_vr $\text{wewKwZ.} = \frac{x\sim y}{x}$

wewKwZ.i cKvi‡f` : wewKwZ.wZb cKvi; h_v-

K. ^`N¨-wewKwZ.ev Abyè`N¨ wewKwZ.(Longitudinal Strain),

L. AvKvi-wewKwZ.ev Kšb wewKwZ.(Shearing Strain) Ges

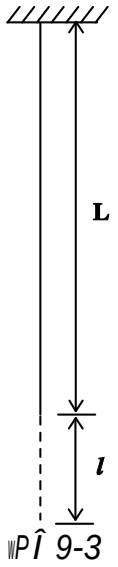
M. AvqZb-wewKwZ.(Volume Strain)

‰`N¨-wewKwZ. t ewnf¨K ej c‡qv‡Mi d‡j hw` †Kvb e¯‘z ^`‡N¨i cwieZb N‡U, Z‡e Zv‡K AYyè`N¨ wewKwZ. e‡j | GKK ^`‡N¨i cwieZb Øviv e¯‘z ^`N¨ wewKwZ.cwigvc Kiv nq|

awi, GKwU e¯‘z Aw` ^`N¨ =L

ej c‡qv‡M Gi ^`‡N¨i cwieZb = ℓ I

∴ $\text{‰`N¨-wewKwZ.} = \frac{\ell}{L}$ .... (9-1)



wPÎ 9-3

D`wniY 1

GKwU Zv‡ii Aw` ^`N¨ 9m ej c‡qvM Kivi d‡j Zv‡ii ^`N¨ 10m nj| Zvi wUi ^`N¨-weKwlZ.KZ n‡e? Avgiv Rwb,

$\text{^`N¨ weKwlZ.} = \frac{\ell}{\text{L}}$

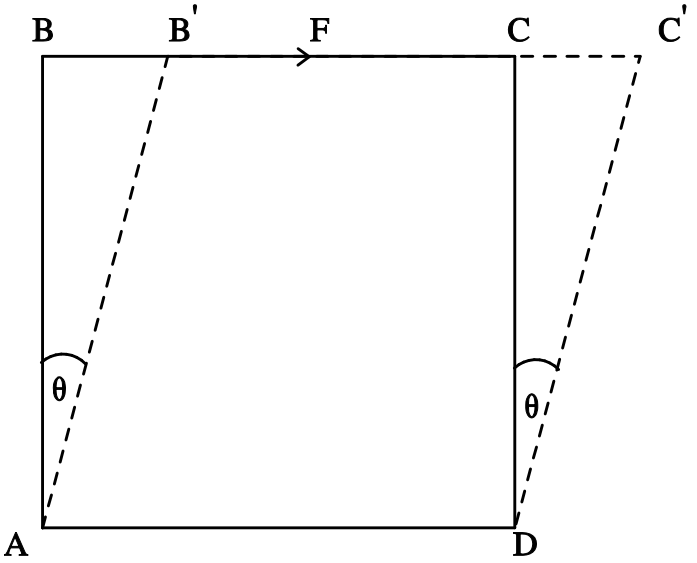
GLv‡b,

L = Zv‡ii Aw` ^`N¨ = 9m

ℓ = Zv‡ii ^`‡N¨i cwieZb = (10-9)m = 1m

$\therefore$ ‰`N¨ weKwlZ. $= \frac{1}{9} \cong .01$

L. **AvKvi ev Kšb-weKwlZ.** t ej c‡qv‡Mi d‡j hw` †Kvb e¯‘z AvKv‡ii cwieZb N‡U, Z‡e Zv‡K AvKvi weKwlZ.e‡j| AvKvi cwieZ‡b mp, †KŠwYK weP¨vwZ Øviv AvKvi-weKwlZ.cwigvc Kiv hvq|



wPÎ : 9.4

g‡b Kwi, ABCD GKwU eM‡¶Î [wPÎ -9-4], eM†¶‡Îi AD Zj `p fv‡e AvUKv‡bv Av‡Q| Gi BC evûi Dci F cwigvY ej ¯úkK eivei wµqv Ki‡j B we›`y B'-we›`y‡Z Ges C we›`y C' -we›`y‡Z ¯vbvšwiZ n‡e|

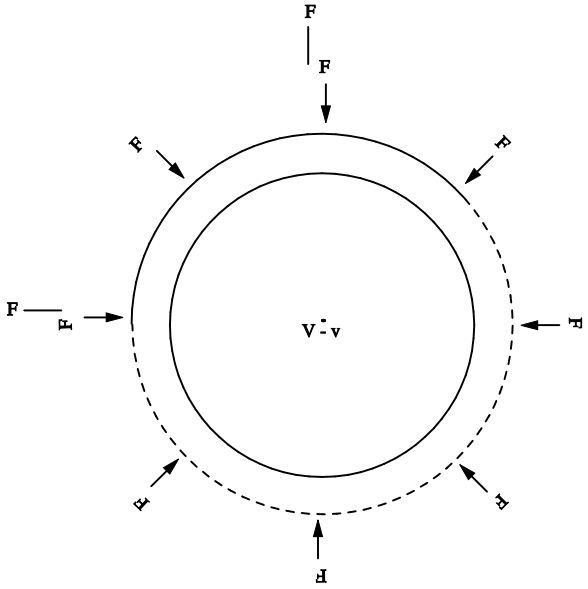
d‡j e¯‘wU AB/ C/ D i¤‡m cwiYZ n‡e| AZGe †`Lv hvq †h, ej c‡qv‡M e¯‘z AvKv‡ii cwieZb N‡U‡Q| Gi bvg AvKvi weKwlZ.|

G AvKvi weKwlZ. e¯‘z †KŠwYK wePvwiZ Øviv cwigvc Kiv nq| g‡b Kwi †KŠwYK weP¨vwiZ = θ Ges θ Lvgvi †QvU|

$\therefore$ AvKvi wePvwiZ = $\theta = \frac{\text{CC}'}{\text{CD}} = \frac{\text{x}}{\text{y}} = \frac{\text{Av‡cwÿK miY}}{\text{e¨eavb `i‡Z}}$ .... (9-2)

$\therefore$ GLv‡b BB' = CC/ = x Ges CD= y aiv nq| GLb y=1, n‡j, θ = x

M. **AvqZb wewKwZ.** t ej c‡qv‡Mi d‡j hw` e¯‘i AvqZ‡bi cwieZb N‡U Z‡e Zv‡K AvqZb wewKwZ. e‡j Ges GKK AvqZ‡bi AvqZb cwieZb Øviv AvqZb wewKwZ. cwigvc Kiv nq|



wPÎ 9-5

g‡b Kwi, †Kvb GKwU e¯‘i Aw` AvqZb = V

Ges ej c‡qv‡Mi d‡j AvqZ‡bi cwieZb = v

$\therefore$ AvqZb wewKwZ. = $\frac{\text{AvqZ‡bi cwieZb}}{\text{Aw` AvqZb}}$

ev AvqZb wewKwZ. = $\frac{\mathbf{v}}{\mathrm{V}}$ ..... (9-3)

wewKwZ. GKB RvZxq `ywU iwnki Abygvw`, myZivs Gi GKK Ges gvÎv mgxKiY †bB|

D`vniY 2

GKwU †Mvj‡Ki Aw` AvqZb $9\mathrm{m}^3$, ej c‡qvM Kivi d‡j †Mvj KwU msKl©Z n‡q $6\mathrm{m}^3$ AvqZb cvß nq| †Mvj KwUi AvqZb wewKwZ. KZ?

Avgiv Rwb,

AvqZb wewKwZ. = $\frac{\mathrm{v}}{\mathrm{V}}$

GLv‡b,

V = Aw` AvqZb = $9\mathrm{m}^3$,

v = AvqZ‡bi cwieZb = $(9-6)\mathrm{m}^3 = 3\mathrm{m}^3$,

$\therefore$ AvqZb wewKwZ. = $\frac{3}{9} = 0.33$ (cvq)

cxob (Stress) *t evB‡i ‡_‡K ej c‡qv‡M †Kvb e¯‘z AvKv‡i ev AvKwZi cwieZb NUv‡j w¯wZ¯vcKZvi Rb¨ e¯‘z wfZi GKwU evav`vbKvix e‡ji mwó nq| G e‡ji gvb chy³ e‡ji mgvb I wecixZ | e¯‘z GKK †¶Îd‡j Drcb G evav`vbKvix e‡ji gvb‡K cxob e‡j|*

g‡b Kwi, †Kvb GKwU e¯‘z †¶Îdj = A

Ges chy³ ej = F

$$\therefore \text{cxob} = \frac{ej}{\text{†¶Îdj}} = \frac{F}{A} \quad \text{... ....} \quad (9\text{-}4)$$

D`vniY 3

GKwU 25 m^2 *†¶Îdj wewkó †gvUv Zv‡ii Dci* 50N *ej c‡qvM Kiv n‡j Gi AvKwZi cwieZb nq, e¯wUi cxo‡bi gvb KZ?*

Avgiv Rwb,

$$\text{cxob} = \frac{ej}{\text{†¶Îdj}} = \frac{F}{A}$$

GLv‡b,

F = *ej* = 50N

A = *†¶Îdj* = 25 m^2

$$\therefore \text{cxob} = \frac{50}{25} = 2Nm^{-2}$$

cxo‡bi cKvi‡f` t cxob wZb cKvi, h_v :

1. *^`N¨ cxob (*Longitudinal Stress*)*
2. *Kšb cxob (*Sheering Stress*) Ges*
3. *AvqZb cxob (*Volume Stress*)*

1. *‰`N¨ cxob : ^`N¨ weKwZ. NUvevi Rb¨ cwZ GKK †¶Îd‡ji Dci ^`N¨ eivei chy³ ej‡K ^`N¨ cxob e‡j| awi, GKwU Zv‡ii c¯‘”Q‡`i †¶Îdj* A *Ges Gi ^`N¨ eivei chy³ ej* F

   $$\therefore \text{‰`N¨ cxob} = \frac{F}{A}$$

2. *Kšb cxob t AvKvi weKwZ. NUvevi Rb¨ †h cxob c‡qvM Ki‡Z nq Zv‡K AvKvi cxob e‡j| hw` †Kvb GKwU e¯‘z* A *‡¶Îd‡ji Dci* F *cwigvY ¯úwkbx A_vr ¯úkK eivei ej c‡qvM K‡i AvKvi weKwZ. NUv‡bv nq Z‡e*

   $$\text{AvKvi cxob} = \frac{F}{A}$$

3. *AvqZb cxob : AvqZb weKwZ. NUvevi Rb¨ †h cxob c‡qvM Kiv nq Zv‡K AvqZb cxob e‡j| g‡b Kwi, GKwU e¯‘z Pviw`K n‡Z* F *cwigvY ej Awfj¤fv‡e c‡qvM K‡i Gi AvqZb weKwZ. NUv‡bv n‡q‡Q| hw` Z‡ji †¶Îdj* A *nq Z‡e,*

   $$\text{AvqZb cxob} = \frac{F}{A}$$

cxo‡bi GKK (Unit of Stress)

c×wZ	*GKK*	*GKK (AwfKIxq)*
Gg. †K. Gm	*wbDUb/eMwgUvi*	*wK‡jvMvg IRb/eMwgUvi*

cxo‡bi gvÎv (Dimension of Stress) :

Avgiv Rwb,

$$cxob = \frac{ej}{\text{‡¶Îdj}}$$

$$\therefore [cxob] = \frac{[F]}{[A]} = \left[\frac{[MLT^{-2}]}{L^2}\right] = [ML^{-1}T^{-2}]$$

9.2.2 û‡Ki mÎ (Hooke's law)

1678 Lx÷v‡ã Bs‡iR c`v_©we` ievU ûK cxob I wewKwZi g‡a¨ GKwU m¤úK© ¯'vcb K‡ib| G m¤úK©wU û‡Ki mÎ bv‡g cwiwPZ, wb‡¤ û‡Ki mÎ‡Îi eYbv †`qv n‡jv|

mÎ : Ów¯'wZ¯'vcK mxgvi g‡a¨ e¯'vz cxob Gi wewKwZi mgvbycvwZK,Ó

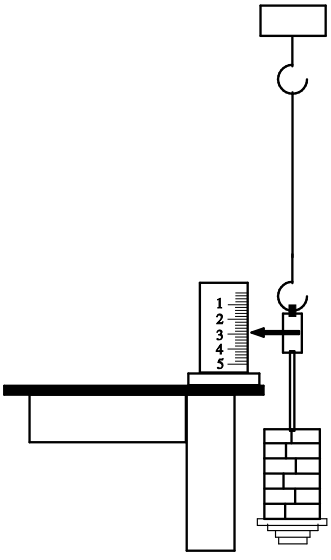
A_vr, cxob × wewKwZ.

ev, cxob = avgK × wewKwZ.

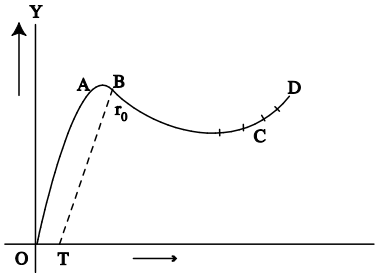
ev, $\frac{cxob}{wewKwZ.}$ = avgK

G a"e‡Ki gvb e¯'vz Dcv`vb Ges GK‡Ki c×wZi Dci wbfi K‡i| G‡K w¯'wZ¯'vcK ¸Yv¼ ev w¯'wZ¯'vcK gvbv¼ (Co-efficient of elasticity) e‡j| G‡K w¯'wZ¯'vcK a"eKË I (Elastic Constant) ejv nq|

e¨vL¨v: GKwU B¯úv‡Zi Zv‡ii GK cvš GKwU `p Aej¤‡bi mv‡_ AvUKvB| Zv‡ii Aci cv‡š mshy³ û‡K IRb S‡i‡bv hvq| GB IR‡bi cwigvY Aí Aí K‡i evov‡j Zv‡ii ^`N¨ e„× cvq (wPÎ 9-6)| Zv‡ii G ^`N¨ e„× chy³ e‡ji mgvbycvwZK| A_vr ej w¯'wZ¯'vcK mxgv AwZµg K‡iwb| ûK †_‡K chy³ ej Acmviv Ki‡j Zviwu c‡ei Ae¯'vq wd‡i hv‡e| ej µgk evov‡Z _vK‡j GK mgq Zviwu w¯'wZ¯'vcK mxgvi evB‡i P‡j hv‡e| d‡j ZLb ej Acmviv Ki‡j I Zviwu c‡ei Ae¯'vq wd‡i †h‡Z cvi‡e bv| Gfv‡e ievU ûK †`Lvb †h, w¯'wZ¯'vcK mxgvi g‡a¨ e¯'vz ‰`‡N¨i e„× wewKwZKvix e‡ji mgvbycvwZK|



wPÎ 9.6



wPÎ 9.7

cvß djvdj e¨envi K‡i chy³ fvi I ^`N¨ e„×i †jL -wPÎ AsKb Ki‡j 9-7 bs wP‡Îi b¨vq GKwU †jL wPÎ cvIqv hv‡e| wP‡Î 0 we›`y‡_‡K A we›`ydj g‡a¨ e¯‘wU c‡¶ w¯‹z¯‹vc‡Ki b¨vq AvPib K‡i| A we›`y e¯‘i w¯‹z¯‹vcK mxgv wb‡`k K‡i| w¯‹z¯‹vcK mxgv AwZµg Kivi cil fvi Pvcv‡j Ges fvi miv‡j Zviv‡U Avi c‡ei Ae¯vq wd‡i Avm‡e bv| G Ae¯vq †jL wPÎv‡U BT Gi gZ n‡e| Zviv‡U‡Z ¯vqx weKwZ. OT ‡_‡K hv‡e| Gici Avil fvi Pvcv‡j Zviv‡U †Kvb †Kvb ¯v‡b mi“ n‡Z _vK‡e| G Ae¯vq †jLwPÎv‡U C we›`ywb‡`k Ki‡e| Gicil fvi Pvcv‡j Zviv‡U mi“ n‡Z n‡Z D we›`ydj wQ‡o hvq| †jLwP‡Î D n‡"Q mnbmxgv| D we›`ydj cxo‡bi gvb‡K Amn cxob e‡j Ges Amn fvi = Zv‡ii c¯‘‡"Q‡`i †¶Îdj × Amn cxob| GLv‡b D‡ïS Kiv c‡qvRb †h, cxob w¯‹z¯‹vcK mxgv A‡c¶v Kg n‡j l Zv h` e¯‘dj Dci A‡bK mgq a‡i wµqv K‡i Z‡e †m‡¶‡Î e¯‘dj weKwZ. ¯vqx nq|

mvi-ms‡¶c

weKwZ. : evB‡i ‡_‡K ej c‡qvM Ki‡j †Kvb e¯‘dj GKK gvÎvi †h cwieZb nq Zv‡K weKwZ. e‡j|
cxob : e¯‘dj GKK †¶Îdj mgvb evav`vbKvix e‡ji gvb‡K cxob e‡j|
û‡Ki m¤ú~ : Ò¯‹z¯‹vcK mxgvi g‡a¨ e¯‘dj cxob Gi weKwZi mgvbycvwZK|Ó

c‡qvRbxq mgxKiY

1. ^`N¨ $weKwZ. = \frac{\ell}{L}$
2. Kš—b weKwZ. = †KŠwYK wePvwi = θ
3. AvqZb weKwZ. = $\frac{v}{V}$
4. cxob = $\frac{F}{A}$
5. û‡Ki m¤ú~ = $\frac{cxob}{weKwZ.}$ = avgvK

c‡kvËi gj¨vqb

K. mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1. wb‡Pi †Kvb evK¨wU mZ¨ ?

   K. weKwZi GKK wbDUb/wgUvi^2 L. weKwZi GKK wbDUb|
   M. weKwZi †Kvb GKK †bB. N. weKwZi GKK Rvgv|

2. cxo‡bi GKK ‡KvbwU?

   K. Jm-^{2} L. Nm-^{2}
   M. Nm^2 N. Nm

3. û‡Ki mfv Abyfv‡i cxob weKwZi

   K. e¨v¯vbxq wZK L. e‡Mi e¨v¯vbxq wZK
   M. mgvbxq wZK N. e‡Mi mgvbxq wZK|

L. msw¶ß ck

1. weKwZ ej‡Z wK eySvq?
2. weKwZ KZ cKvi I wK ?
3. cxob ej‡Z wK eySvq?
4. cxob KZ cKvi I wK?
5. û‡Ki mfvwU wjLyb|

MwYwZK ck

1. ej c‡qv‡Mi d‡j GKwU ^`‡N¨i cwieZb nq 4m| Zvi wUi Aw` ^`N¨ hw` 10 m nq, Z‡e Gi ^`N¨ weKwZ KZ n‡e?
2. GKwU †Mvj‡Ki Aw` AvqZb 25 m^3 | ej c‡qv‡M Gi AvqZ‡bi cwieZb nq 1m^3 | †MvjKwUi AvqZb weKwZ KZ?
3. GKwU 100 m^2 †¶Îdj wewkó †gvUv Zv‡ii Dci 10N ej c‡qvM Kiv n‡j Gi AvKwZi cwieZb nq| cxo‡bi gvb KZ?

cvV-3

w¯wZ¯vcKZvi wewfb ¸YvsK I cqm‡bi AYgvZ

D‡Ïk¨-

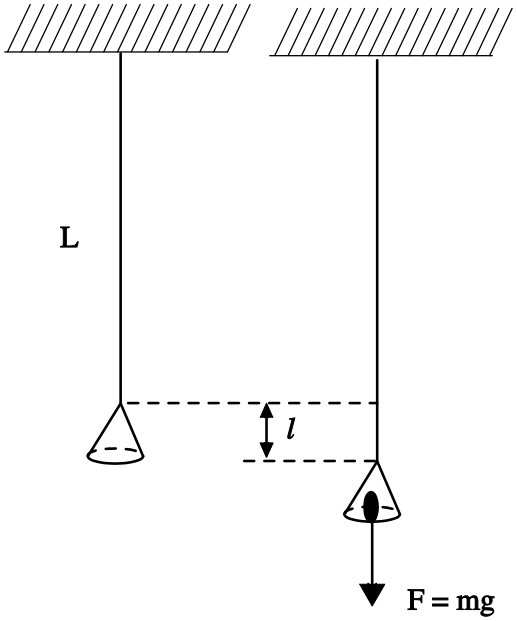
G cvV †k‡l Avcwb-

- w¯wZ¯vcKZvi wewfb ¸bvs‡Ki e¨vL¨v Ki‡Z cvi‡eb|
- cqm‡bi AYgv‡Zi eYbv w`‡Z cvi‡eb|
- e¯‘i wewKwZi Rb¨ KZ.Kv‡Ri mgxKiY wjL‡Z cvi‡eb|

9.3.1 w¯wZ¯vcKZvi wewfb ¸YvsK (Different modulus of Elasticity)

û‡Ki m‡½ n‡Z Avgiv cvB, w¯wZ¯vcK mxgvi g‡a¨ cxob Ges e¯‘i wewKwZi AbycvZ GKwU aviv msL¨v| G aviv msL¨v‡K w¯wZ¯vcK ¸YvsK e‡j|

$$\therefore \text{ w¯wZ¯vcK ¸YvsK} = \frac{\text{cxob}}{\text{wewKwZ.}}$$



wPÎ 9-8

gvÎv : †h‡nZzwewKwZi †KvW gvÎv †bB, myZivs w¯wZ¯vcK ¸Yvs‡Ki gvÎv n‡e cxo‡bi gvÎv A_vr

[w¯wZ¯vcK M¥vsK] = $\mathrm{ML^{-1}T^{-2}}$

wewfb cKvi cxo‡bi Rb¨ wewfb cKvi wewKwZ. I wewfb cKvi w¯wZ¯vcK ¸YvsK Av‡Q| w¯wZ¯vcK ¸YvsK gj¨Z wZb cKvi, h_v-

1. *Bqs-Gi w¯wZ¯vcK ¸YvsK (*Young's modulus of elasticity*)*
2. *AvqZ‡bi w¯wZ¯vcK ¸YvsK (*Volume or Bulk modulus of elasticity)
3. *KwV‡b¨i ev `pZvi w¯wZ¯vcK ¸YvsK (*Rigidity modulus of elasticity)

1. Bqs-Gi w¯wZ¯vcK ¸YvsK : w¯wZ¯vcK mxgvi g‡a¨ †Kvb e¯‘i ^`N¨ cxob I ^`N¨ weKwZi Abygv‡Z GKwU ag© msL¨v| G ag© msL¨v‡K e¯‘i Dcv`v‡bi Bqs-Gi ¸YvsK e‡j | G‡K ÔYÕ Øviv cKvk Kiv nq|

AZGe, Bqs-Gi ¸YvsK, $Y = \frac{\text{‰`N¨ cxob}}{\text{^`N¨ weKwZ}}$.

e¨vL¨v : L ‰`N¨, r e¨vmva I A c¯‘‡”Q` wewkó Zv‡ii GKcvš †Kvb `p Aej¤b n‡Z Sz‡j‡q †`B [wPÎ 9.7]| hw` Zviwui bx‡Pi cv‡š ÔMÕ fi ev F = Mg ej c‡qvM Kiv‡i d‡ji Gi ^`N¨ ℓ cwigvY ew„× cvq, Z‡e,

Bqs-Gi ¸YvsK, $= \frac{\text{‰`N¨ cxob}}{\text{^`N¨ weKwZ}} = \frac{F/A}{\ell/L}$

$= \frac{F \times L}{A \times \ell} = \frac{mg \times L}{\pi r^2 \times \ell}$ .... (9-5)

GLv‡b, [g = Awf‡KvlYq Ziv]

[A = Zv‡ii c¯‘‡”Q‡`i †¶Îdj = πr^2]

hw` Y = $\frac{FL}{A\ell}$ mgxKi‡b, A=1GKK Ges ℓ =L nq, Z‡e Y=F n‡e|

myZivs GKK c¯‘‡”Q‡`i †¶Îdj wewkó †Kvb Zv‡ii ^`N¨ eivei †h ej c‡qvM Ki‡j Zviwui ^`N¨ ew„× Aww` ^`‡N¨i mgvb nq, Zv‡K Bqs-Gi ¸YvsK e‡j |

B¯úv‡Zi Bqs-Gi ¸YvsK = 2×10^{11} Nm^{-2} ej‡Z eySvq †h, GK eM©gUvi c¯‘‡”Q`-Gi †¶Îdj wewkó †Kvb B¯úv‡Zi Zv‡ii ^`N¨ eivei 2×10^{11} N ej c‡qvM Kiv n‡j Zviwui ^`N¨ ew„× Aww` ^`‡N¨i mgvb n‡e|

Y Gi gvÎv : †h‡nZzwewKwZi †Kvb gvÎv †bB, myZivs Y-Gi gvÎv Ges cxo‡bi gvÎv GKB|

A_vr [Y] = $ML^{-1}T^{-2}$

Y Gi GKK : Bqs-Gi w¯wZ¯vcK ¸Yvs‡Ki GKK, wb¤i¡c :-

	GKK (wbi‡c¶)	GKK (Awf‡KvlYq)
Gg. †K. Gm	wbDUb/eM©gUvi	wK‡jvMvg IRb/eM©gUvi

2. **AvqZ‡bi w¯wZ¯vcK ¸YvsK** : e¯‘i AvqZb cxob I AvqZb weKwZi Abygv‡Z GKwU ag© msL¨v| G ag© msL¨v‡K e¯‘i Dcv`v‡bi AvqZb ¸YvsK e‡j | G‡K ÔKÕ Øviv cKvk Kiv nq|

AZGe, AvqZb ¸YvsK, $K = \frac{\text{AvqZb cxob}}{\text{AvqZb weKwZ}}$.

e¨vL¨v : V AvqZ‡bi †Kvb e¯‘i Pviw`K n‡Z F ej c‡qvM Kwi| GB ej c‡qv‡Mi d‡j e¯‘wUi AvqZb v nvm cvq (wPÎ 9-5)

∴ AvqZb weKwZ = $\frac{v}{V}$ |

hw` e¯‘wUi c‡ôi †¶Îdj A nq|

Z‡e, AvqZb cxob = F/A

mxgvi AvqZb ¸YvsK, $K = \frac{F/A}{v/V} = \frac{P}{v/V} = \frac{PV}{v}$

[GLv‡b $P = Pvc = \frac{F}{A}$] .... (9-6)

AvqZb ¸Yvs‡Ki gvÎv I GKK Bqvs-Gi ¸Yvs‡Ki AYyjvc|

3. Kšb ev KwVb¨ ev `pZvi w¯wZ¯vcK ¸YvsK t w¯wZ¯vcK mxgvi g‡a¨ Kšb cxob I Kšb wewKwZi Abycv‡Z GKwU aviv msL¨v| G aviv msL¨v‡K Kšb ¸YvsK e‡j| G‡K ûη' Øviv cKvk Kiv nq|

AZGe, Kšb ¸YvsK, $\eta = \frac{\text{Kšb cxob}}{\text{Kšb wewKwZi}}$

e¨vL¨v t A †¶Îdj wewkó GKwU AvqZvKvi e¯‘i Dci F ej Avbyf~wgKfv‡e c‡qvM Kiv‡i d‡j h` Kšb †KvY θ Ercb nq .... (wPÎ 9-4)|

Z‡e, Kšb ¸YvsK $\eta = \frac{\text{Kšb cxob}}{\text{Kšb wewKwZi}} = \frac{F/A}{\theta}$ .... (9-7)

wcZ‡ji Kšb ¸YvsK $9\times10^{10}\text{Nm}^{-2}$ ej‡Z eySvq ‡h, GKwU wcZ‡ji Nb‡Ki AvKwZi cwieZb K‡i 1 †iwWqvb e¨eZb †KvY Drcb Ki‡Z Gi Dcwi‡ji GK eMgUvi †¶Îd‡ji Dci $9\times10^{10}\text{N}$ ej c‡qvM Ki‡Z n‡e|

Kšb ¸Yvs‡Ki gvÎv I GKK Bqvs-Gi ¸Yvs‡Ki AYyjvc|

D`vniY 1

0.1 wgUvi evû wewkó A¨vjyg‡bqv‡gi ˆZix GKwU Nb‡Ki †Kvb Z‡j 89.67×10^5 wbDUb AvKvi cxob mwó‡Kvix ¯úwkbx ej c‡qvM Ki‡j wecixZ w¯i Zi‡ji mv‡c‡¶ Zjwi 3.05×10^{-3} wgUvi miY N‡U| AvKvi cxob, AvKvi wewKwZi I `pZvi w¯wZ¯vcK ¸YvsK wbYq Ki“b|

mgvavbt

AvKvi cxob : $= \frac{F}{A} = \frac{89.67\times10^5}{0.1\times0.1}$

$= 89.67\times10^7$ wbDUb/wgUvi^2

AvKvi wewKwZi $= \frac{\text{Av‡c¶K miY}}{\text{e¨eavb `i~Z}} = \frac{x}{y} = \frac{3.05\times10^{-3}}{0.1}$

$= 3.05\times10^{-2}$

`pZvi w¯wZ¯vcK ¸YvsK $\eta = \frac{\text{AvKvi cxob}}{\text{AvKvi wewKwZi}}$

$= \frac{89.67\times10^7}{3.05\times10^{-2}}$ wbDUb/wgUvi^2

$= 2.94\times10^{10}$ wbDUb/wgUvi^2

9.3.2 cqm‡bi Abygv`vZ (Poisson's Ratio)

†Kvb Zv‡ii ^`N¨ eivei ej c‡qvM Ki‡j ^`N¨ wewKwZi mv‡_ mv‡_ cvk wewKwZ. N‡U A_vr Zv‡ii e¨vm ev e¨vmva K‡g hvq|

w`wZ¯cK mxgvi g‡a¨ ^`N¨ wewKwZ. I cvk wewKwZi AYygvZ GKwU ag© msL¨v| wewÁvbx cqmb G Abygv`vZ Awe¯vi K‡ib e‡j G‡K cqm‡bi Abygv`vZ ejv nq| G‡K σ Øviv cKvk Kiv nq|

$$\therefore \text{ cqm‡bi Abygv`vZ } \sigma = \frac{\text{cvk wewKwZ.}}{\text{^`N¨ wewKwZ.}}$$

awi, †Kvb Zv‡ii Aw` ^`N¨ LGes e¨vm D_1 ej c‡qv‡Mi d‡j hw` ^`N¨ e„w× l Ges e¨v‡mi nvm d nq, Zvn‡j-

$$\text{^`N¨ wewKwZ.} = \frac{\ell}{L} \text{ Ges cvk wewKwZ.} = \frac{d}{D}$$

$$\therefore \text{ cqm‡bi Abygv`vZ, } \sigma = \frac{\text{cvk wewKwZ.}}{\text{^`N¨ wewKwZ.}} = \frac{d/D}{\ell/L} = \frac{dL}{D\ell} \quad \text{.... .... (9-8)}$$

`yU wewKwZi Abygv`vZ e‡j Gi †Kvb gvÎv ev GKK †bB|

D`vniY 2

GKwU Zv‡i 0.01 ^`N¨ wewKwZ‡Z cvk wewKwZ. 0.0024 n‡j Zv‡ii Dcv`v‡bi cqm‡bi Abygv`vZ wbYq Ki“b|

mgvavb t

$$\text{Avgiv Rwb, cqm‡bi Abygv`vZ } \sigma = \frac{\text{cvk wewKwZ.}}{\text{^`N¨ wewKwZ.}}$$

$$= \frac{0.0024}{0.01}$$

$$= 0.24$$

9.3.3 e¯‘wewKwZi Rb¨ m¤úvw`Z KvR

(Work done in deforming a body)

†Kvb e¯‘K wewKwZ.Ki‡Z n‡j Gi Dci ev¯B‡i †_‡K ej c‡qvM K‡i wKQyKvR Ki‡Z nq Ges H KvR e¯‘‡Z w`wZkw³ i|‡c mwÂZ _v‡K| Avevi ev¯B‡ii ej Acmwiw‡Z n‡j e¯‘wU Zvi Av‡Mi Ae¯vq wd‡i Av‡m|

e¯‘wewfb wewKwZ.mgó Ki‡Z †h KvR mwaZ nq wb‡P Zv Av‡jvPbv Kiv nj|

awi, L Aw` ^`N¨ Ges A c¯‘‡”Q`wewkó GKwU Zvi GKwU `p Aej¤^b ‡_‡K Sjv‡bv Av‡Q| g‡b Kwi F ej c‡qvM Kivi d‡j Gi ^`N¨ dℓ cwigvY e„w× cvq|

$$\therefore \text{ KZ.KvR } dw = F d\ell$$

$$\therefore \ell \text{ cwigvY ^`N¨ e„w×‡Z †gvU KZ.KvR, } w = \int_0^{\ell} F d\ell \quad \text{.... .... (1)}$$

Bqs-Gi ¸YvsK †_‡K Avgiv Rwb-

$$Y = \frac{FL}{A\ell}$$

GLv‡b, L = Zv‡ii Aw` ^`N¨

A = Zv‡ii c¯‡”Q‡` i †¶Îdj

ℓ = ‡gvU ^`N¨ ewn×

Ges F = ej

$$\therefore\ F = \frac{YA\ell}{L} \quad \text{.... .... (9-9)}$$

mgxKiY-1 G F Gi gvb ewm‡q cvB-

$$w = \int_0^{\ell} \frac{YA\ell}{L}\, d\ell$$

$$= \frac{YA}{L}\int_o^{\ell} \ell\, d\ell$$

$$= \frac{YA}{L}\left[\frac{l^2}{2}\right]_o^{\ell}$$

$$= \frac{1}{2}\frac{YA\ell^2}{L}$$

G cwigvY KvRB Zv‡ii g‡a¨ w¯wZkw³ wnmv‡e mwÂZ _vK‡e|

Zv‡ii AvqZb, V = c¯‡”Q‡` i †¶Îdj × ^`N¨ = AL

GKK AvqZ‡bi KZ.KvR = GKK AvqZ‡bi w¯wZkw³

$$E = \frac{1}{2}\ \frac{YA\ell^2}{LV} = \frac{1YA\ell^2}{2L.AL}$$

$$= \frac{1}{2}\ \frac{Y\ell}{L} \times \frac{\ell}{L} = \frac{1}{2} \times \frac{F}{A} \times \frac{\ell}{L}$$

$$= \frac{1}{2} \times cxob \times weKwZ. \quad \text{.... .... (9-10)}$$

Abÿ¡c fv‡e †`Lv‡bv hvq †h,

AvqZb weKwZi Rb¨ GKK AvqZ‡b w¯wZkw³ ev KZ.KvR

$$E = \frac{1}{2} \times AvqZb\ cxob \times AvqZb\ weKwZ.|$$

AvKvi weKwZi Rb¨ GKK AvqZ‡b w¯wZkw³ ev KZ.KvR-

$$E = \frac{1}{2} \times AvKvi\ cxob \times AvKvi\ weKwZ.|$$

mvi-ms‡¶c

Bqs-Gi w¯wZ¯vcK ¸YvsK: w¯wZ¯vcK mxgvi g‡a¨ e¯‘i ^`N¨ cxob I ^`N¨ wewKwZi Abycv‡Z GKwU ag© msL¨v| G ag© msL¨v‡K e¯‘i Dcv`v‡bi Bqs-Gi ¸YvsK e‡j |

AvqZ‡bi w¯wZ¯vcK ¸YvsK : w¯wZ¯vcK mxgvi g‡a¨ e¯‘i AvqZb cxob I AvqZb wewKwZi Abycv‡Z GKwU ag© msL¨v| G ag© msL¨v‡K e¯‘i Dcv`v‡bi AvqZ‡bi ¸YvsK e‡j |

Kšb ev Kwnbv¨ ev `pZvi w¯wZ¯vcK ¸YvsK: w¯wZ¯vcK mxgvi g‡a¨ Kšb cxob I Kšb wewKwZi Abycv‡Z GKwU ag© msL¨v| G ag© msL¨v‡K Kšb ¸YvsK e‡j |

cqm‡bi Abycv‡Z: w¯wZ¯vcK mxgvi g‡a¨ cvk wewKwZ. I ‰`N¨ wewKwZi AYycv‡Z cqm‡bi Abycv‡Z e‡j |

c‡qvRbxq mgxKiY

Bqs-Gi ¸YvsK $t\ \mathrm{Y} = \frac{\mathrm{F/A}}{\ell/\mathrm{L}} = \frac{\mathrm{FL}}{\mathrm{A}\ell} = \frac{\mathrm{mgL}}{\pi \mathrm{r}^2 \ell}$

AvqZb ¸YvsK $t\ \mathrm{K} = \frac{\mathrm{F/A}}{\mathrm{v/V}} = \frac{\mathrm{FV}}{\mathrm{Av}}$

`pZvi ¸YvsK $t\ \eta = \frac{\mathrm{F/A}}{\theta} = \frac{\mathrm{F}}{\mathrm{A}\theta}$

cqm‡bi Abycv‡Z : $\sigma = \frac{\mathrm{Ld}}{\mathrm{D}\ell}$

w¯wZ¯vcK w¯wZkw³ (^`N¨ wewKwZi Rb¨)

$\mathrm{W} = \frac{1}{2} \times \frac{\mathrm{YA}\ell^2}{\mathrm{L}}$

GKK AvqZ‡b w¯wZkw³ t

$\mathrm{E} = \frac{1}{2} \times$ cxob $\times$ wewKwZ.|

c‡kvËi gj¨vqb

mwVK DË‡ii cv‡k wUK wPý (√) w`b|

1. Bqs-Gi ¸YvsK †KvbwU ?

   K. $\mathrm{Y} = \frac{\mathrm{FL}}{\mathrm{A}\ell}$ L. $\mathrm{Y} = \frac{\mathrm{FA}}{\mathrm{L}\ell}$

   M. $\mathrm{Y} = \frac{\mathrm{AL}}{\mathrm{F}\ell}$ N. $\mathrm{Y} = \frac{\mathrm{F}\ell}{\mathrm{AL}}$

2. AvqZ‡bi w¯wZ¯vcK ¸YvsK †KvbwU ?

   K. $\mathrm{K} = \mathrm{PV}\mathbf{v}$ L. $\mathrm{K} = \frac{\mathrm{P}\mathbf{v}}{\mathrm{V}}$

   M. $\mathrm{K} = \frac{\mathrm{V}\mathbf{v}}{\mathrm{P}}$ N. $\mathrm{K} = \frac{\mathrm{PV}}{\mathbf{v}}$

3. KwVb¨i w¯ŒZ¯vcK ¸YvsK †KvbwU?

K. $\eta = FA\theta$ L. $\eta = \frac{\theta}{F/A}$

M. $\eta = \frac{F/A}{\theta}$ N. $\eta = \frac{F\theta}{A}$

4. cqm‡bi Abyôv‡Zi mgxKiYwU †KvbwU ?

K. $\sigma = \frac{Ld}{D\ell}$ L. $\sigma = \frac{d\ell}{DL}$

M. $\sigma = \frac{D\ell}{dL}$ N. $\sigma = \frac{d}{DL\ell}$

L. msw¶ß ck

1. Bqs-Gi w¯ŒZ¯vcK ¸YvsK Kv‡K e‡j ?
2. AvqZ‡bi w¯ŒZ¯vcK ¸YvsK Kv‡K e‡j ?
3. Kš—b ev KwVb¨ ev `pZvi w¯ŒZ¯vcK ¸YvsK ej‡Z wK eySvq ?
4. cqm‡bi Abyôv‡Zi msÁv wjLyb|

M. MwYwZK ck

1. wcZ‡ji GKwU Zv‡i 4.51×10^{6} wbDUb/wg:^{2} ‰`N¨ cxo‡b ‰`N¨ weKwZ. 5×10^{-5} n‡jv| wcZ‡ji Bqs-Gi w¯ŒZ¯vcK ¸YvsK wbYq Ki“b|
2. 3×10^{7} wbDUb/wg:^{2} AvqZb cxo‡b GKwU c`v‡_i AvqZb weKwZ. $1.5\times10^{-4}$ n‡j, c`v_wUi AvqZ‡bi w¯ŒZ¯vcK ¸YvsK wbYq Ki“b|
3. w¯i Zvcgv Îvq 20 evqygÛjxq Pv‡ci cwieZ‡b GKwU e¯‘i AvqZ‡bi cwieZb 0.01% nj| Gi AvqZ‡bi w¯ŒZ¯vcK ¸YvsK KZ ?
   [1 evqygÛjxq Pvc = 1.013×10^{10} wbDUb/wg:^{2}]
4. GK wgUvi `xN GKwU Zv‡ii e¨vm 0.01wg:| Gi ^`N¨ eivei GKwU ej c‡qvM Kiv e¨vm 0.01×10^{-3} wg: nvm cvq I ^`N¨ $0.1\times10^{-2}$ wg: e„× cvq| Zv‡ii Dcv`v‡bi cqm‡bi Abyôv‡Z wbYq Ki“b|
5. 1×10^{-6} wg: Ges 2 wg:^{2} c¯‹”Q‡`i †¶Îdj Ges 2 wg: ^`‡N¨i GKwU myweg Zvi‡K 1×10^{-3} wgUvi cmwiZ Ki‡Z Kv‡Ri cwigvY wbYq Ki“b| ZviwU Dcv`v‡bi Bqs Gi ¸YvsK, [Y = 1×10^{11} wbDUb/wg:^{2}]

cvV-4
Bqs-Gi ¸YvsK wbYq

D‡Ïk¨-
G cvV †k‡l Avcwb-

- fwYqvi c×wZ‡Z Bqs-Gi ¸YvsK wbYq Ki‡Z cvi‡eb,
- B¯úvZ ivev‡ii †P‡q †ewk w¯wZ¯vcK-e¨vL¨v Ki‡Z cvi‡eb|

9.4.1 Bqs-Gi ¸YvsK wbYq

(Determination of Young's Modulus)

Bqs-Gi ¸YvsK wbY‡qi Rb¨ cavbZ `yB c×wZ Av‡Q|

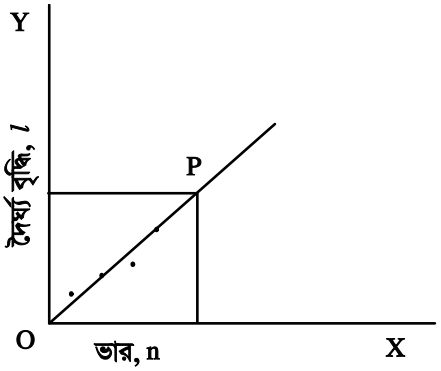
1. fwbqvi c×wZ (Vernier Method)
2. mwji c×wZ (Searle's Method)

1. fwbqvi c×wZ (Vernier Method)

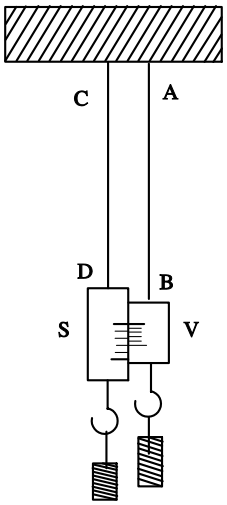
Avgiv Rwb,

$$\text{Bqs-Gi ¸YvsK } Y = \frac{F/A}{\ell/L} = \frac{F\times L}{A\times \ell} = \frac{mg\times L}{\pi r^2\times \ell}$$

GLv‡b, F = Zv‡ii chy³ ej
m = Zv‡ii gy³ cv‡š Sjzv‡bv fi,
g = AwfKlxq Zi¶,
L = Zv‡ii Aww` ^`N¨
ℓ = Zv‡ii ‰`N¨ ewn×,
A = πr^2 = Zv‡ii c¯‡”Q‡`i †¶Îdj,
r = Zv‡ii e¨vmva,



wPÎ 9-9 (K)



wPÎ : 9-9 (L)

h‡ši eYbv : *†h c`v‡_i Bqs-Gi ¸YvsK wbYq Ki‡Z n‡e †m c`v‡_i ^Zix mgq-^`N¨ I mge¨v‡mi `ywU Zvi* AB *I* CD *GKwU `p Aej¤^b †_‡K Sz‡j v‡bv _v‡K (wPÎ 9-9 K)| |* AB *cix¶vaxb I* CD *mnvqK Zvi| |* CD*-Gi mv‡_ cavb †¯‹j* ÔS' *Ges* AB*-Gi mv‡_ fwbqvi †¯‹j* Ô**V**Õ *Ggbfv‡e AvUKv‡bv _v‡K †hb fwbqvi †¯‹jwU gj‡¤ †¯‹‡j i Mv †e‡q evavnxbfv‡e DVvbvgv Ki‡Z cv‡i| |* AB *I* CD *Zv‡i GKwU K‡i ûK jvMv‡bv Av‡Q| Uvb Uvb K‡i ivLvi Rb¨* CD *Zv‡ii û‡K GKwU IRb Ges* AB *Zv‡ii û‡KI GKwU w¯‹i IRb Sz‡j v‡bv nq|*

Kvh c×wZ

L wbYq : *wgUvi †¯‹‡j i mvnv‡h¨ cix¶vaxb Zv‡ii Sz‡j b we›`yn‡Z fwbqvi †¯‹‡j i kb¨ `vM chš †g‡c Aww` ^`N¨* L *wbYq Kiv nq|*

r wbYq : *¯‹zM‡Ri mvnv‡h¨ cix¶vaxb Zv‡ii wewfb ¯‹v‡bi e¨vm cwigvc Kiv nq| Gfv‡e cwPwU cvV ‡bqv nq| Gevi cvV¸‡jvi Mo †ei K‡i Mo e¨vm wbYq Kiv nq| G Mo e¨v‡mi A‡aKB n‡jv e¨vmva* r.

Amnfvi wbYq : Zv‡ii c¯‹‡"Q‡`i i †¶Îdj wbYq Kwi| Zv‡ii c¯‹‡"Q‡`i i †¶Îdj‡K Zv‡ii Amn-cxob w`‡q ¸Y Ki‡j Amn-fvi cvIqv hv‡e| G Amnfv‡ii A‡aK ev Zvi I Kg fvi AB *Zv‡i Pwc‡q cix¶vi KvR mgvav Kiv nq| Gi d‡j Zviwu w¯‹Z¯vcK mxgvi g‡a¨ _v‡K|*

**fvi I ^`N¨ e„ô wbYq t** *c_‡g gj‡¤ †¯‹j I fwbqvi †¯‹‡j i cvV wbB| Gici* AB *Zv‡i Aa wK‡jvMvg IR‡bi fvi PvcvB Ges cavb †¯‹j I fwbqvi †¯‹‡j i cvV wb‡q ^`N¨-e„ô wbYq Kwi| Gfv‡e cici K‡qKevi Aa wK‡jvMvg K‡i fvi e„ô K‡i ^`N¨-e„ô wbYq Kwi| AZ:ci GKwU GKwU K‡i Aawk‡jvMvg fvi bwg‡q c‡ei b¨vq cavb I fwbqvi †¯‹‡j i cvV ‡bIqv nq| Gici cwZwU fv‡ii Rb¨ G `ywU cv‡Vi Mo †_‡K Zv‡ii ^`N¨-e„ô †ei Kwi|*

†jLwPÎ AsKb : X *A¶ eivei fi* m *Ges* Y *A¶ eivei ^`N¨-e„ô ℓ wb‡q †jLwPÎ AsKb Ki‡j gj‡¤ we›`ywgx GKwU mij‡iLv cvIqv hv‡e (wPÎ 9-10 (L)| |†jLwP‡Îi Dci GKwU we›`yÕ n‡Z* X *I* Y*-A‡¶i Dci j¤^ †U‡b ℓ Ges* m *Gi gvb wbYq|*

djvdj t *mgxKiY* $Y = \frac{mgL}{\pi r^2 \ell}$ *-G* m,L,g,ℓ,r *Gi gvb ewm‡q* Y *Gi gvb wbYq Kwi Kwi|*

D`vniY 2

1 *eM wg:wg: cK‡"Q` wewkó GKwU Zv‡i 20 wK‡jwgUvi fi Sz‡j v‡bv Ae¯v Zv‡ii ^`N¨ 600 †mwg: nq| fiwU mwi‡q wb‡j Zviwui ^`N¨ 599.5 †mwg: nq ev 0-5 †mwg: cwigvc msKwPZ nq| Zv‡ii Bqs-Gi w¯‹Z¯vcK ¸YvsK ewni Ki|*

9.4.2 B¯úvZ ivev‡ii †P‡q †ewk w¯‹Z¯vcK

(Steel is more Elastic than Rubber)

g‡b Kwi, GKwU B¯úvZ I ivevi Dfq Zv‡ii ^`N¨* L *Ges c¯‹"Q‡`i i †¶Îdj A*| Zvi `ywi GK cvš GKwU `p e¯‹zZ AvUwK‡q Aci cv‡š ej* F *c‡qvM Kiv nq| G‡Z G‡`i ^`N¨ e„ô h_vµ‡g* ℓ_s *I* ℓ_r *n‡jv|*

AZGe, B¯úv‡Zi Bqs-Gi ¸YvsK $Y_S = \frac{F/A}{\ell_S/L} = \frac{FL}{A\ell_S}$ .... (1)

Ges ivev‡ii Bqs-Gi ¸YvsK $Y_r = \frac{F/A}{\ell_r/L} = \frac{FL}{A\ell_r}$ .... (2)

mgxKiY (1) †K (2) Øviv fvM K‡i cvB -

$$\frac{Y_S}{Y_r} = \frac{FL}{A\ell_S} \times \frac{A\ell_r}{FL} = \frac{\ell_r}{\ell_S}$$

wKšzivev‡ii ^`N¨ ew,× $\ell_r$> B¯úv‡Zi ^`N¨ ew,× ℓ_S

AZGe $Y_S > Y_r$

Avgiv Rwb, th c`v‡_i w¯wZ¯vcK ¸YvsK †ewk †m c`v_ †ewk w¯wZ¯vcK, A_vr B¯úvZ ivevi A‡c¶v †ewk w¯wZ¯vcK|

w¯wZ¯vcK ¸YvsK
ZwjKv

e¯	Bqs-¸YvsK (Nm^{-2})	`pZv ¸YvsK (Nm^{-2})	AvqZb ¸YvsK (Nm^{-2})	cqm‡bi AYgvZv σ
A¨vjvgwbqvg	7×10^{10}	2.5×10^{10}	7.5×10^{10}	0.34
Zvgv	12.3×10^{10}	4.2×10^{10}	13.1×10^{10}	0.33
†jvnv (Zvi)	2.2×10^{10}	5.1×10^{10}	9.6×10^{10}	0.26
B¯úvZ	-	8.9×10^{10}	16×10^{10}	0.28
i¡cv	-	2.8×10^{10}	10.9×10^{10}	0.37
cwb	7.8×10^{10}	-	0.2×10^{10}	-
cvi`	-	-	2.6×10^{10}	-

c‡kvËi gj¨vqb

K. mwVK DË‡i i cv‡k wUK wPý (√) w`b|

1. wb‡Pi †Kvb c`v_wU ‡ewk w¯wZ¯vcK ?

   K. ivevi L. †jvnv

   M. B¯úvZ N. A¨vjyg bqvg

L. msw¶ß ck

1. Bqs-Gi ¸YvsK wbY‡qi Rb¨ e¨eüZ `ywU c×wZi bvg wjLyb
2. B¯úvZ ivev‡i i †P‡q †ewk w¯wZ¯vcK, e¨vL¨v Ki“b|

iPbvgj¨K ck

1. Avš:AvYweK ej ej‡Z wK e‡Sb? G e‡j i cKwZ. †Kgb? G e‡j i cKwZ. †_‡K w¯wZ¯vcKZv, w¯wZ¯vcK mxgv I û‡Ki m‡e e¨vL¨v Ki“b|
2. wewfb cKvi weKwZi bvg wjLyb I e¨vL¨v Ki“b|
3. wewfb cKvi cxo‡bi bvg wjLyb I e¨vL¨v Ki“b|
4. û‡Ki m‡EwU e¨vL¨v Ki“b|
5. w¯wZ¯vcKZvi wewfb ¸Yvs‡Ki msÁv wjLyb|
6. e¯‘i weKwZi Rb¨ m¤úvw`Z Kv‡Ri iwkgvjv wbYq Ki“b Ges G †_‡K cgvY Ki“b, w¯wZk³ = $\frac{1}{2}$ × cxob × weKwZ.
7. Bqs-Gi ¸YvsK wbY‡qi fwbqvi c×wZwU eYbv Ki“b|