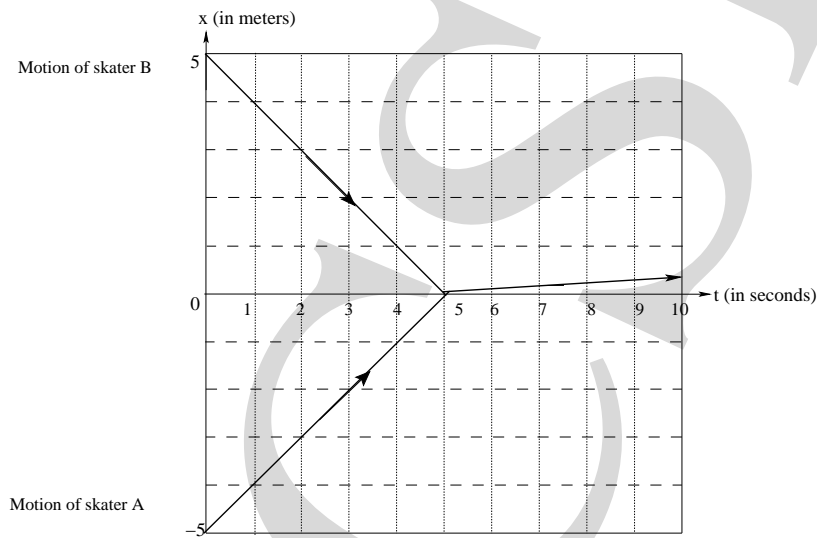


Solutions Indian National Physics Olympiad - 2010

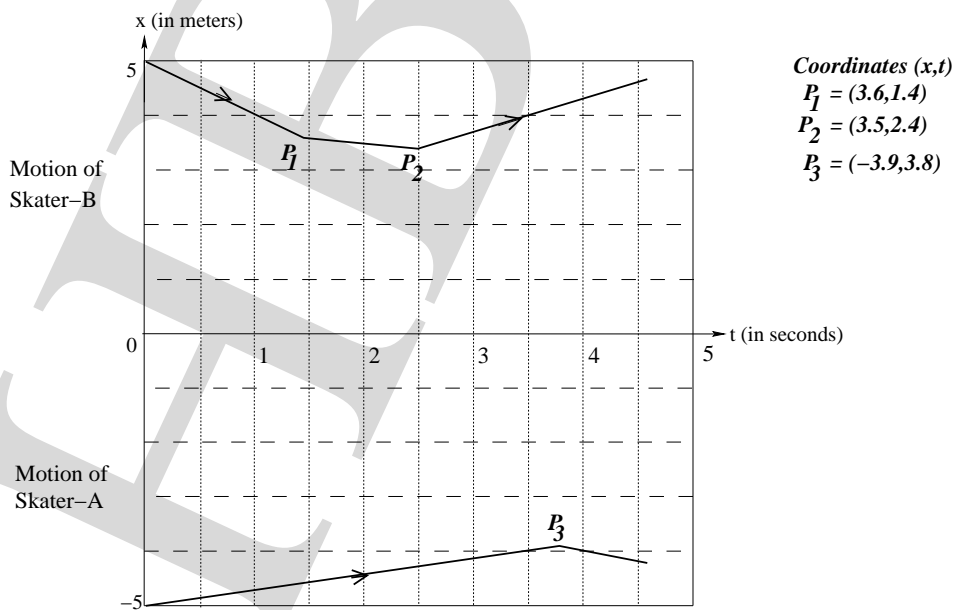
Please note that equivalent methods/solutions may exist.

PART - A

1. (a) $\vec{P}_A = 80 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$, also acceptable $\vec{P}_A = 70 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$;
 $\vec{P}_B = -70 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$
- (b) $\vec{P}_A = 20 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$;
 $\vec{P}_B = -10 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$, also acceptable $\vec{P}_B = -70/8 \hat{i} \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$
- (c) Number of tosses by A = 1 ; Number of tosses by B = 1
- (d) See Fig. (1).



- (e) See Fig. (2).



2. (a) $P_1 = \frac{243}{32}P_0$; $P_2 = \frac{243}{32}P_0$; $P_3 = \frac{243}{32}P_0$

$V_1 = \frac{65}{27}V_0$; $V_2 = \frac{8}{27}V_0$; $V_3 = \frac{8}{27}V_0$

$T_1 = \frac{585}{32}T_0$; $T_1 = \frac{9}{4}T_0$; $T_1 = \frac{9}{4}T_0$

(b) Work done = $\frac{15}{4}P_0V_0$

(c) Heat supplied = $\frac{1899}{64}P_0V_0$

(d) Entropy change in $A_2 + A_3 = 0$

Entropy change in $A_1 = \frac{3R}{2} \ln \frac{585}{32} + R \ln \frac{65}{27}$

3. (a) $A_F = 4.76^\circ$

(b) $\Delta_D = -2.1^\circ$

(c) See Fig. (3). Note that all angles are expressed in degrees.

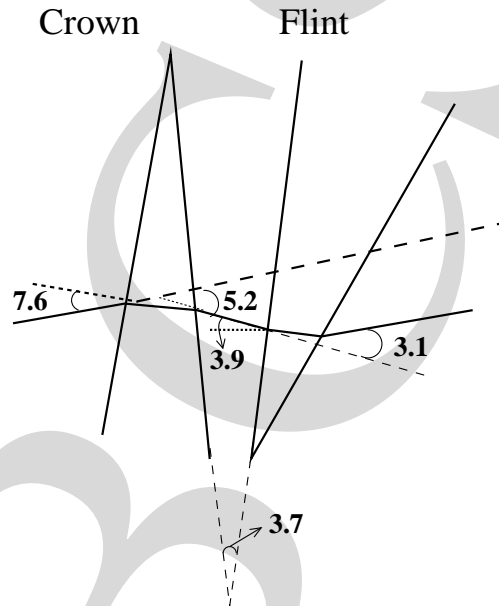


Figure 3:

4. (a) $\alpha = \frac{mgR}{I + mR^2}$

(b) $\omega = \sqrt{\frac{2\alpha H}{R}}$

(c) $K = mgH$

(d) $\vec{B} = \frac{\mu_0}{2\pi} \frac{Q\omega'}{l} \hat{i}$ for $r < R$

$= 0$ for $r > R$

(e) $E = \frac{\mu_0 QR^2 \alpha'}{4\pi lr}$ for $r \geq R$

$= \frac{\mu_0 Qr \alpha'}{4\pi l}$ for $r < R$

(f) $\tau_{em} = QER$

(g) $\alpha' = \frac{mgR}{I + mR^2 + \frac{\mu_0 Q^2 R^2}{4\pi l}}$

(h) $K' = \frac{mgH(I + mR^2)}{I + mR^2 + \frac{\mu_0 Q^2 R^2}{4\pi l}}$

(i) $K' - K = -\frac{B^2}{2\mu_0} \pi R^2 l$

(j) Some possible interpretations are

i. It is the magnetic energy stored in shell.

magnetic energy = magnetic energy density ($B^2/2\mu_0$) \times Volume ($\pi R^2 l$)
and/or

ii. It is the self inductance energy ($1/2 Li^2$) of the system.
and/or

iii. Poynting vector argument can also show that it is magnetic energy.

$$(2\pi Rl) \left(\frac{1}{\mu_0} \int \vec{E} \times \vec{B} dt \right) = K' - K = \frac{-B^2 \pi R^2 l}{2\mu_0}$$

5. (a) $\lambda_k = 0.12 \text{ hr}^{-1}$

(b) $A = 3.70 \times 10^4 \text{ s}^{-1}$, also acceptable $A = 2.62 \times 10^4 \text{ s}^{-1}$.

(c) 5.0 liters

PART - B

- | | |
|-------|-------|
| 1. b | 11. e |
| 2. e | 12. e |
| 3. d | 13. b |
| 4. d | 14. e |
| 5. e | 15. d |
| 6. d | 16. c |
| 7. a | 17. c |
| 8. c | 18. d |
| 9. b | 19. c |
| 10. c | 20. a |

