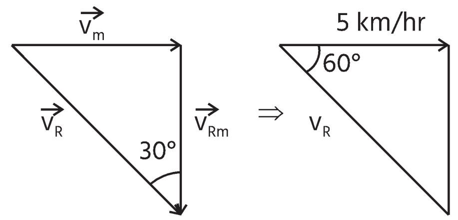
1. $s = u \times t$ ...(i)

and $s = (u+20)\left(\frac{80}{100}t\right)$

$\Rightarrow (u+20)\left(\frac{80}{100}t\right) = u \times t \Rightarrow 4u + 80 = 5u$

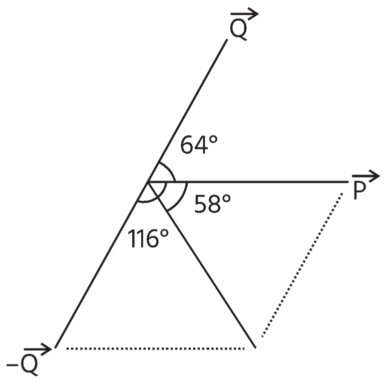
$\Rightarrow u = 80$ m/s

2. The velocity triangle will be



$v_R \cos 60^\circ = 5\text{km/hr} \Rightarrow v_R = \frac{5}{1} = 10\text{km/hr}$

3. $a = v\frac{dv}{dx}$

4. 

Angle between $\vec{P}$ and $\vec{P} - \vec{Q}$ is

$90^\circ - \frac{\theta}{2} = 90^\circ - 32^\circ = 58^\circ$

5. In vertical direction

$\vec{v}_{RM} = \vec{v}_{RW} - \vec{v}_M \Rightarrow \vec{v}_{RM} = (-b\hat{k} + 2\hat{j}) - \vec{v}_M$

$-b\hat{k} = -b\hat{k} + 2\hat{j} - \vec{v}_M \Rightarrow \vec{v}_M = (2\hat{j})\text{m/s}$

6. $s = u + \frac{1}{2}a(2n-1) \Rightarrow 21 = \frac{1}{2}a(2\times 4 - 1)$

$a = 6\text{m/s}^2$

7. $\ell = ct^2; 2000 = c \times 10^2; c = 20\text{m/s}^2$

$v = \frac{d\ell}{dt} = 2ct = 2 \times 20 \times 10 = 400\text{m/s}$

8. At highest point v is perpendicular to g.

9. $T = 2\pi\sqrt{\frac{R^3}{GM}} \Rightarrow T = 2\pi\sqrt{\frac{R^3}{G \times \frac{4}{3}\pi R^3 \rho}}$

$T^2 = 4\pi^2 \frac{3}{4\pi G\rho} \Rightarrow T^2\rho = \frac{3\pi}{G}$

10. $\mu mg\cos\theta = mg\sin\theta \Rightarrow \mu = \tan\theta$

11. $[U] = [ML^2T^{-2}]$, $[B] = [x] = [L]$

$[A] = \frac{[ML^2T^{-2}][L]}{[L^{1/2}]} = [ML^{5/2}T^{-2}]$

hence $[AB] = [ML^{7/2}T^{-2}]$

12. 5, 1, 2

13. $a = \mu g = 2\text{m/s}^2 \Rightarrow v = u + at$

$4 = 2 \times t \Rightarrow t = 2\text{ s} \Rightarrow s = \frac{1}{2}at^2 = \frac{1}{2} \times 2 \times 2^2 = 4\text{m}$

14. Angle of repose : $\tan\theta = \mu$

In both cases objects at static equilibrium.

Frictional force acting = Weight component down the plane

$f_1 = 40g\sin 30^\circ \Rightarrow \frac{f_1}{f_2} = \frac{\sin 30^\circ}{\sin 37^\circ} = \frac{5}{6} \Rightarrow f_2 = 40g\sin 37^\circ$

15. $a = \frac{10\times 10 - 10 \times 10 \times 0.4}{10+10} = 3\text{m/s}^2$

16. Given $\theta = 2t^3 - 3t_2 - 4t - 5$

$\omega = \frac{d\theta}{dt} = 6t^2 - 6t - 4 \Rightarrow \alpha = \frac{d\omega}{dt} = 12t - 6$

Now, $\alpha|_{t=1s} = 12(1) - 6 = 6\text{rad/s}^2$

17. $t = \frac{\omega_f - \omega_i}{\alpha} = \frac{22 - [-18]}{2} = \frac{40}{2} = 20\text{s}$

18. $v \propto x^{1/3}$

19. $x = \frac{t^3}{3} + \frac{t^4}{4}$; $v = \frac{dx}{dt} = t^2 + t^3$

$w = \Delta K = \frac{1}{2}m[v_2^2 - v_0^2]$

$= \frac{1}{2} \times 5[(12)^2 - 0] = 360\text{J}$

20. At equilibrium $\frac{\partial U}{\partial x}=0 \Rightarrow \frac{12a}{x^{13}}=\frac{6b}{x^7}$

$x^6=\frac{2a}{b}$

21. $x = 2t^4 + 5$; $v = 8t^3$

$v_f = 8$

$k_f = 1/2\, mv^2 = 1/2 \times 2 \times (8)^2 = 64J$

22. $\text{Power}=\frac{\text{total energy}}{\text{Ttme}}=\frac{mgh+\frac{1}{2}mv^2}{t}$

$=10\times10\times20+\frac{1}{2}\times10\times10^2=2000+\frac{1000}{2}$

$= 2500 = 2.5$ kW

23. $\vec{F}=F$ (unit vector along $6\hat{i}-2\hat{k}+3\hat{j}$))

$=F\left[\frac{6\hat{i}+3\hat{j}-2\hat{k}}{\sqrt{36+9+4}}\right]=\frac{F}{7}\left(6\hat{i}+3\hat{j}-2\hat{k}\right)$

Displacement of particle

$\vec{S}=(1-2)\hat{i}+(4-1)\hat{j}+(-1-0)\hat{k}=-\hat{i}+3\hat{j}-\hat{k}$

$\therefore \vec{F}\cdot\vec{S}=5$

$\Rightarrow\frac{F}{7}\left(6\hat{i}+3\hat{j}-2\hat{k}\right)\cdot\left(-\hat{i}+3\hat{j}-\hat{k}\right)=5$

$\Rightarrow\frac{F}{7}(-6+9+2)=5\Rightarrow\frac{F}{7}(5)=5\Rightarrow F=7N$

24. At $X=8, K=30J, U=40+(8-6)^2$

Total energy $E=30+44$

For K_{max} ,U is min

$E = K_{max} + U_{min} \Rightarrow K_{max} = 34J$

25. Horizontal component of velocity of projection

$u_x=u\cos30^\circ=\frac{\sqrt{3}}{2}u=\frac{\sqrt{3}}{2}\times100=50\sqrt{3}m/s$

$\therefore P_i=mu_x=50\sqrt{3}m$ (along horizontal direction) at highest point

$P_f = P_i$ ($\because$ Two pieces will be in opposite direction with same velocity)

$\therefore \frac{m}{3}v_3=50\sqrt{3}m$

$v_3=150\sqrt{3}$ = 150 × 1.732

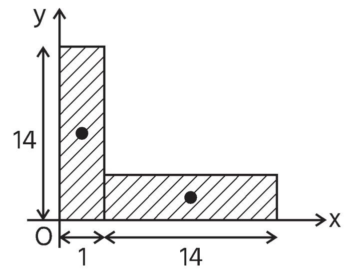
=259.8 ≈ 260 m/s in horizontal direction

26. $X_{cm}=\frac{m_1x_1+m_2x_2}{m_1+m_2}=\frac{16\sigma\times1+12\sigma\times5}{16\sigma+12\sigma}=\frac{19}{7}$

X_{cm} = 2.7 m from O

27. $y_c=\frac{m\times7+m\times\frac{1}{2}}{2m}=\frac{15}{4}cm$

$x_c=\frac{m\times8+m\times0.5}{2m}=\frac{17}{4}cm$



28. $J=mv_2$ $p-J=mV_1$

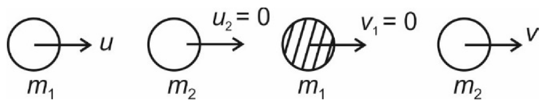
$e=\frac{v_2-v_1}{u}=\frac{mv_2-mv_1}{mu}=\frac{J-(p-J)}{p}$

$e=\frac{2J}{p}-1\Rightarrow J=0.9p$

29. $F=\frac{m\Delta v}{t}=\frac{5\times10^{-3}\times\sqrt{2}\times2}{0.02}=\frac{1}{\sqrt{2}}N$

30. $m_1\Delta x_1=m_2\Delta x_2$

$\Delta x_1+\Delta x_2=6$ $\therefore \Delta x_2=1m$

31. 

By conservation of linear momentum

$m_1u+m_2(0)=m_1(0)+m_2v$

$v=\frac{m_1u}{m_2}$

Coefficient of restitution

$=\frac{VOS}{VOA}=\frac{v-0}{u-0}=\frac{\left(\frac{m_1u}{m_2}\right)}{u}=\frac{m_1}{m_2}$

32. $I_{cm}+MR^2$

$MK^2=\frac{2}{3}MR^2+MR^2=\frac{5}{3}MR^2$

$\Rightarrow \frac{K^2}{R^2} = \frac{5}{3} \Rightarrow K = \sqrt{\frac{5}{3}}R$

33. Apply law of conservation of angular momentum.

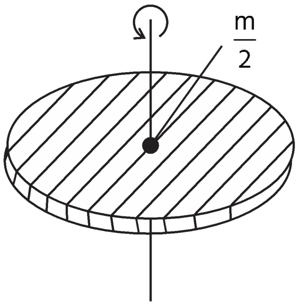
$mv_1 d_1 = mv_2 d_2$

$v_2 = \frac{v_1 d_1}{d_2}$

34. Ratio $= \frac{\frac{1}{2}I\omega^2}{\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2} = \frac{1}{1+\frac{R^2}{K^2}} = \frac{2}{5}$

35. $\ell = ma^2 + m\left(\frac{a}{2}\right)^2 = \frac{5ma^2}{4}$.

36. $I = 2\times\frac{1}{3}m\ell^2 + m\ell^2 = \frac{5}{3}m\ell^2 = \frac{5}{3}kgm^2$

37. 

As no external torque acts so angular momentum of system remains constant

$I_1\omega_1 = I_2\omega_2$

$\frac{1}{2}mR^2\omega = \left(\frac{1}{2}mR^2 + m\times 0\right)\omega'$

$\omega' = \omega$

38. According to law of conservation of angular momentum,

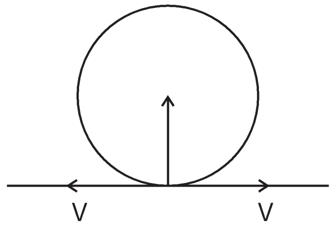
$I\omega$ = constant

or $\frac{R^2}{T}$ = constant ($\because I \propto R^2$ and $\omega \propto \frac{1}{T}$ and $I \propto \frac{1}{\omega}$)

$\therefore T \propto R^2$

As, $R' = \frac{1}{n}R \Rightarrow \frac{T}{T'} = \left(\frac{R}{R'}\right)^2 \Rightarrow \frac{T}{T'} = \left(\frac{R\times n}{R}\right)^2$

$\therefore T' = \frac{T}{n^2} = \frac{24}{n^2}h$

39. 

$a_A = \frac{V^2}{R}$; $V_A = V\hat{i} - V\hat{i} =$ Zero

40. KE = |–total energy|

$\frac{1}{2}mv^2 = E \therefore v = \sqrt{\frac{2E}{m}}$

$\therefore$ Angular momentum

$L = mvr = m\sqrt{\frac{2E}{m}r^2} = \sqrt{2Emr^2}$

41. Gravitational potential energy

$U = + m_0$. potential at origin

$= +m_0 \cdot \left(-\frac{GM}{R}\right) = -\frac{GMm_0}{R}$

42. Time taken will be minimum when it travels from $\frac{-A}{2}$ to $\frac{A}{2}$ because of more average speed.

So, $t = \frac{T}{12} + \frac{T}{12} = \frac{T}{6} = 2s$

43. $v^2 = \omega^2 A^2 - \omega^2 x^2$

$y = c - mx \rightarrow$ straight line.

44. Suppose the length of the parts are l_1 and l_2 then

$l_1 = 3l_2$ $\quad l_1 + l_2 = l$

$l_2 = \frac{l}{4}, l_1 = \frac{3l}{4}$ $\quad \therefore k_1 = \frac{k}{3/4} = \frac{4k}{3}$

$k_2 = \frac{k}{1/4} = 4k$

45. $mR\omega^2 = \frac{GMm}{R^2}$; $\quad R^3\left(\frac{2\pi}{T}\right)^2 = G\left(\frac{4}{3}\pi R_s^3\right)\rho_s$

$\rho_s = \frac{4\pi^2 R^3}{T^2 G\frac{4}{3}\pi R_s^3} = \frac{3\pi R^3}{GT^2 R_s^3}$

Answer-Key

1.	4	**2.**	2	**3.**	2	**4.**	2	**5.**	2	**6.**	4	**7.**	4	**8.**	1	**9.**	1	**10.**	4
11.	2	**12.**	1	**13.**	4	**14.**	3	**15.**	3	**16.**	3	**17.**	2	**18.**	4	**19.**	4	**20.**	2
21.	4	**22.**	2	**23.**	2	**24.**	2	**25.**	4	**26.**	2	**27.**	4	**28.**	3	**29.**	3	**30.**	4
31.	1	**32.**	4	**33.**	2	**34.**	1	**35.**	4	**36.**	2	**37.**	1	**38.**	2	**39.**	4	**40.**	1
41.	1	**42.**	2	**43.**	2	**44.**	2	**45.**	1	**46.**	3	**47.**	1	**48.**	4	**49.**	4	**50.**	1
51.	2	**52.**	4	**53.**	3	**54.**	3	**55.**	3	**56.**	4	**57.**	4	**58.**	3	**59.**	1	**60.**	3
61.	4	**62.**	1	**63.**	3	**64.**	3	**65.**	4	**66.**	3	**67.**	1	**68.**	4	**69.**	3	**70.**	4
71.	2	**72.**	4	**73.**	2	**74.**	2	**75.**	3	**76.**	3	**77.**	1	**78.**	3	**79.**	2	**80.**	1
81.	3	**82.**	3	**83.**	1	**84.**	4	**85.**	2	**86.**	2	**87.**	3	**88.**	1	**89.**	1	**90.**	2
91.	3	**92.**	1	**93.**	4	**94.**	3	**95.**	3	**96.**	1	**97.**	3	**98.**	3	**99.**	2	**100.**	3
101.	4	**102.**	2	**103.**	4	**104.**	3	**105.**	2	**106.**	3	**107.**	3	**108.**	3	**109.**	4	**110.**	3
111.	1	**112.**	2	**113.**	2	**114.**	4	**115.**	4	**116.**	2	**117.**	1	**118.**	4	**119.**	3	**120.**	1
121.	2	**122.**	2	**123.**	1	**124.**	1	**125.**	2	**126.**	1	**127.**	3	**128.**	2	**129.**	2	**130.**	4
131.	3	**132.**	3	**133.**	4	**134.**	3	**135.**	4	**136.**	4	**137.**	2	**138.**	4	**139.**	4	**140.**	2
141.	4	**142.**	3	**143.**	1	**144.**	4	**145.**	1	**146.**	3	**147.**	4	**148.**	4	**149.**	3	**150.**	3
151.	1	**152.**	4	**153.**	3	**154.**	4	**155.**	4	**156.**	2	**157.**	2	**158.**	3	**159.**	4	**160.**	4
161.	3	**162.**	2	**163.**	4	**164.**	2	**165.**	3	**166.**	2	**167.**	3	**168.**	3	**169.**	3	**170.**	1
171.	3	**172.**	1	**173.**	3	**174.**	1	**175.**	1	**176.**	4	**177.**	3	**178.**	4	**179.**	4	**180.**	2

1. $\mu mg\cos\theta = mg\sin\theta \Rightarrow \mu = \tan\theta$

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hence $[AB] = [ML^{7/2}T^{-2}]$

3. 5, 1, 2

4. $t = \frac{\omega_f - \omega_i}{\alpha} = \frac{22-[-18]}{2} = \frac{40}{2} = 20s$

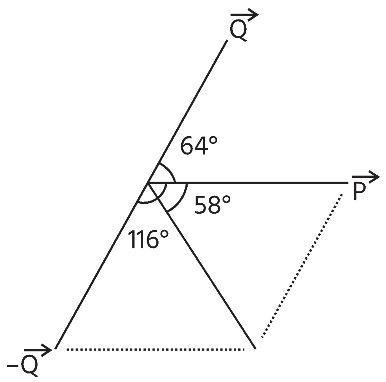
5. $v \propto x^{1/3}$

6. $x = \frac{t^3}{3} + \frac{t^4}{4}$; $\quad v = \frac{dx}{dt} = t^2 + t^3$

$$w = \Delta K = \frac{1}{2}m\left[v_2^2 - v_0^2\right]$$

$$= \frac{1}{2}\times 5\left[(12)^2 - 0\right] = 360J$$

7. $a = v\frac{dv}{dx}$

8. 

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Total energy $E = 30 + 44$

For K_{max}, U is min

$E = K_{max} + U_{min} \Rightarrow K_{max} = 34J$

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at highest point

$P_f = P_i$ $\quad$ ($\because$ Two pieces will be in opposite direction with same velocity)

$\therefore \frac{m}{3}v_3 = 50\sqrt{3}m$

$v_3 = 150\sqrt{3} = 150 \times 1.732$

$=259.8 \approx 260$ m/s in horizontal direction

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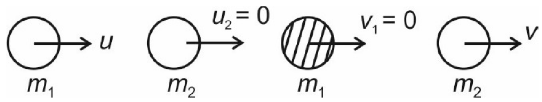
13. 

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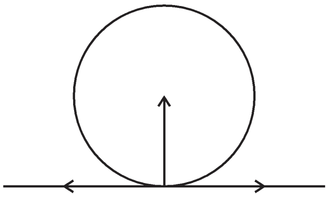
17. 

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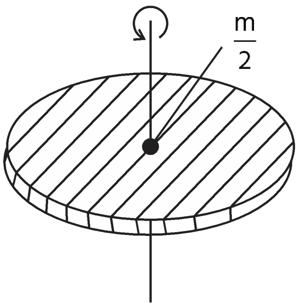
20. $I = 2 \times \frac{1}{3}m\ell^2 + m\ell^2 = \frac{5}{3}m\ell^2 = \frac{5}{3}kgm^2$

21. 

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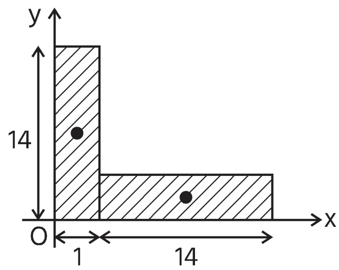
y = c – mx $\rightarrow$ straight line.

25. $y_c = \frac{m \times 7 + m \times \frac{1}{2}}{2m} = \frac{15}{4}cm$

$x_c = \frac{m \times 8 + m \times 0.5}{2m} = \frac{17}{4}cm$



26. $J = mv_2$ $p - J = mV_1$

$e = \frac{v_2 - v_1}{u} = \frac{mv_2 - mv_1}{mu} = \frac{J - (p - J)}{p}$

$e = \frac{2J}{p} - 1 \Rightarrow J = 0.9p$

27. $F = \frac{m\Delta v}{t} = \frac{5 \times 10^{-3} \times \sqrt{2} \times 2}{0.02} = \frac{1}{\sqrt{2}}N$

28. $m_1\Delta x_1 = m_2\Delta x_2$

$\Delta x_1 + \Delta x_2 = 6$ $\therefore \Delta x_2 = 1m$

29. At equilibrium $\frac{\partial U}{\partial x} = 0 \Rightarrow \frac{12a}{x^{13}} = \frac{6b}{x^7}$

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$k_f = 1/2\ mv^2 = 1/2 \times 2 \times (8)^2 = 64J$

31. $\text{Power} = \dfrac{\text{total energy}}{\text{Ttme}} = \dfrac{mgh + \frac{1}{2}mv^2}{t}$

$= 10 \times 10 \times 20 + \dfrac{1}{2} \times 10 \times 10^2 = 2000 + \dfrac{1000}{2}$

$= 2500 = 2.5$ kW

32. $\vec{F} = F$ (unit vector along $6\hat{i} - 2\hat{k} + 3\hat{j}$))

$= F\left[\dfrac{6\hat{i} + 3\hat{j} - 2\hat{k}}{\sqrt{36+9+4}}\right] = \dfrac{F}{7}\left(6\hat{i} + 3\hat{j} - 2\hat{k}\right)$

Displacement of particle

$\vec{S} = (1-2)\hat{i} + (4-1)\hat{j} + (-1-0)\hat{k} = -\hat{i} + 3\hat{j} - \hat{k}$

$\therefore \vec{F} \cdot \vec{S} = 5$

$\Rightarrow \dfrac{F}{7}\left(6\hat{i} + 3\hat{j} - 2\hat{k}\right) \cdot \left(-\hat{i} + 3\hat{j} - \hat{k}\right) = 5$

$\Rightarrow \dfrac{F}{7}(-6+9+2) = 5 \Rightarrow \dfrac{F}{7}(5) = 5 \Rightarrow F = 7N$

33. Ratio $= \dfrac{\frac{1}{2} I\omega^2}{\frac{1}{2} I\omega^2 + \frac{1}{2}mv^2} = \dfrac{1}{1 + \frac{R^2}{K^2}} = \dfrac{2}{5}$

34. Suppose the length of the parts are l_1 and l_2 then

$l_1 = 3l_2$ $\quad$ $l_1 + l_2 = l$

$l_2 = \dfrac{l}{4}, l_1 = \dfrac{3l}{4}$ $\quad$ $\therefore k_1 = \dfrac{k}{3/4} = \dfrac{4k}{3}$

$k_2 = \dfrac{k}{1/4} = 4k$

35. $mR\omega^2 = \dfrac{GMm}{R^2}$; $\quad R^3\left(\dfrac{2\pi}{T}\right)^2 = G\left(\dfrac{4}{3}\pi R_s^3\right)\rho_s$

$\rho_s = \dfrac{4\pi^2 R^3}{T^2 G \frac{4}{3}\pi R_s^3} = \dfrac{3\pi R^3}{GT^2 R_s^3}$

36. $a = \mu g = 2m/s^2 \Rightarrow v = u + at$

$4 = 2 \times t \Rightarrow t = 2\ s \Rightarrow s = \dfrac{1}{2}at^2 = \dfrac{1}{2} \times 2 \times 2^2 = 4m$

37. Angle of repose : $\tan\theta = \mu$

In both cases objects at static equilibrium.

Frictional force acting = Weight component down the plane

$f_1 = 40g\sin 30^\circ \Rightarrow \dfrac{f_1}{f_2} = \dfrac{\sin 30^\circ}{\sin 37^\circ} = \dfrac{5}{6} \Rightarrow f_2 = 40g\sin 37^\circ$

38. $a = \dfrac{10 \times 10 - 10 \times 10 \times 0.4}{10 + 10} = 3m/s^2$

39. Given $\theta = 2t^3 - 3t_2 - 4t - 5$

$\omega = \dfrac{d\theta}{dt} = 6t^2 - 6t - 4 \Rightarrow \alpha = \dfrac{d\omega}{dt} = 12t - 6$

Now, $\alpha\big|_{t=1s} = 12(1) - 6 = 6 rad/s^2$

40. $s = u + \dfrac{1}{2}a(2n-1) \Rightarrow 21 = \dfrac{1}{2}a(2 \times 4 - 1)$

$a = 6m/s^2$

41. $\ell = ct^2; 2000 = c \times 10^2; c = 20m/s^2$

$v = \dfrac{d\ell}{dt} = 2ct = 2 \times 20 \times 10 = 400m/s$

42. At highest point v is perpendicular to g.

43. $T = 2\pi\sqrt{\dfrac{R^3}{GM}} \Rightarrow T = 2\pi\sqrt{\dfrac{R^3}{G \times \frac{4}{3}\pi R^3 \rho}}$

$T^2 = 4\pi^2 \dfrac{3}{4\pi G\rho} \Rightarrow T^2\rho = \dfrac{3\pi}{G}$

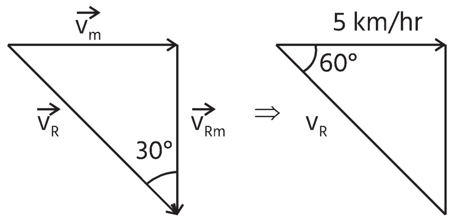
44. s = u × t ...(i)

and $s = (u+20)\left(\dfrac{80}{100}t\right)$

$\Rightarrow (u+20)\left(\dfrac{80}{100}t\right) = u \times t \Rightarrow 4u + 80 = 5u$

$\Rightarrow u = 80$ m/s

45. The velocity triangle will be



$v_R \cos 60^\circ = 5km/hr \Rightarrow v_R = \dfrac{5}{1} = 10km/hr$

Answer-Key

1.	4	**2.**	2	**3.**	1	**4.**	2	**5.**	4	**6.**	4	**7.**	2	**8.**	2	**9.**	2	**10.**	2
11.	4	**12.**	2	**13.**	1	**14.**	4	**15.**	2	**16.**	2	**17.**	4	**18.**	1	**19.**	4	**20.**	2
21.	1	**22.**	1	**23.**	2	**24.**	2	**25.**	4	**26.**	3	**27.**	3	**28.**	4	**29.**	2	**30.**	4
31.	2	**32.**	2	**33.**	1	**34.**	2	**35.**	1	**36.**	4	**37.**	3	**38.**	3	**39.**	3	**40.**	4
41.	4	**42.**	1	**43.**	1	**44.**	4	**45.**	2	**46.**	3	**47.**	3	**48.**	3	**49.**	3	**50.**	3
51.	4	**52.**	4	**53.**	2	**54.**	4	**55.**	2	**56.**	1	**57.**	3	**58.**	3	**59.**	2	**60.**	3
61.	1	**62.**	1	**63.**	4	**64.**	2	**65.**	1	**66.**	3	**67.**	2	**68.**	3	**69.**	1	**70.**	4
71.	4	**72.**	3	**73.**	1	**74.**	1	**75.**	2	**76.**	4	**77.**	3	**78.**	4	**79.**	1	**80.**	1
81.	2	**82.**	2	**83.**	3	**84.**	3	**85.**	3	**86.**	4	**87.**	3	**88.**	1	**89.**	4	**90.**	4
91.	3	**92.**	4	**93.**	2	**94.**	3	**95.**	3	**96.**	3	**97.**	2	**98.**	2	**99.**	4	**100.**	4
101.	3	**102.**	1	**103.**	3	**104.**	2	**105.**	2	**106.**	4	**107.**	3	**108.**	4	**109.**	3	**110.**	3
111.	1	**112.**	3	**113.**	1	**114.**	4	**115.**	1	**116.**	2	**117.**	1	**118.**	4	**119.**	3	**120.**	3
121.	2	**122.**	2	**123.**	1	**124.**	4	**125.**	2	**126.**	1	**127.**	4	**128.**	3	**129.**	1	**130.**	4
131.	3	**132.**	2	**133.**	3	**134.**	3	**135.**	2	**136.**	3	**137.**	4	**138.**	4	**139.**	4	**140.**	2
141.	2	**142.**	2	**143.**	3	**144.**	2	**145.**	3	**146.**	1	**147.**	1	**148.**	4	**149.**	2	**150.**	4
151.	4	**152.**	3	**153.**	4	**154.**	3	**155.**	2	**156.**	4	**157.**	1	**158.**	3	**159.**	1	**160.**	4
161.	4	**162.**	2	**163.**	4	**164.**	3	**165.**	3	**166.**	3	**167.**	3	**168.**	3	**169.**	4	**170.**	4
171.	3	**172.**	3	**173.**	1	**174.**	3	**175.**	1	**176.**	4	**177.**	1	**178.**	4	**179.**	2	**180.**	4