Chapter 4

4.1 (b)

4.2 (d)

4.3 (b)

4.4 (b)

4.5 (c)

4.6 (b)

4.7 (d)

4.8 (c)

4.9 (c)

4.10 (b)

4.11 (a), (b)

4.12 (c)

4.13 (a), (c)

4.14 (a), (b), (c)

4.15 (b), (d)

4.16 $\frac{v^2}{R}$ in the direction **RO**.

4.17 The students may discuss with their teachers and find answer.

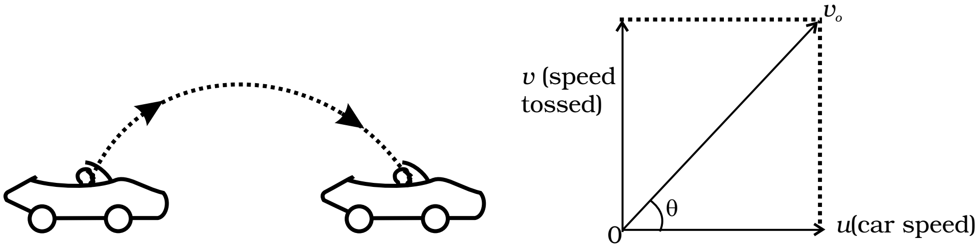
4.18 (a) Just before it hits the ground.

(b) At the highest point reached.
(c) $a = g =$ constant.

4.19 acceleration – g.
velocity – zero.

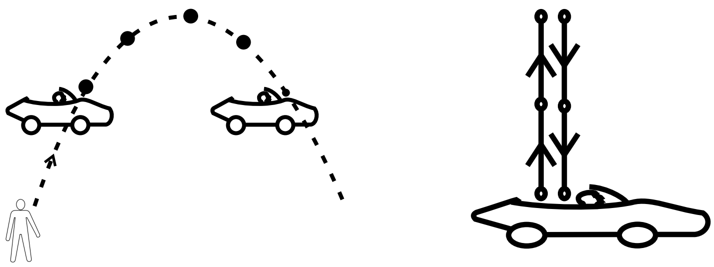
4.20 Since **B** × **C** is perpendicular to plane of **B** and **C**, cross product of any vector will lie in the plane of **B** and **C**.

4.21



For a ground-based observer, the ball is a projectile with speed v_o and the angle of projection θ with horizontal in as shown above.

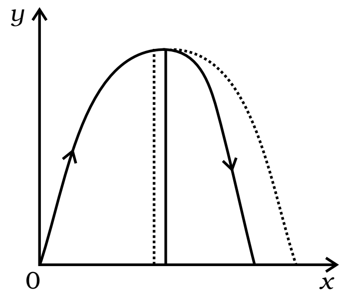
4.22



(a) (b)

Since the speed of car matches with the horizontal speed of the projectile, boy sitting in the car will see only vertical component of motion as shown in Fig (b).

4.23 Due to air resistance, particle energy as well as horizontal component of velocity keep on decreasing making the fall steeper than rise as shown in the figure.



4.24 $R = v_o\sqrt{\frac{2H}{g}}, \phi = \tan^{-1}\left(\frac{H}{R}\right) = \tan^{-1}\left(\frac{1}{v_o}\sqrt{\frac{gH}{2}}\right) = 23°12'$

4.25 Acceleration $\frac{v^2}{R} = \frac{4\pi^2 R}{T^2}$

4.26 (a) matches with (iv)

(b) matches with (iii)

(c) matches with (i)

(d) matches with (ii)

4.27 (a) matches with (ii)

(b) matches with (i)

(c) matches with (iv)

(d) matches with (iii)

4.28 (a) matches with (iv)

(b) matches with (iii)

(c) matches with (i)

(d) matches with (ii)

4.29 The minimm vertical velocity required for crossing the hill is given by

$v_\perp^2 \geq 2gh = 10{,}000$

$v_\perp > 100$ m/s

As canon can haul packets with a speed of 125m/s, so the maximum value of horizontal velocity, $v_{\|}$ will be

$v_{\|} = \sqrt{125^2 - 100^2} = 75\,\text{m/s}$

The time taken to reach the top of the hill with velocity $v_\perp$ is given by

$\frac{1}{2}gT^2 = h \Rightarrow T = 10\,\text{s}.$

In 10s the horizontal distance covered = 750 m.

So cannon has to be moved through a distance of 50 m on the ground.

So total time taken (shortest) by the packet to reach ground across the hill $= \frac{50}{2}\text{s} + 10\text{s} + 10\text{s}$ = 45 s.

4.31 (a) $L = \dfrac{2v_o^2 \sin\beta \cos(\alpha+\beta)}{g\cos^2\alpha}$

(b) $T = \dfrac{2v_o \sin\beta}{g\cos\alpha}$

(c) $\beta = \dfrac{\pi}{4} - \dfrac{\alpha}{2}$

4.32 $\dfrac{Av_0^2}{g}\sin\theta$

4.33 $\mathbf{V}_r = 5\hat{\mathbf{i}} - 5\hat{\mathbf{j}}$

4.34 (a) $5\,\text{m/s}\ at\ 37°$ to N.

(b) (i) $\tan^{-1}(3/\sqrt{7})$ of N, (ii) $\sqrt{7}$ m/s

(c) in case (i) he reaches the opposite bank in shortest time.

4.35 (a) $\tan^{-1}\left(\dfrac{v_o \sin\theta}{v_o \cos\theta + u}\right)$

(b) $\dfrac{2v_o \sin\theta}{g}$

(c) $R = \dfrac{2v_o \sin\theta (v_o \cos\theta + u)}{g}$

(d) $\theta_{max} = cos^{-1}\left[\dfrac{-u + \sqrt{u^2 + 8v_o^{\,2}}}{4v_o}\right]$

(e) $\theta_{max} = 60^o$ *for* $u = v_o$.

$\theta_{max} = 45^o$ *for* $u = 0$.

$u < v_o$

$$\therefore\ \theta_{max} \approx cos^{-1}\left(\frac{1}{\sqrt{2}} - \frac{u}{4v_o}\right) = \pi/4 \quad (if\ u \ll v_o)$$

$$u > v_o \quad \theta_{max} \approx cos^{-1}\left[\frac{v_o}{u}\right] = \pi/2 \quad (v_o \ll u)$$

(f) $\theta_{max} \gtrsim 45°$.

4.36 $\mathbf{V} = \omega\hat{\mathbf{r}} + \omega\theta\,\hat{\boldsymbol{\theta}}$ *and* $\mathbf{a} = \left(\dfrac{d^2\theta}{dt^2} - \omega^2\theta\right)\hat{\mathbf{r}} + \left(\theta\dfrac{d^2\theta}{dt^2} + 2\omega^2\right)\hat{\boldsymbol{\theta}}$

4.37 Consider the straight line path APQC through the sand.

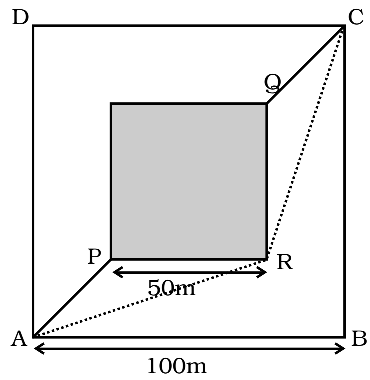
Time taken to go from A to C via this path

$$T_{sand} = \frac{AP + QC}{1} + \frac{PQ}{v}$$

$$= \frac{25\sqrt{2} + 25\sqrt{2}}{1} + \frac{50\sqrt{2}}{v}$$

$$= 50\sqrt{2}\left[\frac{1}{v} + 1\right]$$

The shortest path outside the sand will be ARC.



Time taken to go from A to C via this path

$= T_{\text{outside}} = \dfrac{\text{AR} + \text{RC}}{1}\ \text{s}$

$= 2\sqrt{75^2 + 25^2}\ \text{s}$

$= 2 \times 25\sqrt{10}\ \text{s}$

For $T_{\text{sand}} < \text{T}_{\text{outside}}$, $50\sqrt{2}\left[\dfrac{1}{v} + 1\right] < 2 \times 25\sqrt{10}$

$\Rightarrow \dfrac{1}{v} + 1 < \sqrt{5}$

$\Rightarrow \dfrac{1}{v} < \sqrt{5} - 1$ or $v > \dfrac{1}{\sqrt{5} - 1} \approx 0.81\ \text{m/s}.$