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<th>Medical AITS Test-01</th>
<th>Date: 10 Nov, 2019</th>
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SOLUTIONS

1. 

\[ ax = P, \quad a = \frac{P}{x} = \frac{ML^{-1}T^{-2}}{L} = ML^{-2}T^{-2} \]

\[ c = t^2 = T^2; \quad \frac{b}{T^2} = P \]

or \[ b = PT^2 = ML^{-1}T^{-2} \times T^2 = ML^{-1} \]

2. 

(c) The given relation is \[ S = A (1 - e^{-Bx}) \]

As \( B \cdot x \) is number (dimensionless)

\[ \therefore \quad B = \frac{1}{xt} = \frac{1}{\text{ms}} = \text{m}^{-1}\text{s}^{-1} \]

3. 

(a) one system

MKS system

\[ L_1 = 10 \text{ cm} \quad L_2 = 1 \text{ m} = 100 \text{ cm} \]

\[ M_1 = 10 \text{ g} \quad M_2 = 1 \text{ kg} = 1000 \text{ g} \]

\[ T_1 = 0.1 \text{ s} \quad T_2 = 1 \text{ s} \]

\[ n_1 = 1 \quad n_2 = ? \]

Force \( [\text{MLT}^{-2}] \)

\[ n_2 = n_1 \left( \frac{M_1}{M_2} \right)^a \left( \frac{L_1}{L_2} \right)^b \left( \frac{T_1}{T_2} \right)^c \]

\[ = 1 \left( \frac{10 \text{ g}}{1000 \text{ g}} \right)^1 \left( \frac{10 \text{ cm}}{100 \text{ cm}} \right)^1 \left( \frac{0.1 \text{ s}}{1 \text{ s}} \right)^{-2} \]

\[ = 1 \times \frac{1}{100} \times \frac{1}{10} \times 10 \times 10 = 0.1 \text{ N} \]

4. 

(b) Here, \[ P = \frac{a^2 b^2}{cd} \]

\[ \frac{\Delta P}{P} = \frac{a^2 \Delta b + b^2 \Delta a}{a b} \]

\[ \frac{\Delta P}{P} \times 100 = \pm (3 \times 1\% + 2 \times 2\% + 3\% + 4\%) = \pm 14\% \]
5.

(c): Let \( v = \kappa \lambda^a \rho^b g^c \)

\[ [M^0 L T^{-1}] = L^a [ML^{-3})^b [LT^{-2}]^c = M^b L^{a-3b} t^{-2c} \]

Applying principle of homogeneity of dimensions, we get

\[ b = 0, a - 3b + c = 1, -2c = -1, c = \frac{1}{2} \]

\[ a = 1 + 3b - c = 1 + 0 - \frac{1}{2} = \frac{1}{2} \]

\[ \therefore \quad v = k \lambda^{1/2} p^0 g^{1/2} ; \quad v^2 \approx \lambda g \]

6.

(d): Refer to Fig. 2.1(S), the body will go from \( P \) to \( Q \), where displacement \( = \overrightarrow{PQ} \) and angle subtended at \( O \), i.e., \( \angle PQO = \pi/3 \)

Here, \( \overrightarrow{OP} = R \)

\( \overrightarrow{OQ} = R, \theta = \pi/3 \)

\[ \therefore \quad \overrightarrow{PQ} = \sqrt{(OP)^2 + (OQ)^2 - 2(OP)(OQ) \cos \pi/3} \]

\[ = \sqrt{R^2 + R^2 - 2R \times R \times 1/2} = R \]

7.

(b): \( t = ax^2 + bx \)

Differentiating it w.r.t. \( t \), we have

\[ 1 = (2ax + b) \times \frac{dx}{dt} \]

or velocity, \( v = \frac{dx}{dt} = \frac{1}{2ax + b} = (2ax + b)^{-1} \)

Acceleration \( a = \frac{dv}{dt} = -(2ax + b)^{-2} \times 2a \frac{dx}{dt} \)

\[ = -2a \frac{x}{(2ax + b)^2} \frac{dx}{dt} = -2a v^2 \times v = -2a v^3 \]

8.

(c): \( a = \frac{dv}{dt} = \frac{dv}{dx} \frac{dx}{dt} = v \frac{dv}{dx} = -\alpha x^2 \) (Given)

or \( v \ dv = -\alpha x^2 \ dx \)

Integrating it within the conditions of motion; i.e., as \( x \) changes from 0 to \( x \), \( v \) changes from \( u \) to 0, we get

\[ \int_0^x v \ dv = \int \frac{-\alpha x^2}{2} \ dx \quad \text{or} \quad \left( \frac{v^2}{2} \right)_0^x = -\frac{\alpha x^3}{3} \]

or \( \frac{u^2}{2} = \frac{\alpha x^3}{3} \quad \text{or} \quad x = \left( \frac{3u^2}{2\alpha} \right)^{1/3} \)
9. (c): Using the relation, \( s = ut + \frac{1}{2} \alpha t^2 \), time to fall a distance \( s \),
when \( u = 0 \), \( a = g \) will be \( t = \sqrt{\frac{2s}{g}} \). Let \( t_1, t_2, t_3 \) ... be the
time taken to fall 1 m, 2 m, 3 m ... respectively. Then
\[
 t_1 = \sqrt{\frac{2 \times 1}{g}} ; \quad t_2 = \sqrt{\frac{2 \times 2}{g}} ; \quad t_3 = \sqrt{\frac{2 \times 3}{g}} .
\]
So the time taken to fall 1 m = \( t_1 - 0 = \sqrt{\frac{2}{g}} \) \( (\sqrt{1} - 0) \)
time taken to fall 2nd metre = \( (t_2 - t_1) = \sqrt{\frac{2}{g}} (\sqrt{2} - \sqrt{1}) \)
time taken to fall 3rd metre = \( (t_3 - t_1) = \sqrt{\frac{2}{g}} (\sqrt{3} - \sqrt{2}) \)
\( \therefore \) ratio of successive 1 m distance
\[
\frac{1}{\sqrt{1}} : \frac{\sqrt{2} - \sqrt{1}}{\sqrt{3} - \sqrt{2}} : \ldots
\]

10. (c): If \( t \) is the total time of flight, then as per question
\[ D_t = S_5 \quad \text{or} \quad \frac{10}{2} (2t - 1) = \frac{1}{2} \cdot 10 \times S^2 \quad \text{or} \quad t = 13 \text{ s} \]

11. (a): Case (i), \( u = 0 \), \( a = a \), \( t = n s \), \( v = v \)
\[ v = u + at \quad \therefore \quad v = 0 + a \times n \quad \text{or} \quad a = v/n \]
When \( t = (n - 2) s \), \( S = ut + \frac{1}{2} \alpha t^2 = 0 + \frac{1}{2} \times \frac{v}{n} (n - 2)^2 \)
When \( t = n \), \( S' = 0 + \frac{1}{2} \frac{v}{n} n^2 \)
\( \therefore \) Distance travelled in last 2 seconds is
\[ S' - S = \frac{1}{2} \frac{v}{n} n^2 - \frac{1}{2} \frac{v}{n} (n - 2)^2 = \frac{1}{2} \frac{v}{n} [n^2 - (n - 2)^2] \]
\[
= \frac{1}{2} \frac{v}{n} [n^2 - n^2 + 4n - 4] = \frac{2v}{n} (n - 1)
\]

12. (b): Let \( v \) be the velocity of the train after time \( t_1 \). Then,
\[ v = \alpha t_1 = \beta t_2 ; \quad x_1 = \frac{1}{2} \alpha t_1^2 \quad \text{and} \quad x_2 = \frac{1}{2} \beta t_2^2 \]
\( \therefore \)
\[
\frac{\beta}{\alpha} = \frac{t_1}{t_2} \quad \text{and} \quad \frac{x_1}{x_2} = \frac{\alpha t_1^2}{\beta t_2^2} = \frac{\alpha}{\beta} \times \frac{t_1^2}{t_2^2} = \frac{\beta}{\alpha} \quad \therefore \quad \frac{x_1}{x_2} = \frac{\beta}{\alpha} = \frac{t_1}{t_2}
\]
13. 

(a) : Taking vertical upward motion of particle from point of projection to highest point, we have:

\[ u = u, \ a = -g, \ v = 0, \ t = t_1 \ (say) \]

As, \[ v = u + at, \] so, \[ 0 = u - gt_1 \] \[ \text{or} \quad t_1 = \frac{u}{g} \]

Taking vertical downward motion of particle from point of projection to the ground, we have

\[ u = -u, \ a = g, \ S = H, \ t = nt_1 = \frac{nu}{g} \]

\[ S = ut + \frac{1}{2} gt^2 \]

\[ H = -u \left( \frac{nu}{g} \right) + \frac{1}{2} g \left( \frac{n^2 u^2}{g^2} \right) = -\frac{nu^2}{g} + \frac{n^2 u^2}{2g} = \frac{n u^2}{2g} [n - 2] \]

or \[ 2gH = n u^2 (n - 2) \]

14. 

(b) : \[ x = 4(t - 2) + a(t - 2)^2 \]

velocity, \[ v = \frac{dx}{dt} = 4(1 - 0) + a \times 2(t - 2) \times 1 \]

Acceleration, \[ a = \frac{dv}{dt} = 2a \]

When \( t = 0, \) \( v = 4 - 4a \) and the particle is not at origin.

15. 

(c) : Speed = distance/time taken. Therefore,

\[ \frac{v_1}{v_2} = \frac{S_0 / t_1}{S_0 / t_2} = \frac{t_2}{t_1} = \frac{4}{2} = \frac{2}{1} \]

16. 

(b) : Using \( v^2 = u^2 + 2as, \) for second part of motion we have

\[ (8)^2 = (6)^2 + 2 \times a \times 7 \quad \text{or} \quad 28 = 14a \quad \text{or} \quad a = 2 \text{ ms}^{-2} \]

For first part of motion,

\[ (6)^2 = u^2 + 2 \times 2 \times 5 \quad \text{or} \quad u = 4 \text{ ms}^{-1} \]
17. 

(b) : Relative speed of trains = 30 + 30 = 60 km h\(^{-1}\)

Time taken by the trains to meet = \(\frac{90}{60} = \frac{3}{2}\) h

Speed of bird = 50 km h\(^{-1}\)

Distance travelled by bird = \(50 \times \frac{3}{2} = 75\) km

18. 

(c) : Let the student catches the bus after time \(t\). Then distance travelled by student in \(t\) second

\[= 50 + \text{distance travelled by bus in } t \text{ seconds}\]

or \(ut = 50 + \frac{1}{2} at^2 = 50 + \frac{1}{2} \times 1 \times t^2 \) or \(t^2 - 2 ut + 100 = 0\)

or \(t = \frac{2u \pm \sqrt{4u^2 - 400}}{2} = u \pm \sqrt{u^2 - 100}\)

\(u\) will be minimum if \(u^2 - 100 = 0\) or \(u = 10\) m/s

19. 

(b) : First 50 metres fall is under the effect of gravity only. The velocity acquired, \(u = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 50}\) m/s

= 10\(\sqrt{9.8}\) m/s. Taking onward motion of parachutist with retardation 2 m/s\(^2\), we have,

\(u = 10\sqrt{9.8}\) m/s, \(a = -2\) m/s\(^2\), \(v = 3\) m/s

\(s = \frac{v^2 - u^2}{2a} = \frac{(3)^2 - (2 \times 9.8 \times 50)}{2 \times (-2)} = 243\) m

\(\therefore\) Total height = 50 + 243 = 293 m

20. 

(b) : Let \(v_w\) be the velocity of water and \(v_b\) be the velocity of motor boat in still water. If \(x\) is the distance covered, then as per question \(x = (v_b + v_w) \times 6 = (v_b - v_w) \times 10\)

On solving, \(v_w = v_b/4\)

\(\therefore\) \(x = [v_b + v_b/4] \times 6 = 7.5\ v_b\)

Time taken by motor boat to cross the same distance in still water is \(t = \frac{x}{v_b} = \frac{7.5\ v_b}{v_b} = 7.5\ h\)
21.

\[ (d) : \mathbf{V}_{av} = \frac{(x_2 - x_1) \hat{i} + (y_2 - y_1) \hat{j}}{t_2 - t_1} = \frac{(13 - 2) \hat{i} + (14 - 3) \hat{j}}{5 - 0} = \frac{11 \hat{i} + 11 \hat{j}}{5} = \frac{11}{5} (\hat{i} + \hat{j}) \]

22.

\[ (d) : \text{Let } \theta \text{ be the angle between } \mathbf{A}_1 \text{ and } \mathbf{A}_2. \text{ Then} \]

\[ A_1^2 + A_2^2 + 2 A_1 A_2 \cos \theta = R^2 \text{ or } A^2 + A^2 + 2 AA \cos \theta = 3 A^2 \]

or \[ \cos \theta = \frac{1}{2} = \cos 60^\circ \text{ or } \theta = 60^\circ \]

The angle between \( \mathbf{A}_1 \) and \( -\mathbf{A}_2 \) is \( (180^\circ - 60^\circ) = 120^\circ \). \[
\therefore \text{Resultant of } \mathbf{A}_1 \text{ and } -\mathbf{A}_2 \text{ is} \]

\[ R' = [A_1^2 + A_2^2 + 2 A_1 A_2 \cos (180^\circ - 60^\circ)]^{1/2} \]

\[ = [A^2 + A^2 + 2 AA \cos 120^\circ]^{1/2} = A \]

23.

\[ (a) : \text{Work done, } W = \mathbf{F} \cdot s = (6 \hat{i} + 2 \hat{j} - 3 \hat{k}) \cdot (2 \hat{i} - 3 \hat{j} - x \hat{k}) \]

\[ 0 = 12 - 6 + 3x \text{ or } 3x = -6 \text{ or } x = -2 \]

24.

\[ (b) : \text{Here, } \mathbf{A} = (\hat{i} + 2 \hat{j} + 3 \hat{k}); \mathbf{B} = (3 \hat{i} - 2 \hat{j} + \hat{k}) \]

\[ \mathbf{A} \times \mathbf{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & 3 \\ 3 & -2 & 1 \end{vmatrix} = \hat{i}(2 + 6) + \hat{j}(9 - 1) + \hat{k}(-2 - 6) \]

\[ = 8 \hat{i} + 8 \hat{j} - 8 \hat{k} \]

\[ |\mathbf{A} \times \mathbf{B}| = \sqrt{8^2 + 8^2 + (-8)^2} = 8\sqrt{3} \]

Area of parallelogram \( = |\mathbf{A} \times \mathbf{B}| = 8\sqrt{3} \)
25. 
(a) : Here, \( \vec{A} = 2\hat{i} + 3\hat{j}, \quad \vec{B} = (\hat{i} + \hat{j}) \);

\[
\vec{B} = \frac{\vec{B}}{B} = \frac{(\hat{i} + \hat{j})}{\sqrt{1^2 + 1^2}} = \frac{\hat{i} + \hat{j}}{\sqrt{2}}
\]

Component of \( \vec{A} \) along \( \vec{B} \) is

\[
= (\vec{A} \cdot \vec{B}) \hat{B} = \left[(2\hat{i} + 3\hat{j}) \cdot \left(\frac{\hat{i} + \hat{j}}{\sqrt{2}}\right)\right] = \frac{5}{2} (\hat{i} + \hat{j})
\]

Magnitude of the component of \( \vec{A} \) along \( \vec{B} \) is

\[
= \frac{5}{2} \left[\sqrt{1^2 + 1^2}\right] = \frac{5}{2} \times \sqrt{2} = \frac{5}{\sqrt{2}}
\]

26. 
(a) : Let \( d \) be the diameter of the circular disc. The time taken by a particles to reach from 0 to A, 0 to B and 0 to C be \( t_1 \), \( t_2 \) and \( t_3 \) respectively.

Time taken by particle to reach from 0 to B is

\[
t_2 = \sqrt{\frac{2d}{g}}
\]

For a particle sliding along any groove which makes an angle \( \theta \) with \( OB \), \( h = \frac{1}{2} at_1^2 \)

Here, \( h = d \cos \theta \) and \( a = g \cos \theta \)

\[
\therefore \quad d \cos \theta = \frac{1}{2} (g \cos \theta) t_1^2 \quad \text{or} \quad t_1 = \sqrt{\frac{2d}{g}} = t_3
\]

\[
\therefore \quad t_1 : t_2 : t_3 = 1 : 1 : 1
\]

27. 
(b) : Let \( \vec{v} \) be perpendicular to \( \vec{u} \) after time \( t \) of the projection of projectile. So \( \vec{v} \cdot \vec{u} = 0 \)

But \( \vec{v} = \vec{u} + \vec{a} t \) \( \therefore (\vec{u} + \vec{a} t) \cdot \vec{u} = 0 \)

\[
\vec{u} \cdot \vec{u} + (\vec{a} \cdot \vec{u}) t = 0 \quad \text{or} \quad \vec{u}^2 + gat \cos (90^\circ + \theta) = 0
\]

\[
[\because a = g \text{ and angle between } \vec{u} \text{ and } \vec{g} \text{ is } (90^\circ + \theta)]
\]

or \( u - gt \sin \theta = 0 \) \( \text{or} \ \ t = \frac{u}{g \sin \theta} \)
28. \( (b) \): \( y = bx^2 \)

\[
\frac{dy}{dt} = 2bx \frac{dx}{dt} \quad \text{or} \quad v_y = 2bxv_x
\]

\[
\frac{d (v_y)}{dt} = 2bx \frac{dv_x}{dt} + 2bv_x \frac{dx}{dt} = 0 + 2bv_x^2
\]

\[
\therefore \frac{dv_x}{dt} = 0, \quad \text{because the particle has constant acceleration along } y\text{-direction.}
\]

\[
\therefore \quad \frac{dv_y}{dt} = a = 2bv_x^2 \quad \text{or} \quad v_x = \sqrt{\frac{a}{2b}}
\]

29. \( (c) \): Let \( H \) be the maximum height reached by body and \( \theta \) be the angle of its projection. As per question \( R = 2H \)

\[
\therefore \quad \frac{2u^2 \sin \theta \cos \theta}{g} = 2 \times \frac{u^2 \sin^2 \theta}{2g} \quad \text{or} \quad \tan \theta = 2
\]

Then \( \sin \theta = \frac{2}{\sqrt{5}} \) \quad and \quad \cos \theta = \frac{1}{\sqrt{5}}

Horizontal range, \( R = \frac{2u^2 \sin \theta \cos \theta}{g} \)

\[
= \frac{2u^2 \times (2/\sqrt{5}) \times (1/\sqrt{5})}{g} = \frac{4u^2}{5g}
\]

30. \( (d) \): For the same horizontal range, angle of projection of projectile will be \( \theta \) and \( (90^\circ - \theta) \). If one angle is \( \pi/3 \) (= 60°) then the other angle of projection is \( (90^\circ - 60^\circ) = 30^\circ \).

Max. height, \( h_1 = \frac{u^2 \sin^2 60^\circ}{2g} = \frac{u^2 (\sqrt{3}/2)^2}{2g} = \frac{3u^2}{8g} \)

or \( \frac{u^2}{g} = \frac{8h_1}{3} \)

\[
h_2 = \frac{u^2 \sin^2 30^\circ}{2g} = \frac{u^2(1/2)^2}{2g} = \frac{u^2}{8g} \times \frac{1}{8} = \frac{8h_1}{3} \times \frac{1}{8} = \frac{h_1}{3}
\]
(b) : Here, \( \mathbf{u} = 3 \hat{i} + 4 \hat{j} \);
\[ u = \sqrt{3^2 + 4^2} = 5 \text{ ms}^{-1} \]
\[ \tan \theta = \frac{4}{3} ; \quad \sin \theta = \frac{4}{5} \quad \text{and} \quad \cos \theta = \frac{3}{5} \]

Horizontal range,
\[ R = \frac{u^2 2 \sin \theta \cos \theta}{g} = \frac{5^2 \times 2 \times (4/5) \times (3/5)}{10} = 2.4 \text{ m} \]

32.

(c) : Let \( u_x, u_y \) be the horizontal and vertical components of initial velocity and \( \theta \) be the angle of projection. Here, \( v_x = 6 \text{ ms}^{-1}, \)
\[ v_y = 2 \text{ ms}^{-1}, \quad y = 0.4 \text{ m}. \]
\[ u_x = v_x = 6 \text{ ms}^{-1} \]
Taking vertical upward motion from starting point to a height 0.4 m, we have
\[ v_y^2 = u_y^2 - 2g \cdot 0.4 \quad \text{or} \quad u_y^2 = v_y^2 + 2g \cdot 0.4 = 2^2 + 2 \times 10 \times 0.4 = 12 \]
\[ u_y = \sqrt{12} = 2\sqrt{3} \]
\[ \tan \theta = \frac{u_y}{u_x} = \frac{2\sqrt{3}}{6} = \frac{1}{\sqrt{3}} = \tan 30^\circ \quad \text{or} \quad \theta = 30^\circ \]

33.

(c) : Here, \[ \frac{3h}{2} = \frac{u^2 \sin^2 \theta}{2g} \quad \text{or} \quad \sqrt[3]{\frac{3h}{g}} = \frac{u \sin \theta}{g} \]

Time of flight, \[ T = \frac{2u \sin \theta}{g} = 2\sqrt[3]{\frac{3h}{g}} \]

34.

(d) : The particle will strike the point \( D \) if velocity of particle w.r.t. platform is along \( AD \) or component of its relative velocity along \( AB \) is zero. It will be so if \( v \cos \theta = u \)
or \( \cos \theta = u/v \quad \text{or} \quad \theta = \cos^{-1} (u/v) \)
35. (c): In projectile motion, the horizontal component velocity remains constant throughout the motion, so
\[ u \cos \theta = v \cos \phi \quad \text{or} \quad v = u \cos \theta / \cos \phi = u \cos \theta \sec \phi \]

36. (a): Refer to Fig. 3(FPH).12

\[ OB = \text{half horizontal range} = \frac{1}{2} \left[ \frac{u^2 \sin 2\theta}{g} \right] \]

\[ AB = \text{Max. height} = \frac{u^2 \sin^2 \theta}{2g} \]

\[ \tan \phi = \frac{AB}{OB} = \frac{u^2 \sin^2 \theta / 2g}{u^2 \sin 2\theta / 2g} = \frac{\sin^2 \theta}{2 \sin \theta \cos \theta} = \frac{1}{2} \tan \theta \]

37. (b): Here, \( y = 12x - \frac{3}{4}x^2 \)

Comparing it with equation of path of projectile, we have
\[ y = x \tan \theta - \frac{gx^2}{2u^2 \cos^2 \theta} \]

We have: \( \tan \theta = 12 \) and \( \frac{g}{2u^2 \cos^2 \theta} = \frac{3}{4} \)

\[ \sin \theta = \frac{12}{\sqrt{12^2 + 1}} = \frac{12}{145} \quad \text{and} \quad \cos \theta = \frac{1}{\sqrt{145}} \]

\[ \frac{g}{2u^2 \cos^2 \theta} = \frac{3}{4} \quad \text{or} \quad \frac{2u^2 \cos^2 \theta}{g} = \frac{4}{3} \]

or \( \frac{2u^2}{g} \times \frac{1}{145} = \frac{4}{3} \) or \( \frac{2u^2}{g} = \frac{4 \times 145}{3} \)

Horizontal range, \( R = \frac{2u^2 \sin \theta \cos \theta}{g} \)

\[ = \left( \frac{4 \times 145}{3} \right) \times \frac{12}{\sqrt{145}} \times \frac{1}{\sqrt{145}} = 16\text{m} \]
38.

(c): Refer to Fig. 3(FPH).9, let the stone thrown horizontally from A reaches to location B; where

\[ v = 2u \quad \ldots(i) \]

Here, \( v_x = u \)

and \( v_y = g \times 2 = 2g \)

\[ v = \sqrt{v_x^2 + v_y^2} \]

\[ = \sqrt{u^2 + 4g^2} \]

From (i),

\[ u^2 + 4g^2 = (2u)^2 = 4u^2 \]

or \( 3u^2 = 4g^2 \)

or \( u = 2g/\sqrt{3} \)

39.

(a): Here, \( x = (u \cos \theta) t = 6t \) or \( u \cos \theta = 6 \) \( \ldots(i) \)

\[ y = u \sin \theta t - \frac{1}{2}gt^2 = 8t - 5t^2 \]

\[ \therefore \quad u \sin \theta - \frac{1}{2}gt^2 = 8t - 5t^2 \]

\[ \therefore \quad u \sin \theta = 8 \] \( \ldots(ii) \)

and \( \frac{g}{2} = 5 \) or \( g = 10 \text{ ms}^{-2} \)

Squaring and adding (i) and (ii), we get

\[ u^2 \cos^2 \theta + u^2 \sin^2 \theta = 6^2 + 8^2 = 100 \]

or \( u^2 = 100 \) or \( u^2 = 10 \text{ ms}^{-1} \); From (i), \( \cos \theta = \frac{6}{10} \);

From (ii) \( \sin \theta = \frac{8}{10} \)

Horizontal range \( = \frac{2u^2 \sin \theta \cos \theta}{g} = \frac{2 \times 10^2 \times 8 \times \frac{6}{10}}{10 \times 10} = 96 \text{ m} \)
(d) : Refer to Fig. 3.9(H.11, let velocity of rain be,
\[ \vec{v}_r = a \hat{i} + b \hat{j} \]

1st Case : Velocity of man,
\[ \vec{v}_m = (2 \text{ km h}^{-1}) \hat{i} \]

Velocity of rain w.r.t. man
\[ \vec{v}_{rm} = \vec{v}_r - \vec{v}_m = (a \hat{i} + b \hat{j}) - 2 \hat{i} = (a - 2) \hat{i} + b \hat{j} \]

Since rain appears to fall vertically downwards so
\[ a - 2 = 0 \quad \text{or} \quad a = 2 \]

2nd Case : \( \vec{v}_m = (4 \text{ km h}^{-1}) \hat{i} \)
\[ \vec{v}_{rm} = \vec{v}_r - 4 \hat{i} = (a \hat{i} + b \hat{j}) - 4 \hat{i} = (a - 4) \hat{i} + b \hat{j} \]

Since rain appears to fall at 30° to the vertical, so
\[ \tan 30° = \frac{a - 4}{b} \quad \text{or} \quad \frac{1}{\sqrt{3}} = \frac{a - 4}{b} = \frac{2 - 4}{b} = \frac{-2}{b} \]

or \( b = -2\sqrt{3} \)

Hence, \( \vec{v}_r = 2 \hat{i} - 2\sqrt{3} \hat{j} \)

or \( v_r = \sqrt{2^2 + (2\sqrt{3})^2} = 4 \text{ km h}^{-1} \)

If \( \theta \) is the angle of \( \vec{v}_r \) with horizontal, then
\[ \tan \theta = \frac{-2\sqrt{3}}{2} = -\sqrt{3} \quad \text{or} \quad \theta = 120° \]

Angle with vertical = 120° – 90° = 30°
41. 

(b) Refer to Fig. 3.9(H,8),

\[ \vec{v}_C = (\overrightarrow{OA}) = (20 \text{ ms}^{-1}) \hat{i} ; \quad \vec{v}_{TC} = \overrightarrow{OB} = (20\sqrt{3} \text{ ms}^{-1}) \]

As, \( \vec{v}_{TC} = \vec{v}_T + (-\vec{v}_C) \)

\[ \therefore \overrightarrow{OB} = \vec{v}_T + \overrightarrow{OC} \quad \text{or} \quad \vec{v}_T = \overrightarrow{OB} + (-\overrightarrow{OC}) \]

\[ \therefore \vec{v}_T = (20\sqrt{3}) \hat{j} + (20)(-\hat{i}) = 20\sqrt{3} \hat{j} - 20 \hat{i} \]

\[ \therefore \vec{v}_T = (20\sqrt{3})^2 + (-20)^2 = 40 \text{ m/s} \]

42.

\[ \frac{S_{\text{nth}}}{S_n} = \frac{u + a \left( n - \frac{1}{2} \right)}{un + \frac{1}{2}an^2} = \frac{a(2n-1)}{an^2} = \frac{2n-1}{n^2} = \frac{2}{n} - \frac{1}{n^2} \]

43.

\[ t = \frac{d}{\sqrt{v_{B/R}^2 - v_R^2}} \]

\[ \frac{1}{4} \text{ hr} = \frac{1 \text{ km}}{\sqrt{25 - v_R^2}} \]

\[ 25 - v_R^2 = 16 \]

\[ v_R = 3 \text{ km/h} \]

44.

\[ \left( \frac{\text{KE}_{\text{min}}}{\text{KE}_{\text{min}}^2} \right) = \frac{4}{1} \Rightarrow \frac{u_1^2 \cos^2 \theta_1}{u_2^2 \cos^2 \theta_2} = \frac{4}{1} \Rightarrow \frac{u_1 \cos \theta_1}{u_2 \cos \theta_2} = \frac{2}{1} \]

\[ H_1 = \frac{4}{1} \Rightarrow \frac{u_1^2 \sin^2 \theta_1}{u_2^2 \sin^2 \theta_2} = \frac{4}{1} \Rightarrow \frac{u_1 \sin \theta_1}{u_2 \sin \theta_2} = \frac{2}{1} \]

\[ R_1 = \left( u_1 \cos \theta_1 \right) \left( u_1 \sin \theta_1 \right) = 4 \]

\[ R_2 = \left( u_2 \cos \theta_2 \right) \left( u_2 \sin \theta_2 \right) = \frac{1}{1} \]
45. 
\[ T = \frac{2u_x}{g} = \frac{2v_0 \cos \theta}{g} \] 
\[ S_x = u_x T + \frac{1}{2} a_x T^2 \]

\[ 0 = (v_0 \sin \theta)(T) - \frac{1}{2} (4 \text{ m/s}^2)(T^2) \]

\[ 2T = v_0 \sin \theta \]

\[ 2 \left( \frac{2v_0 \cos \theta}{g} \right) = v_0 \sin \theta \]

\[ \tan \theta = 0.4 \]

46. (3) Conceptual

47. (3)

48. (1)

49. (1)

50. (2) Conceptual

51. (4) Conceptual

52. (4)

53. (3)

\[ \gamma, \text{ ionic character } = 16 \left( x_A - x_B \right) + 3.5 \left( x_A - x_B \right)^2 \]

\[ x_A = 3.0, \quad x_B = 2.1 \]

\[ \gamma, \text{ I.C. } = 16 \times 0.9 + 3.5 \times 0.8 \]

\[ = 17.24 \gamma \]
54. (3) due to H-bonding \( H_2O \rightarrow \text{H}_{2} \text{P} \).

\[ H_2O > H_2Te > H_2Se > H_2S \]

55. (3) due to H-bonding \( H_2O \rightarrow \text{H}_{2} \text{P} \).

\[ H_2O > H_2Te > H_2Se > H_2S \]

56. (1)

57. (2) concept - [Handwritten text]

58. (3) \( C_{10}H_{14}N_2 + \frac{1}{2}O_2 \rightarrow 10CO_2 + 7H_2O + N_2 \uparrow \)

\[ 1 \text{ mole} \quad 1 \text{ mole} \]

\[ 10 \text{ moles} \quad 1 \text{ mole} \quad \downarrow 44.9 \text{ gm} \]

59. (3) 22.4 L water = \( N_A \) moles

\[ 1 \text{ ml} \text{ water} = 20 \text{ drops} \text{ (given)} \]

\[ 1 \text{ drop} = \frac{N_A}{22400} \text{ moles} \]

\[ = \frac{6.022 \times 10^{23}}{4.98 \times 10^3} \]

\[ = 1.24 \times 10^{-18} \]

60. (4) 1.5 mole \( \frac{1}{2}O \) = 2.7 gm \( H_2O \) (least)
61. (3)  
Let 3.2 gm of each \( \text{H}_2, \text{He} \) and \( \text{O}_2 \) are mixed.  
\[ \text{Mole fraction of } \text{O}_2 = \frac{\frac{32}{2}}{\frac{32}{2} + \frac{32}{4} + \frac{32}{8}} \] 
\[ \text{Partial Press. of } \text{O}_2 = \text{Mole fraction } \times \text{Total Press.} \] 
\[ = \frac{1}{6} \times 7.5 = 0.3 \text{ atom} \]

62. (3)  
\[ \text{C}_6 \text{H}_{14} + 19\text{O}_2 \rightarrow 6\text{CO}_2 + 7\text{H}_2\text{O} \]  
\[ \text{n-hexane} \quad 304\text{gm} \quad 264\text{gm} \quad 12\text{gm} \]  
\[ \text{Now} \quad 86\text{gm n-hexane} = 304\text{gm o}_2 \]  
\[ \text{i.e.} \quad 86\text{kg n-hexane} = 304\text{kg o}_2 \]  
\[ \therefore \quad 8.15\text{kg n-hexane} = x \]  
\[ \therefore \quad x = \frac{2.15 \times 304}{86} = 7.06\text{kg} \]

63. (1)  
100gm chlorophyll contains 2.68gm Mg  
\[ \quad 2 \text{gm chlorophyll will give} = \frac{2.68\times2}{100} = 0.053\text{gm} \]  
Atomic wt of Mg = 24.3  
\[ \text{No. of Mg atoms in } 0.053\text{gm Mg} = \frac{0.053 \times 6.022 \times 10^{23}}{24.3} = 1.33 \times 10^{21} \text{ atoms} \]

64. (1)

65. (4)

66. (3)

67. (1)  
100 ml air = 0.025 ml \( \text{CO}_2 \)  
i.e. 1ml air = 0.00025 ml \( \text{CO}_2 \)  
\[ \text{Molccull of } \text{CO}_2 = \frac{0.00025 \times \text{NA}}{22400} \]  
\[ = 6.7 \times 10^{15} \text{ molecules} \]

68. (3)

69. (4)  
\[ \frac{E_4}{E_6} = \frac{E_4}{4^2} = \frac{1}{4} \Rightarrow E_4 = E_6 = \frac{\sqrt{2}}{4} \text{ kJ/m}^4 \]
70. (1)
71. (1)
\[
\begin{align*}
\overline{V}_H &= R_H \left( \frac{L}{n_1} - \frac{L}{n_2} \right) \text{ for } H - a \text{ in } \\
\overline{V}_{Be^{3+}} &= R_H \times 16 \left( \frac{1}{2} - \frac{1}{2} \right) = 2 = 4 \text{ B}^2 \\
\overline{V}_{Be^{3+}} &= 16 \overline{V}_H = 16 \times 1.5 \times 10^{-10} = 2.4 \times 10^{-8}
\end{align*}
\]
72. (2)
\[\text{One speed of light } \quad v = \frac{1}{10} \left( 3 \times 10^8 \right) = 3 \times 10^6 \text{ m/s} \]
then use \[p = mv = 9.1 \times 10^{-31} \times 3 \times 10^6\]
then \[\lambda = \frac{h}{p} = 2.4 \times 10^{-10} \text{ m}\]
73. (3)
74. (2)
75. (4)
76. (3)
Conceptual
77. (1)
\[\text{Stroke } s = \frac{1}{2} \text{ indicates for only } 1.0\]
78. (2)
Concept of Quantum no
79. (3)
80. (3)
AB_3E type contain 4 bond pair + 1 lone pair
\[\Rightarrow \text{See saw}\]
81. (1)
B . O = 3
82. (4)
VSEPR theory
83. (1)
84. (3)
O_2^-
85. (1)
Mut Concent
86. (1)
\[\text{CH}_4, \text{N}_2, \text{H}_2, \text{H}_2O\]
87. (3) Aristote divided organisms as plants, animals and human beings.
88. (3) Animalia are heterotrophic, multicellular, lacking a cell wall
89. (4) Informative
90. (2)

| 91. | 1 | Aristotle divided organisms as plants, animals and human beings. |
| 92. | 4 | Animalia are heterotrophic, multicellular, lacking a cell wall |
| 93. | 2 | Cocci-Spherical shaped bacteria
     Bacillli- Rod shaped bacteria
     Vibrio -comma shaped bacteria
     Spirillum-Spiral bacteria |
| 94. | 4 | During Favourable conditions- Binary fission
    During unfavourable conditions- Endospore formation |
| 95. | 3 | 1- caused by bacteria
    2-placed under kingdom Protista
    4- Diatoms are chief producers of ocean. |
| 96. | 4 | Mycoplasma is wall less |
| 97. | 2 | Astaxanthin is a orange red pigment present in eye spot of Euglena |
| 98. | 2 | Red sea is caused by Cyanobacteria- Trichodesmium erythrium
    Red tide is caused by Red dinoflagellates Gymnodinium and Gonyaulax |
| 99. | 1 | Fragmentation may occur in the hyphae of Agaricus fungi. Others are unicellular protists. |
| 100. | 2 | Claviceps is Ascomycetes |
| 101. | 2 | Basidiospore is haploid sexual spore, produced exogenously
    Ascospore-Haploid, endogenous
    Oospore- Diploid
    Zygospore-Diploid |
| 102. | 2 | Phycomycetes are lower fungi- so have coenocytic mycelium. |
| 103 | 4 | Ascomycetes-Sac fungi |
| 104. | 1 | NCERT Diagrams |
| 105. | 4 | Ustilago is smut fungi
    Agaricus-Mushroom
    Puccinia-Rust fungi |
| 106. | 4 | Virus has either DNA or RNA as genetic material. Never both together. |
| 107. | 2 | M.W. Beijerinck called this infectious fluid as contagium vivum fluidum. |
| 108. | 1 | Capsid is present outside genetic material in virusus. |
| 109. | 1 | Herpes virus- ds DNA |
| 110. | 3 | NCERT Diagram |
| 111. | 4 | Binomial epithet has 2 latin names(italicized if printed) and authors name which are not italicized. |
| 112. | 4 | External and internal structure, along with the structure of cell, development process and ecological information of organisms are essential and form the basis of modern taxonomic studies. |
| 113. | 1 | Systema Naturae is a book written by Carolus Linnaeus, the 10th edition of which was the starting point of Binomial Nomenclature. |
| 114. | 4 | Tautonym is a scientific name in which the same word is used for both genus and species. |
| 115. | 3 | Wheat-Triticum
    Brinjal, Potato-Solanum
    Lion, Tiger-Panthera
    Dog- Canis |
<p>| 116. | 1 | Species is a group of organisms which are morphologically similar and can freely interbreed and produce fertile offsprings. |</p>
<table>
<thead>
<tr>
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<tr>
<td><strong>117.</strong></td>
<td>2</td>
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<tr>
<td><strong>118.</strong></td>
<td>3</td>
</tr>
</tbody>
</table>
| Agaricus- Edible Fungus-Basidiomycetes  
Phytophthora- Oomycetes  
Mucor-Zygomycetes |   |
| **119.** | 4 |
| They are all different classes which come under Phylum Chordata (eg Class Ambhibia, Class reptilia etc) |   |
| **120.** | 1 |
| It is the common name for lion |   |
| **121.** |   |
| Potato- *Solanum tuberosum*,  
Brinjal - *Solanum melongena* |   |
| **122.** | 3 |
| Related Orders are kept in Class |   |
| **123.** |   |
| Dicots and Monocots are related Classes, kept under Division Angiospermae |   |
| **124.** | 3 |
| Dinoflagellates have 2 flagella, one is placed in the longitudinal groove and one is placed in the transverse groove. |   |
| **125.** | 2 |
| Sac fungi - Ascomycetes |   |
| **126.** | 2 |
| Eukaryotes are assigned to Kingdom Protista, Fungi, Plantae and Animalia. |   |
| **127.** | 1 |
| Mycorrhiza is symbiotic association of fungi with roots of higher plants like gymnosperms and angiosperms. |   |
| **128.** | 2 |
| Archaea has some novel features unique to them like, presence of Pseudopeptidoglycan in cell wall, presence of branched chain lipids in membrane etc. |   |
| **129.** | 2 |
| During budding, a bud developed on a yeast cell may form another bud itself, even before detaching from the parent cell. It gives an appearance of a multicellular structure, called pseudomycelium |   |
| **130.** | 2 |
| Mycoplasma is resistant to Penicillin since they lack a cell wall |   |
| **131.** | 3 |
| Paramoecium and Plasmodium belong to kingdom Protista, Penicillum belongs to Fungi  
Lichen is a symbiosis of fungi and algae  
Nostoc and Anabaena are examples of Monera (Cyanobacteria) |   |
| **132.** | 3 |
| Trypanosoma, Giardia, Monocystis- Flagellated protozoans  
Noctiluca-Diatom  
(All belong to Protista) |   |
| **133.** | 3 |
| Mucor is a lower fungi, does not show dikaryophase. |   |
| **134.** | 2 |
| Rhizobium- Symbiotic bacteria  
Yeast- production of alcohol  
Myxomycetes (slime moulds) are saprophytic. Ring worm is caused by Fungi |   |
| **135.** | 4 |
| Archeabacteria are extremophiles and prevail in extreme conditions, like deep sea, hot thermal vents etc. |   |