

PACE-IIT & MEDICAL

MUMBAI / DELHI-NCR / PUNE / HYDERABAD / AKOLA / GOA / JALGOAN / BOKARO / AMRAVATI / PATNA / BARAMATI

IIT – JEE: 2027

MAJOR TEST - 1

DATE: 27/07/25

ANSWER KEY

PAPER – 2 (CODE: 21)

MATHEMATICS

Q. No.	1	2	3	4	5	6	7	8	9	10
Ans.	A	C	B	B	AB	BCD	AB	1	8	3
Q. No.	11	12	13	14	15	16	17			
Ans.	0	2	98	2	5	8	4			

PHYSICS

Q. No.	18	19	20	21	22	23	24	25	26	27
Ans.	D	A	D	A	ABCD	AC	ABC	13	37	3
Q. No.	28	29	30	31	32	33	34			
Ans.	60	0	30	60	45	37	5			

CHEMISTRY

Q. No.	35	36	37	38	39	40	41	42	43	44
Ans.	C	A	B	C	ABCD	ACD	ABCD	3	2	10
Q. No.	45	46	47	48	49	50	51			
Ans.	9	2	4	5.25 - 5.30	4	40	45			

1. (A)

$$\tan \frac{\pi}{28} \tan \frac{2\pi}{28} \dots \tan \frac{13\pi}{28}$$

$$\left(\tan \frac{\pi}{28} \cot \frac{\pi}{28} \right) \left(\tan \frac{2\pi}{28} \cot \frac{2\pi}{28} \right) \dots \tan \frac{\pi}{4} = 1$$

2. (C)

$$32 \sin \frac{A}{2} \sin \frac{5A}{2} = 16 [\cos 2A - \cos 3A]$$

$$= 16 \left[(2 \cos^2 A - 1) - (4 \cos^3 A - 3 \cos A) \right]$$

$$= 16 \left[\left(2 \frac{9}{16} - 1 \right) - \left(4 \cdot \frac{27}{64} - 3 \cdot \frac{3}{4} \right) \right]$$

$$= 2 - 16 \left(\frac{27}{16} - \frac{36}{16} \right) = 2 + 9 = 11$$

3. (B)

4. (B)

$$f(-1) = 1 + 2a - 3 + a = 3a - 2$$

$$\hat{f}(2) = 4 + 6 - 4a + a = 10 - 3a$$

Case I

$$\hat{f}(-1)f(2) < 0 \Rightarrow (3a - 2)(10 - 3a) < 0$$

$$\Rightarrow a \in \left(-\infty, \frac{2}{3} \right) \cup \left(\frac{10}{3}, \infty \right)$$

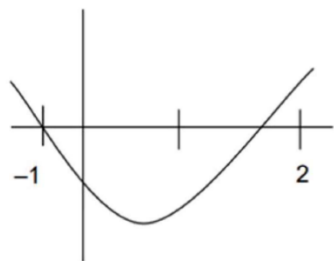
Case II

$$f(-1) = 0 \Rightarrow a = \frac{2}{3}$$

$$f(2) = 10 - 3a = 10 - 2 = 8 > 0$$

Also, x- coordinate of vertex lies in $(-1, 2)$

$\Rightarrow$ Exactly one root lies between -1 and 2 for this value $a \left(= \frac{2}{3} \right)$



Case III

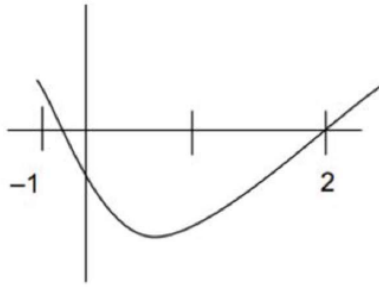
$$f(2) = 0 \Rightarrow a = \frac{10}{3}$$

$$f(-1) = 3a - 2 - 3 \left(\frac{10}{3} \right) - 2 = 8 > 0$$

$$X - \text{coordinate of vertex} = \frac{2a - 3}{2} = \frac{11}{6} < 2$$

$\Rightarrow$ Exactly one root lies between -1 and 2 for this value of $a\left(\frac{10}{3}\right)$

$$\therefore a \in \left(-\infty, \frac{2}{3}\right] \cup \left[\frac{10}{3}, \infty\right)$$



5. (AB)

(A) 1 Radian = 57.16 (approx.)

$$\sin 1 > \sin 5^\circ$$

(B) $\cos 3$ is $-ve$ so LHS is $-ve$ and RHS is $+ve$

(C) $\tan 1 + \tan 4$ is $+ve$ $\tan 2$ $-ve$

(D) $\tan 3 > \tan 1^\circ$ $-ve$ $+ve$

6. (BCD)

$$x = \frac{1 - \sin \phi}{\cos \phi} \quad \& \quad y = \frac{(1 + \cos \phi)}{\sin \phi}$$

$$x = \frac{1 - \cos(90^\circ - \phi)}{\sin(90^\circ - \phi)} \quad \& \quad y = \frac{2 \cos^2 \frac{\phi}{2}}{2 \sin \frac{\phi}{2} \cos \frac{\phi}{2}}$$

$$x = \frac{2 \sin^2 \left(45^\circ - \frac{\phi}{2}\right)}{2 \sin \left(45^\circ - \frac{\phi}{2}\right) \cos \left(45^\circ - \frac{\phi}{2}\right)} \quad \& \quad y = \frac{1}{\tan \frac{\phi}{2}}$$

$$x = \tan \left(45^\circ - \frac{\phi}{2}\right)$$

$$x = \frac{\left(1 - \frac{1}{y}\right)}{\left(1 + \frac{1}{y}\right)} \Rightarrow x = \frac{(y-1)}{(y+1)}$$

7. (A, B)

Let the common root be y . Then $y^2 + py + q = 0$ and $y^2 + \alpha y + \beta = 0$

On solving by cross multiplication, we have

$$\frac{y^2}{p\beta - q\alpha} = \frac{y}{q - \beta} = \frac{1}{\alpha - p}$$

$$\therefore y = \frac{q - \beta}{\alpha - p} \quad \text{and} \quad \frac{y^2}{y} = y = \frac{p\beta - q\alpha}{q - \beta}$$

8. (1)
 $M = \cot \alpha \cdot \cot(2\alpha) \cdots \cot(2n-2)\alpha \cdot \cot(2n-1)\alpha$

$$\left\{ \begin{array}{l} \because 4n\alpha = \pi \\ \therefore 2n\alpha = \frac{\pi}{2} \end{array} \right\}$$

 $\therefore M = \cot \alpha \cdot \cot(2\alpha) \cdots \cot\left(\frac{\pi}{2} - 2\alpha\right) \cdot \cot\left(\frac{\pi}{2} - \alpha\right)$
 $M = \cot \alpha \cdot \cot(2\alpha) \cdots \tan(2\alpha) \cdot \tan(\alpha)$
 $M = 1$
 $\therefore M^{100} = 1^{100}$
 $\Rightarrow M^{100} = 1$

9. (8)
 Use the formula $\cot \theta - \tan \theta = 2 \cot 2\theta$ and we know that
 $(1 + \tan \theta)(1 + \tan(45^\circ - \theta)) = 2$
 $(2 + \cot 41.5^\circ - \cot 48.5^\circ)(2 + \cot 26^\circ - \cot 64^\circ)$
 $= (2 + 2 \cot 83^\circ)(2 + 2 \cot 52^\circ)$
 $= 4(1 + \tan 7^\circ)(1 + \tan 38^\circ) = 8$

10. (3)
 Given $2\left(\sin \frac{A+B}{2} \cos \frac{A-B}{2} + \sin \frac{C+D}{2} \cdot \cos \frac{C-D}{2}\right) = 2 \times 2$
 $\Rightarrow \sin A + \sin B + \sin C + \sin D = 4$
 $\Rightarrow \sin A = \sin B = \sin C = \sin D = 1$
 $\Rightarrow \angle A = \angle B = \angle C = \angle D = 90^\circ$
 $\therefore \sum \cos \frac{A}{2} \cos \frac{B}{2} = \sum \cos^2 45^\circ = 6\left(\frac{1}{\sqrt{2}}\right)^2 = 3$

11. (0)
 If $x^2 + \lambda x + 1 = 0$; $\lambda \in (-2, 2)$ then both roots are imaginary....
 Let roots of this equation be α and β so $\alpha + \beta = -\lambda$ and $\beta\alpha = 1$
 Now cubic $4x^3 + 3x + 2c = 0$ has roots α, β, γ with $\alpha\beta\gamma = -\frac{2c}{4} = -\frac{c}{2}$ and $\alpha + \beta + \gamma = 0$
 Hence $\lambda + \frac{c}{2} = 0$

12. (2)
 Let α, β be the roots of the equation
 $(a+1)x^2 + (2a+3)x + (3a+4) = 0$. Then,
 $\alpha + \beta = -1 \Rightarrow -\left(\frac{2a+3}{a+1}\right) = -1 \Rightarrow a = -2$
 $\therefore$ Product of the roots $= \frac{3a+4}{a+1} = \frac{-6+4}{-2+1} = 2$

13. (98)

$$x^2 - 4\lambda x + 5 = 0 \begin{cases} \alpha \\ \beta \end{cases}$$

$$x^2 - (3\sqrt{2} + 2\sqrt{3})x + (7 + 3\lambda\sqrt{3}) = 0 \begin{cases} \alpha \\ \gamma \end{cases}$$

$$\alpha + \beta = 4\lambda$$

$$\alpha + \gamma = 3\sqrt{2} + 2\sqrt{3}$$

$$\beta + \gamma = 3\sqrt{2} \quad \alpha\gamma = 7 + 3\lambda\sqrt{3}$$

$$\therefore \alpha = 2\lambda + \sqrt{3} \quad \alpha\beta = 5$$

$$\beta = 2\lambda - \sqrt{3} \quad 4\lambda^2 = 8 \Rightarrow \lambda = \sqrt{2}$$

$$\therefore (\alpha + 2\beta + \gamma)^2 = (4\lambda + 3\sqrt{2})^2 = (7\sqrt{2})^2 = 98$$

14. (2)

$$x^3 - x^2(1 + \sin \theta + \cos \theta) + x(\sin \theta + \cos \theta + \sin \theta \cos \theta) - \sin \theta \cos \theta = 0$$

$$\Rightarrow \text{Roots are } 1, \sin \theta, \cos \theta$$

$$\alpha^2 + \beta^2 + \gamma^2 = 1 + \sin^2 \theta + \cos^2 \theta = 2$$

15. (5)

$$x^3 - x^2(1 + \sin \theta + \cos \theta) + x(\sin \theta + \cos \theta + \sin \theta \cos \theta) - \sin \theta \cos \theta = 0$$

$$\Rightarrow \text{Roots are } 1, \sin \theta, \cos \theta$$

For at least 2 to be equal

$$\sin \theta = 1 \text{ or } \cos \theta = 1 \text{ or } \sin \theta = \cos \theta \text{ or } \sin \theta = \cos \theta = 1$$

$$\sin \theta = 1 \Rightarrow \theta = \frac{\pi}{2}$$

$$\cos \theta = 1 \Rightarrow \theta = 0, 2\pi$$

$$\sin \theta = \cos \theta \Rightarrow \theta = \frac{\pi}{4}, \frac{5\pi}{4}$$

$$\sin \theta = \cos \theta = 1$$

16. (8)

$$f(6) = 8(\cos^6 \theta - \sin^6 \theta)$$

$$= 8(\cos^2 \theta - \sin^2 \theta)(\cos^4 \theta + \sin^4 \theta + \sin^2 \theta \cos^2 \theta)$$

$$= 8 \cos 2\theta \left(1 - \frac{\sin^2 2\theta}{4} \right)$$

$$= 8 \cos 2\theta \left(1 - \frac{1 - \cos 4\theta}{8} \right)$$

$$= \cos 2\theta (8 - 1 + \cos 4\theta)$$

$$= 7 \cos 2\theta + \cos 4\theta \cos 2\theta$$

$$= 7 \cos 2\theta + \frac{\cos 6\theta + \cos 2\theta}{2}$$

$$= \frac{15}{2} \cos 2\theta + \frac{1}{2} \cos 6\theta$$

$$a + b = 8$$

17. (4)

$$\frac{g(6)}{2} + 3\sin^2 2\theta$$

$$= \frac{8(\cos^6 \theta + \sin^6 \theta)}{2} + 3\sin^2 2\theta \Rightarrow 4\left(1 - \frac{3}{4}\sin^2 2\theta\right) + 3\sin^2 2\theta$$

PART (B) : PHYSICS

18. (D)

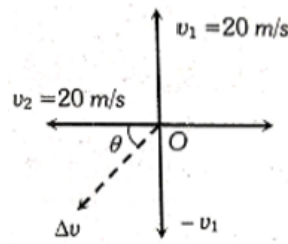
From figure

$$\vec{v}_1 = 20\hat{j} \text{ and } \vec{v}_2 = -20\hat{j}$$

$$\Delta\vec{v} = \vec{v}_2 - \vec{v}_1 = -20(\hat{i} + \hat{j})$$

$$|\Delta\vec{v}| = 20\sqrt{2} \text{ and direction}$$

$$\theta = \tan^{-1}(1) = 45^\circ \text{ i.e. S-W}$$



19. (A)

Here, $\vec{P} + b\vec{R} = \vec{S} \Rightarrow \vec{R} = \frac{\vec{S} - \vec{P}}{b}$

Also $\vec{R} = \vec{Q} - \vec{P}$

$$\therefore \frac{\vec{S} - \vec{P}}{b} = \vec{Q} - \vec{P} \Rightarrow \vec{S} - \vec{P} = b\vec{Q} - b\vec{P}$$

$$\therefore \vec{S} = b\vec{Q} + (1-b)\vec{P}$$

20. (D)

$$\vec{v}_{\text{ball, train}} = \vec{v}_{\text{ball}} - \vec{v}_{\text{train}}$$

or $\vec{v}_{\text{ball}} = \vec{v}_{\text{ball, train}} + \vec{v}_{\text{train}}$

Since ball moves in vertical direction its x-component of velocity must vanish

$$v_{bx} = v \cos 60^\circ - v_T = 0 \quad \dots(1)$$

and $v_{by} = v \sin 60^\circ \quad \dots(2)$

From eqn. (1),

$$v = \frac{v_T}{\cos 60^\circ} = 20 \text{ m/s}$$

and $v_{by} = (20) \sin 60^\circ$

$$= \frac{20\sqrt{3}}{2} \text{ m/s}$$

Maximum height reached by ball

$$= \frac{(v_{by})^2}{2g}$$

$$= \frac{(20\sqrt{3}/2)^2}{2 \times 9.8}$$

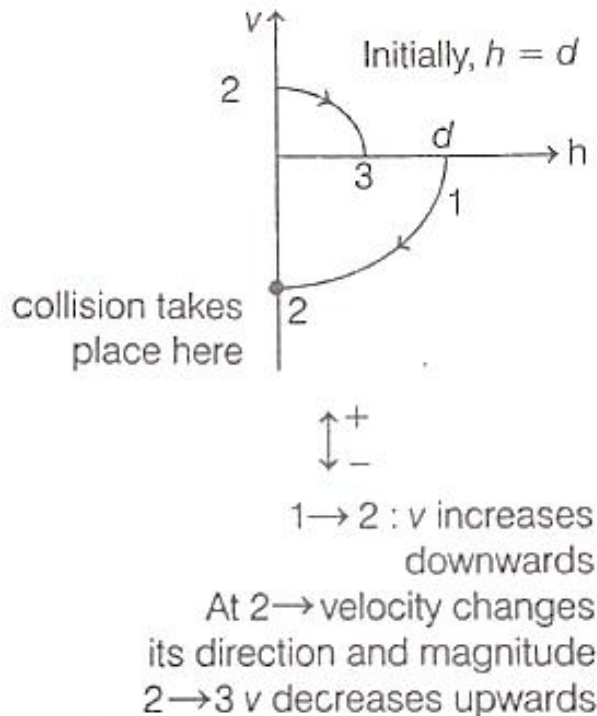
$$= 15.30 \text{ m}$$

21. (A)
For uniformly
accelerated / decelerated motion

$$v^2 = u^2 \pm 2gh$$

i.e. v - h graph will be a parabola (because equation is quadratic).

Initially velocity is downwards (-ve) and then after collision, it reverses its direction with lesser magnitude, i.e. velocity is upwards (+ve). Graph (a) satisfies both these conditions.



22. (A, B, C, D)
They will always lie on a regular octagon but side of octagon will keep decreasing.

Velocity of approach of two adjacent particle is $v - v \cos\left(\frac{2\pi}{8}\right)$

$$v_{\text{app}} = v \left(1 - \frac{1}{\sqrt{2}}\right)$$

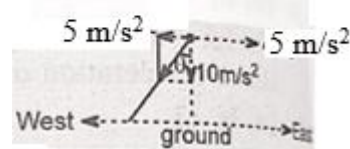
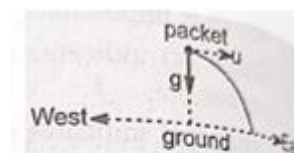
Finally all will meet at the centroid,

$$t = \frac{a}{v_{\text{app}}} = \frac{10}{1 - \frac{1}{\sqrt{2}}} = \frac{10\sqrt{2}}{\sqrt{2} - 1} \text{ s}$$

23. (A, C)
If the velocity of aeroplane is u m/s when the packet is dropped then path of packet is parabolic with respect to ground as shown in figure.

With respect to aeroplane the initial velocity of the packet is zero and acceleration is as shown in figure.

$$\theta = \tan^{-1} \frac{5}{10} = \tan^{-1} \frac{1}{2} \text{ west of vertical.}$$



24. (A, B, C)

$$a = \frac{dv}{dt} = A - Bv$$

→ max. possible velocity is terminal velocity (i.e., when $a = 0$)

$$\Rightarrow A - Bv = 0$$

→ initial acc. is when $t = 0, u = 0$

$$\therefore a = A - 0 = A \text{ m/s}^2$$

$$\rightarrow \frac{dv}{dt} = A - Bv \Rightarrow \int_0^v \frac{dv}{A - Bv} = \int_0^t dt$$

$$\Rightarrow \frac{1}{B} \ln \frac{A - Bv}{A} = -t \Rightarrow 1 - \frac{B}{A}v = e^{-Bt}$$

$$\Rightarrow \frac{A}{B}(1 - e^{-Bt}) = v$$

25. (13)

$$\text{i.e., } 2 = (v \cos \theta - 13)t$$

$$\text{and } 3 = v \sin \theta t$$

On eliminating v from eqns. (1) and (2), we get

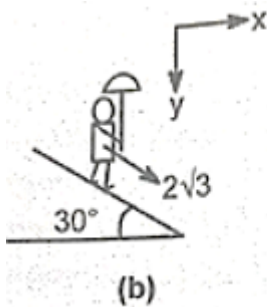
$$t = \frac{1}{13} \left(\frac{3}{\tan \theta} - 2 \right) = \frac{2}{13}$$

26. (37)

$$\vec{v}_{R/M} = x \hat{j} = \vec{v}_R - \vec{v}_M$$

$$\vec{v}_M = 2\sqrt{3} [\cos 30^\circ \hat{i} + \sin 30^\circ \hat{j}] = 3\hat{i} + \sqrt{3}\hat{j}$$

$$\Rightarrow \vec{v}_R = -3\hat{i} + (x - \sqrt{3})\hat{j}$$



$$5 = \sqrt{3^2 + (x - \sqrt{3})^2}$$

$$\Rightarrow 16 = (x - \sqrt{3})^2$$

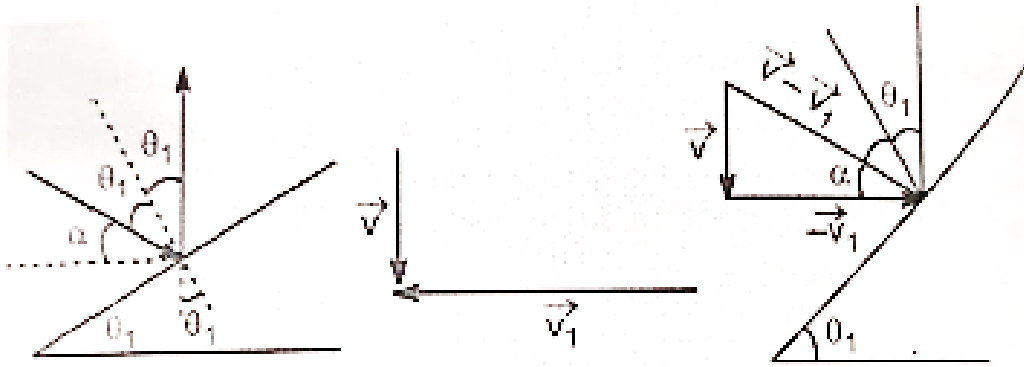
$$\Rightarrow 4 + \sqrt{3} = x$$

$$\vec{v}_R = -3\hat{i} + 4\hat{j}$$

$$\tan \theta = 3/4$$

$$\Rightarrow \theta = 37^\circ$$

27. (3)



From figure,

$$\alpha + 2\theta_1 = \frac{\pi}{2}$$

and $\tan \alpha = \frac{v}{v_1}$

Hence $\tan \alpha = \tan \left(\frac{\pi}{2} - 2\theta_1 \right)$
 $= \cot 2\theta_1$

or $\frac{v}{v_1} = \cot 2\theta_1$

Similarly for second car,

$$\frac{v}{v_2} = \cot 2\theta_2$$

28. (60)

At highest point, $v_1 = u \cos \theta$ at $y = \frac{h}{2} \text{ max}$, $v_y^2 = u^2 \sin^2 \theta - 2g \frac{h_{\text{max}}}{2}$

$$h_{\text{max}} = \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore v_y^2 = u^2 \sin^2 \theta - \frac{2g}{2} \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore v_y = \frac{u \sin \theta}{\sqrt{2}}$$

Resultant velocity at $y = \frac{h_{\text{max}}}{2}$

$$v_2 = \sqrt{v_x^2 + v_y^2} = \sqrt{u^2 \cos^2 \theta + \frac{u^2 \sin^2 \theta}{2}}$$

$$\frac{v_1}{v_2} = \frac{\sqrt{2}}{\sqrt{5}} = \frac{u \cos \theta}{\sqrt{u^2 \cos^2 \theta + \frac{u^2 \sin^2 \theta}{2}}}$$

$$\therefore \frac{2}{5} = \frac{u^2 \cos^2 \theta}{u^2 \cos^2 \theta + u^2 \sin^2 \theta}$$

$$\therefore \tan^2 \theta = 3$$

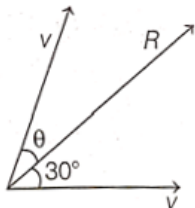
$$\therefore \tan \theta = \sqrt{3}$$

$$\theta = 60^\circ$$

29. (0)
Let angle between the two vectors be θ

$$\begin{aligned}\therefore 3^2 &= 7^2 + 4^2 + 2 \times 7 \times 4 \cos \theta \\ \cos \theta &= -1 \\ \Rightarrow \theta &= 180^\circ \\ \therefore \text{Cross product will be zero.}\end{aligned}$$

30. (30)
As per question, magnitude of velocity of the swimmer is same as that of the river.
So resultant would pass exactly midway through them
 $\therefore$ Angle $\theta = 30^\circ$



31. (60)
Range of stone as observed from ground

$$\begin{aligned}R &= (10 \cos \theta + 10) \frac{2 \times 10 \times \sin \theta}{g} \\ &= (\cos \theta + 1) 20 \sin \theta \\ \frac{dR}{d\theta} &= 20 \sin \theta \times (-\sin \theta) + 20 \cos \theta (\cos \theta + 1) \\ &= 20 \cos^2 \theta - 20 \sin^2 \theta + 20 \cos \theta = 0\end{aligned}$$

$$\Rightarrow 2 \cos^2 \theta + \cos \theta - 1 = 0$$

$$\Rightarrow \cos \theta = \frac{1}{2} \Rightarrow \theta = 60^\circ$$

$$\left(\frac{d^2 R}{d\theta^2} \right)_{\theta=60^\circ} = -ve$$

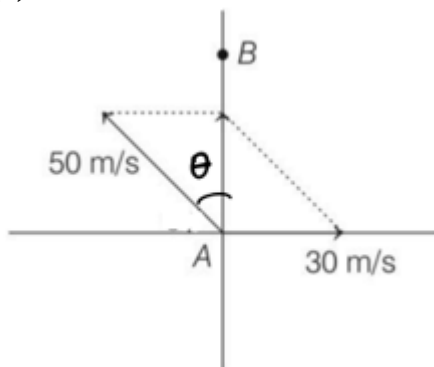
$$\Rightarrow \text{maximum } R \text{ at } \theta = 60^\circ$$

32. (45)
w.r.t boat it is just an simple projectile motion
 $\therefore$ Range is maximum for $\theta = 45^\circ$

Solution of Que. 33 & 34:

33. (37)

34. (5)



$$50 \sin \theta = 30$$

$\theta = 37^\circ$ with north

$$\text{Time taken} = \frac{720}{50 \cos \theta \times \frac{18}{5}} = 5 \text{ h}$$

PART (C) : CHEMISTRY

35. (C)

$$\sqrt{v} = aZ - ab \quad ab = 1, \quad a = \tan 45^\circ = 1$$
$$\sqrt{v} = 1(51) - 1 = 50$$
$$\therefore v = (50)^2 = 2500 \text{ s}^{-1}$$

36. (A)

37. (B)

38. (C)

39. (A, B, C, D)

40. (A, C, D)

41. (A, B, C, D)

42. (3)

43. (2)

44. (10)

	1s	2s	2p	3s	3p	4s
$n + \ell$ value	$1 + 0 = 1$	$2 + 0 = 2$	$2 + 1 = 3$	$3 + 0 = 3$	$3 + 1 = 4$	$4 + 0 = 4$
No. of orbitals	1	1	3	1	3	1

Total no. of orbitals = 10

45. (9)

46. (2)

47. (4)

$2s^2 2p^6 = 8$ electrons total out of which will have $m = -\frac{1}{2}$

48. (5.25 – 5.30)

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta p \geq \frac{h}{4\pi \Delta x}$$

$$\Delta p = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 10^{-10}}$$

49. (4)

$$\Delta x_A \cdot m_A \Delta v_A = \Delta X_B \cdot \Delta V_B \quad \Delta V_B = \Delta V_A$$

$$\frac{\Delta X_A}{\Delta X_B} = \frac{N_B}{M_A} = \frac{1.0 \times 10^{-31}}{1.0 \times 10^{-27}} = 10^{-4}$$

50. (40)
10 different radiations means 5 energy levels are involved.

Let's take $n_1 = n$

Then $n_2 = n + 4$

$$-0.544 = -13.6 \times \left(\frac{1}{5}\right)^2 = -13.6 \times \frac{z^2}{(n+4)^2} \quad \dots(1)$$

$$-0.85 = -13.4 \left(\frac{1}{4}\right)^2 = -13.6 \frac{z^2}{n^2} \quad \dots(2)$$

Solving (1) and (2)

We get to $n = 16$ and $z = 4$

Now, $n_1 = 16$, $n_2 = n + 4 = 20$, $z = 4$

$$z + n_1 + n_2 = 4 + 16 + 20 = 40$$

51. (45)

$$(E_{\text{photon}})_{\text{emitted from He}^+} = 13.6 \times 4 \left\{ \frac{1}{1} - \frac{1}{4} \right\} = 40.8 \text{ eV}$$

Now this photon is being used to ionize H-atom.

$$\text{K.E.}_{\text{ejected e}^-} = E_{\text{photon}} - \text{I.E.}$$

$$= 40.8 - 13.6 = 27.2 \text{ eV}$$

$$\lambda_{\text{de-Broglie}} = \sqrt{\frac{150}{V}} = \sqrt{\frac{150}{27.2}} \text{ \AA} = x$$

$$\text{Now, } 8.16x^2 = 45$$