INDIAN ASSOCIATION OF PHYSICS TEACHERS
National Standard Examination in Physics -2023
Question Paper Code: 61

FIITJEE ANSWERS KEYS

1.	**(c)**	2.	**(b)**	3.	**(c)**	4.	**(d)**
5.	**(a)**	6.	**(c)**	7.	**(b)**	8.	**(d)**
9.	**(a)**	10.	**(a)**	11.	**(b)**	12.	**(b)**
13.	**(a)**	14.	**(b)**	15.	**(b)**	16.	**(c)**
17.	**(c)**	18.	**(b)**	19.	**(a)**	20.	**(d)**
21.	**(b)**	22.	**(b)**	23.	**(a)**	24.	**(a)**
25.	**(a)**	26.	**(b)**	27.	**(b)**	28.	**(d)**
29.	**(a)**	30.	**(c)**	31.	**(d)**	32.	**(c)**
33.	**(c)**	34.	**(c)**	35.	**(c)**	36.	**(a)**
37.	**(d)**	38.	**(d)**	39.	**(b)**	40	**(a)**
41.	**(d)**	42.	**(a)**	43.	**(a)**	44.	**(c)**
45.	**(c)**	46.	**(d)**	47.	**(d)**	48.	**(d)**
49.	**(c, d)**	50.	**(a, b, c, d)**	51.	**(c, d)**	52.	**(a, b, d)**
53.	**(a, c, d)**	54.	**(b, c)**	55.	**(b, d)**	56.	**(a, d)**
57.	**(a, b, c, d)**	58.	**(a, b, c)**	59.	**(a, b, c, d)**	60.	**(a, b, c)**

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FIITJEE SOLUTIONS

1. (c)

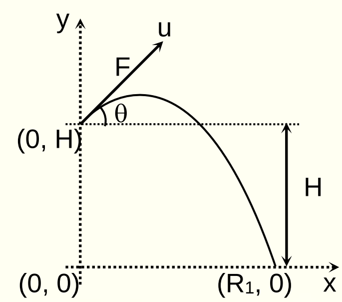
For first ball

$$\Delta\vec{r} = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$R_1\hat{i} - H\hat{j} = (u\cos\theta\hat{i} + u\sin\theta\hat{j})t_1 - \frac{1}{2}g\hat{j}t_1^2$$

$$R_1 = (u\cos\theta)t_1 \quad \text{...(i)}$$

$$-H = (u\sin\theta)t_1 - \frac{1}{2}gt_1^2 \quad \text{...(ii)}$$



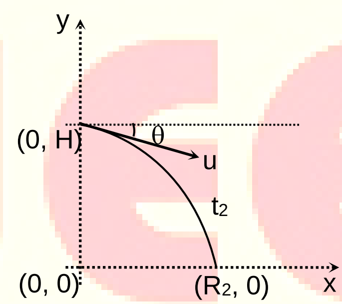
For the second ball

$$\Delta\vec{r} = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$R_2\hat{i} - H\hat{j} = (u\cos\theta\hat{i} - u\sin\theta\hat{j})t_2 - \frac{1}{2}g\hat{j}t_2^2$$

$$R_2 = u(\cos\theta)t_2 \quad \text{...(iii)}$$

$$H = (u\sin\theta)t_2 + \frac{1}{2}gt_2^2 \quad \text{...(iv)}$$



From equation (ii) and (iv)

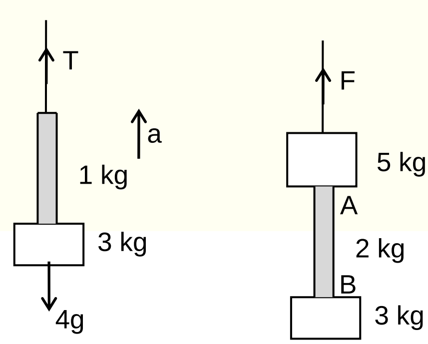
$$t_1 - t_2 = \frac{2u\sin\theta}{g}$$

From (i) and (iii)

$$\Delta R = R_1 - R_2 = u\cos\theta \cdot \frac{2u\sin\theta}{g} = \frac{u^2\sin 2\theta}{g}$$

2. (b)

$T - 4g = 4a$
$T = 4(a + g)$
$T = 4(2.19 + 9.81)$
$T = 48$ N



3. (c)

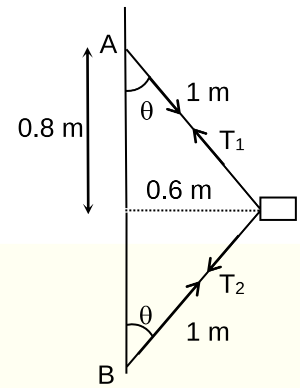
$T_1\cos\theta - T_2\cos\theta = mg$

$T_1 - T_2 = \left(\frac{mg}{0.8}\right)$ ...(i)

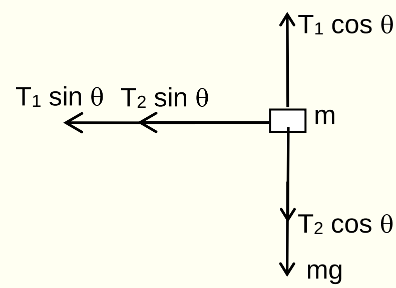
$T_1\sin\theta + T_2\sin\theta = m(0.6)\omega^2$

$T_1\sin\theta + T_2\sin\theta = m(0.6)\left(\frac{2\pi}{1.2}\right)^2$

$T_1 + T_2 = m\left(\frac{2\pi}{1.2}\right)^2$ ...(ii)



From (i) and (ii)
T_1 = 7.94 N and T_2 = 3.03 N



4. (d)

$P = \vec{F}\cdot\vec{v}$

P = Fv cos 0°

P = mav

mav = P

$m\frac{dv}{dt}v = P$

$\int_0^v mvdv = \int_0^t Pdt$

$\frac{mv^2}{2} = Pt$

$v = \sqrt{\frac{2P}{m}}t^{1/2}$

$\int_0^S dS = \sqrt{\frac{2P}{m}}\int_0^t t^{1/2}dt$

$S = \left(\frac{8pt^3}{9m}\right)^{1/2}$

5. (a)

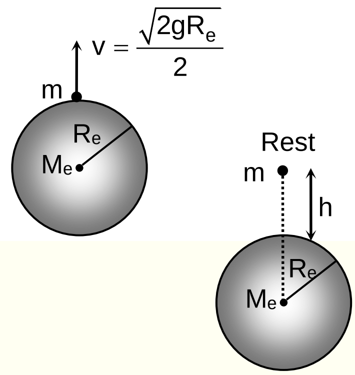
Using conservation of mechanical energy

$$\frac{1}{2}m\left(\frac{\sqrt{2gRe}}{2}\right)^2 - \frac{GM_em}{R_e} = -\frac{GM_em}{(R_e+h)} \quad \ldots(i)$$

$$g = \frac{GM_e}{R_e^2} \quad \ldots(ii)$$

From (i) and (ii)

$$h = \frac{R_e}{3}$$

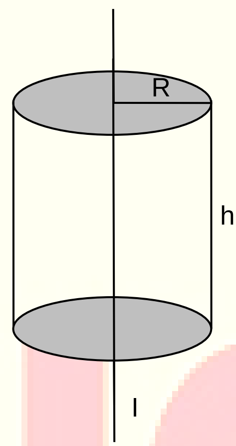


6. (c)

$I \rightarrow$ moment of inertia about vertical axis

$$I = 2\left[\frac{\sigma(\pi R^2)R^2}{2}\right] + \left[\sigma(2\pi Rh)\right]R^2$$

$$I = \sigma.\pi R^3(R+2h)$$



7. (b)

$$\frac{mv^2}{r} = 2Mg \quad \ldots(i)$$

$$\frac{mv'^2}{r'} = Mg \quad \ldots(ii)$$

From (i) and (ii)

$$v^2r' = 2v'^2r \quad \ldots(iii)$$

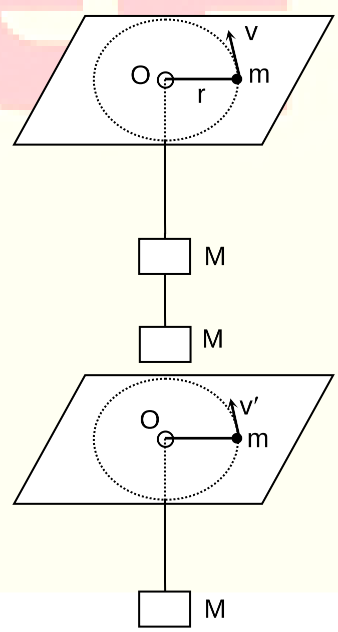
Conservation of angular momentum about O

mvr = mv′r′

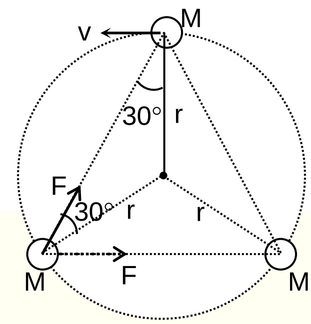
vr = v′r′ $\quad \ldots(iv)$

from (iii) and (iv)

$$r' = (2)^{1/3}\,r$$



8. (d)



$$2F\cos 30^\circ = \frac{Mv^2}{r}$$

$$\frac{2GMM}{\left(2r\frac{\sqrt{3}}{2}\right)^2}\left(\frac{\sqrt{3}}{2}\right) = \frac{Mv^2}{r}$$

$$\frac{\sqrt{3}GM^2}{3r^2} = Mr\omega^2$$

$$\omega^2 = \frac{\sqrt{3}GM}{3r^3}$$

$$\omega = \left(\frac{GM}{r^3\sqrt{3}}\right)^{1/2}$$

9. (a)

$$B = \frac{\Delta P}{-\Delta V / V}$$

$$-\frac{\Delta V}{V} = \frac{\Delta P}{B} \quad \ldots(i)$$

ρV = constant

$\rho dV + V d\rho = 0$

$$-\frac{dV}{V} = \frac{d\rho}{\rho} \quad \ldots(ii)$$

$$\frac{\Delta\rho}{\rho} = -\frac{\Delta V}{V} = \frac{\rho gh}{B}$$

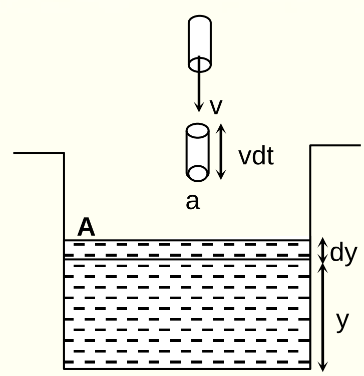
$$\Delta\rho = \frac{\rho^2 gh}{B}$$

10. (a)

avdt = Ady

a $\rightarrow$ area of the hose

A $\rightarrow$ Area of the cylindrical container



$$\int dt = \left(\frac{A}{av}\right)\int_0^h dy$$

$$t = \frac{A}{av}\cdot h$$

$$t = \frac{\pi(2)^2(1.25)}{\pi\left(\frac{1.59}{2}\times 10^{-2}\right)^2(1.2)}\text{ sec}$$

t = 65925.66 sec

$$t = \frac{65925.66}{60\times 60} = 18.3\text{ hour}$$

11. (b)

$$v_T = 72\times\frac{5}{18} = 20\text{ m/s},\ v_C = 108\times\frac{5}{18} = 30\text{ m/s}$$

$$\frac{v_{27}}{v_0} = \sqrt{\frac{300}{273}}$$

$$\Rightarrow v_{27} = 332\sqrt{\frac{300}{227}} = 348 \text{ m/s}$$

$$\Delta f = 800\left[\frac{348+20}{348-30} - \frac{348-20}{348+30}\right] = 800\left[\frac{368}{318} - \frac{328}{378}\right]$$

$$= 800\left[1.157 - 0.867\right] = 232 \text{ Hz (decreases)}$$

12. (b)

$$v = \sqrt{\frac{\mu g x}{\mu}} = \sqrt{gx} = \sqrt{2\frac{g}{2}x}$$

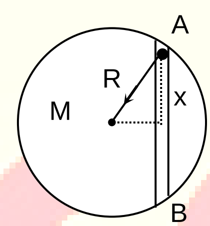
$$L = \frac{1}{2}\frac{g}{2}T^2$$

$$T = 2\sqrt{\frac{L}{g}}$$

13. (a)

$$\vec{a} = -\frac{GM\vec{x}}{R^3}, \text{ So, } T = 2\pi\sqrt{\frac{R}{g}}$$

So, time required = $\pi\sqrt{\frac{R}{g}}$



14. (b)

$80 = 10 \log\frac{I_1}{10^{-12}}$, So $I_1 = 10^{-4}$ W/m^2

$85 = 10 \log\frac{I_2}{10^{-12}}$, So $I_2 = 10^{-3.5}$ W/m^2

So, $I = 10^{-4} + 10^{-3.5} = 10^{-4}(1 + 10^{+0.5}) = 4.16 \times 10^{-4}$

$$I_{dB} = 10\log\left(\frac{4.16\times10^{-4}}{10^{-12}}\right) = 86.2 \text{ dB}$$

15. (b)

$$\omega = \sqrt{\frac{32}{0.5}} = 8 \text{ rad/s}$$

$$A = \frac{v_{max}}{\omega} = \frac{2}{8} = 0.25 \text{ m}$$

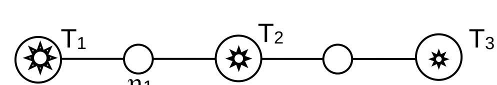
So, x = (0.25 m) sin (8t)

16. (c)

$-v\frac{\partial y}{\partial x} = \frac{\partial y}{\partial t}$ is not satisfied for option (c)

17. (c)

$\eta_1 = 1 - \frac{T_2}{T_1}$ So, $\frac{T_2}{T_1} = 1 - \eta_1$



$$\eta_2 = 1 - \frac{T_3}{T_2} \quad \text{So, } \frac{T_3}{T_2} = 1 - \eta_2$$

$$\eta = 1 - \frac{T_3}{T_1} = 1 - \frac{T_3}{T_2}\frac{T_2}{T_1} = 1 - (1-\eta_1)(1-\eta_2)$$

$$\eta = \eta_1 + \eta_2(1-\eta_1)$$

18. (b)

$$(r)^3 \frac{10^5}{273+16} = (2)^3 \frac{10^5 + 10^3 \times 10 \times 12}{273+8}$$

$$(r)^3 \frac{10^5}{289} = (2)^3 \frac{2.2 \times 10^5}{281}$$

$$r = (2)(1.3)\left(1 + \frac{8}{281 \times 3}\right) = 2.61\text{mm}$$

19. (a)

$$\left(P_A + \frac{4T}{a}\right)a^3 + \left(P_A + \frac{4T}{b}\right)b^3 = \left(P_A + \frac{4T}{c}\right)c^3$$

$$P_A a^3 + 4Ta^2 + P_A b^3 + 4Tb^2 = P_A c^3 + 4Tc^2$$

$$T = \frac{P_A}{4}\frac{(c^3 - a^3 - b^3)}{(a^2 + b^2 - c^2)}$$

20. (d)

$$\frac{2v}{2(0.3+0.6d)} = \frac{3v}{4(0.23+0.3d)} = 1100,$$

where v is speed of sound in air and d is diameter of the both the organ pipes

$$v = 1100(0.3+0.6d) = \left(\frac{4}{3}\right)(1100)(0.23+0.3d)$$

0.3 + 0.6d = 0.3067 + 0.4 d

d = 0.033 m

So, v = 1100(0.3+ 0.6d) = 352 m/s

21. (b)

$$H = -kA\frac{dT}{dx}$$

$$\frac{dT}{dx} = -\frac{H}{kA}$$

As area decreass with x

So, slope of θ versus x also decreases

22. (b)

W = nRΔT

$$W = nR\left(T - \frac{T}{4}\right) = 3nR\left(\frac{T}{4}\right)$$

23. (a)

Power radiated by sun

$P_s = \sigma 4\pi R_S^2 T^4$

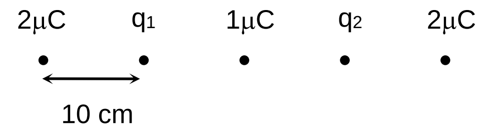
Power received by earth is

$$P = \frac{\sigma 4\pi R_S^2 T^4}{4\pi r^2} \cdot \pi R_E^2$$

$$P = \frac{\sigma\pi R_E^2 R_S^2 T^4}{r^2}$$

24. (a)

For equilibrium of 1μC, we can say both q_1 and q_2 are equal. For equilibrium of 2μC, q_1 and q_2 must be negative



$$\Rightarrow \frac{k(q_1)(2)}{r^2} + \frac{k(2)(1)}{4r^2} - \frac{k(2)(q_2)}{9r^2} + \frac{k(2)(2)}{16r^2} = 0$$

Solving we get

$$q_1 = q_2 = -\frac{27}{80}\mu C$$

25. (a)

Initially acceleration of system is

$$a = \left(\frac{m}{2M+m}\right)g$$

Speed gained when it falls through a distance H′ is

$$v = \sqrt{\frac{2mgH}{2M+m}}$$

When rider is caught by the ring, the acceleration of system is zero

$\therefore$ D = vt

$\Rightarrow D^2 = v^2t^2$

$$\Rightarrow D^2 = \frac{2mgH}{2M+m}t^2$$

$$g = \left(\frac{2M+m}{2mHt^2}\right)D^2$$

26. (b)

$$U = -\vec{p}\cdot\vec{E} = -\frac{pc}{x}$$

$$F = -\frac{dU}{dx} = -\frac{pc}{x^2}$$

$$\vec{F} = -\frac{c\vec{p}}{x^2}$$

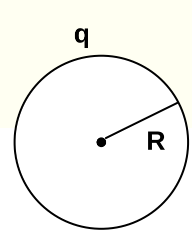
27. (b)

There is a charge $\sigma 4\pi a^2$ at the centre of the shell

Hence, electric field outside the shell is $E = \frac{\sigma b^2}{\varepsilon_0 r^2}$

28. (d)

Let R = radius of spherical conductor



$$\frac{kq}{R} = 450V \qquad \ldots(i)$$

$$\frac{kq}{R+0.15} = 300V \qquad \ldots(ii)$$

Solving (i) and (ii), we get

R = 30 cm, q = 15 nC

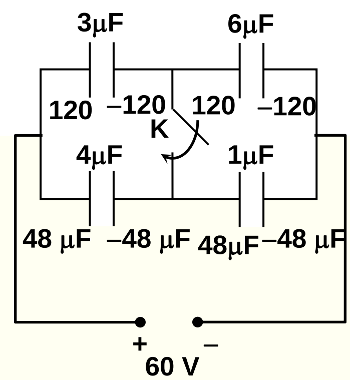
EF just outside the surface is

$$E = \frac{kq}{R^2} = 1500\ N/C$$

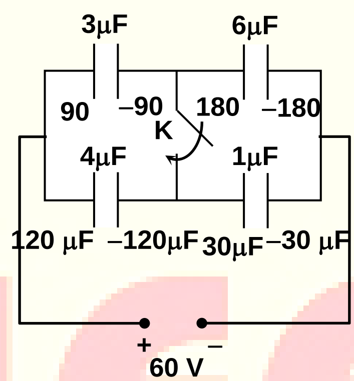
Total energy of conductor is

$U = \frac{kq^2}{2R} = 3.375\ \mu J$

29. (a)
Just before 'K' is closed



Just after 'K' is closed
∴ 90 μC charge flows from b to a



30. (c)
Band gap of semiconductors is
$E = \frac{hC}{\lambda} = \frac{1240\ eV - nm}{2480\ nm} = 0.50\ eV$

31. (d)
$mv = \int F dt$
$m\sqrt{2gH} = qB\ell$
$q = \frac{m\sqrt{2gH}}{\Delta\ell} = 3.84C$

32. (c)
Charge flow ⇒ $10^{-4} \times 60 \times 60 = 0.36$ C
Number of proton striking $N = \frac{0.36}{1.6\times10^{-19}} = \frac{9}{4}\times10^{18}$ proton.
$n = \frac{1}{1000} efficiency$
Number of Be formed. $= \frac{9}{4}\times10^{18}\times\frac{1}{1000} = \frac{9}{4}\times10^{15}$ proton.
Activity $A = \lambda N$
$\lambda \times \frac{9}{4}\times10^{15} = 1.8\times10^{8}$
$\lambda = 0.8\ 10^{-7}$

$T_{1/2} = \frac{0.693}{\lambda} = \frac{0.693}{0.8} \times 10^7 \sec = 2407 hrs.$

33. (c)

$M = \phi/I = \frac{\mu_0 c}{2\pi} \ln\left(\frac{b+a}{a}\right) = 139 nH$

34. (c)

$R^2 + \left(\omega_1 L - \frac{1}{\omega_1 C}\right)^2 = R^2 + \left(\frac{1}{\omega_{2c}} - \omega_2 L\right)^2$

$\omega_1 L + \omega_2 L = \frac{1}{\omega_2 C} + \frac{1}{\omega_1 C}$

$\omega_1\omega_2 = \frac{1}{LC}$

$\omega_r = \frac{1}{\sqrt{LC}} \quad \omega = \sqrt{\omega_1 \omega_2}$

$f_r = \sqrt{f_1 f_2}$.

35. (c)

$F - f = ma_{cm}$ ...(i)

$fR = I_{cm}\,\alpha$

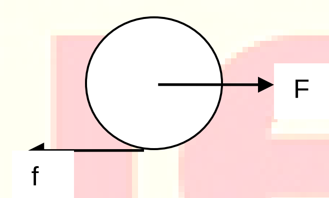
$a_{cm} = R\alpha$

$f = F/3$

$a = 2F/3M$

$\mu_{min}\, Mg = F/3$

$\mu_{min} = F/3\, Mg$.



36. (a)

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$mv = \frac{h}{\lambda} = \frac{6.67 \times 10^{-34} \times 24}{25 \times 914 \times 10^{-10}}$.

$v = \frac{6.67 \times 10^{-34} \times 24}{25 \times 914 \times 10^{-10} \times 1.67 \times 10^{-24}} \approx 4.2 m/s$

37. (d)

B May change to C by beta emission or position emission

38. (d)

39. (b)

40 (a)

Refraction by first surface

$\frac{1.5}{v} + \frac{1}{\infty} = \frac{1.5-1}{-7}$

V = – 21 cm

This image will be object for dot on rear surface.

For I[st] reflection
U = -21, v = ? f = 7/2

$$\frac{1}{v}-\frac{1}{21}=\frac{2}{7}$$

V = +3
This will be object for II[nd] reflection

$$\frac{1}{v}-\frac{1}{3}=\frac{2}{7}$$

$$\frac{1}{v}=\frac{2}{7}+\frac{1}{3}\Rightarrow\frac{13}{21}$$

v = 21/13
Now for refraction from rear surface

$$\frac{1}{v}-\frac{\mu}{u}=\frac{1-\mu}{R}$$

u = $\frac{-21}{17}$

$$\frac{1}{v}+\frac{1.5}{21}=\frac{1-1.5}{7}$$

V = -1 cm

41. (d)
Ray from focus becomes parallel after reflection hence planer wave front.

42. (a)
Case- 1
E_1 : If ray falls on L_1 u = - f , v = $\rightarrow\infty$
E_2: After refraction from L_1 ray falls on L_2
u $\rightarrow\infty$, v $\rightarrow$ f (i.e. f from L_2) or 3f from AB
Case-2: If only ray falls on L_1 u = -f , v $\rightarrow\infty$
Case-3: If only ray falls on L_2,

$$\frac{1}{v}-\frac{1}{-2f}=\frac{1}{f}$$

$\Rightarrow v=2f\quad(\textit{from lens } L_2)$ or, 4f from AB.

43. (a)

$2m_0c^2 = \frac{2hc}{\lambda}$

$\lambda = \frac{h}{m_0c}$

44. (c)

$$\frac{1}{f}=(1.5-1)\left(\frac{1}{-40}-\frac{1}{-20}\right)$$

f = 80 cm
$P_{pq} = 2P_L + P_m$

$$-\frac{1}{f_M}=\frac{2}{80}-\frac{1}{-10}$$

f_M = - 8 cm

Equivalent act as a concave mirror of focal length 8 cm. Hence, if object is placed at COC, image will coincide with object.

45. (c)
$\delta_{net} \Rightarrow \delta_1 - \delta_2 = 0$
$(\sqrt{2}-1)\theta_c - ((\sqrt{3}-1)3^0 = 0$
$\theta_c = 5.3^0$.

46. (d)
$\lambda_{min} = \dfrac{hc}{eV}$
If V increases, λ_{min} decreases and $\lambda_{k\alpha}$ is independent of V.

47. (d)
In (78, 98), virtual image is formed which can't obtained on screen.

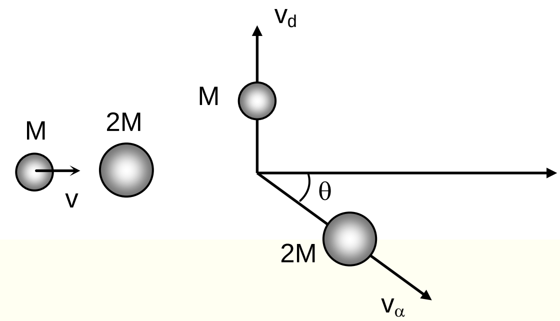
48. (d)
$I = \dfrac{6\times10^{-3}}{10^{-6}} = 6 \times 10^3$ (W/m^2)
Radiation pressure = 2I / C = 4×10^{-5}Pa.

49. (c, d)
$\dfrac{-dU}{dx} = F_x$
$\int_0^U dU = -\int_0^x F_x dx$
$U = -\int_0^x F_x dx$
At x = 2m, U = –8J
When $2 \le x \le 4$
$U + 8 = -\left[\frac{1}{2}\times1\times4-\frac{1}{2}(x-3)4(x-3)\right]$
$U+8=-\left(-2x^2+12x-16\right)$
$U=2x^2-12x+16-8$
$U=2x^2-12x+8$

At x = 3, U = 18 –36 + 8
U = – 10 J
When $4 \le x \le 6$
$-8-U=-\frac{1}{2}\times\left[4+(6-x)2\right](x-4)$
$-8-U=-\frac{1}{2}(12-2x+4)(x-4)$
$+(8+U)=(8-x)(x-4)$
$8+U=-x^2+12x-32$
$U=-x^2+12x-40$

50. (a, b, c, d)

Using conservation of momentum



$Mv = 2Mv_\alpha \cos\theta$

$Mv_\alpha = 2Mv_\alpha \sin\theta$

$v^2 + v_d^2 = 4v_\alpha^2$

…(i)

Also, $\frac{1}{2}Mv^2 = \frac{1}{2}Mv_d^2 + \frac{1}{2}\times 2Mv_\alpha^2$

$v^2 = v_d^2 + 2v_\alpha^2$

$v_d^2 = v^2 - 2v_\alpha^2$

…(ii)

Solving (i) & (ii), we get

$2v^2 - 2v_\alpha^2 = 4v_\alpha^2 \Rightarrow v_\alpha^2 = \frac{v^2}{3} \Rightarrow v_\alpha = \frac{v}{\sqrt{3}}$

From (i), $v_d^2 = \frac{4v^2}{3} - v^2 \Rightarrow v_d^2 = \frac{v^2}{3} \Rightarrow v_d = \frac{v}{\sqrt{3}}$

$2v_\alpha \cos\theta = v \Rightarrow \cos\theta = \frac{\sqrt{3}}{2}$

$\Rightarrow \theta = 30°$

$\eta = \frac{\frac{1}{2}\times 2Mv_\alpha^2}{\frac{1}{2}Mv^2} = \frac{2}{3}$

51. (c, d)

$y_1 = 2.5\times 10^{-3}\sin(30x - 420t)$

$y_2 = 2.5\times 10^{-3}\sin(30x + 420t)$

$y = y_1 + y_2$

$y = (5\times 10^{-3})\sin(30x)\cos(420t)$

For antinodes, $|\sin 30x| = 1$

$30x = (2n-1)\frac{\pi}{2}$

$\Rightarrow x = \frac{\pi}{60}, \frac{\pi}{20}, \frac{\pi}{12}, \frac{7\pi}{60}, ...$

The antinode closest to x = 0.25 m is at x = 0.262 m

At $x = 0.17\text{m}$, $a = \left|(5\times 10^{-3})\sin(5.1)\right|$

a = 4.63 mm.

52. (a, b, d)

PV = nRT

$P = \frac{nRT}{V} = \frac{2\times 8.31\times 290}{120\times 10^{-3}} = 40.2\text{ kPa}$

$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$

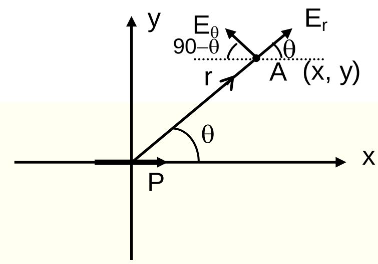
$T_2 = 290\left(\frac{120}{80}\right)^{\frac{2}{5}} = 341K = 68°C$

$$\Delta U = nC_V\Delta T = 2\times\frac{5R}{2}\times(341-290) = 2.12\,kJ$$

$$\Delta W = -\Delta U = -2.12\,kJ$$

53. (a, c, d)

$$V = \frac{Kp\cos\theta}{r^2} \qquad (r >> d)$$



$$V = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}.\vec{r}}{r^3}$$

$$E_r = -\frac{\partial V}{\partial r} = \frac{2Kp\cos\theta}{r^3}$$

$$E_\theta = -\frac{\partial V}{r\partial\theta} = \frac{Kp\sin\theta}{r^3}$$

$$E_x = E_r\cos\theta - E_\theta\sin\theta$$

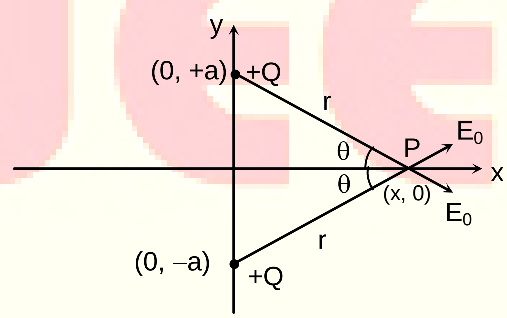
$$E_x = \frac{1}{4\pi\varepsilon_0}\frac{p(2x^2-y^2)}{r^5}$$

$$E_y = E_r\sin\theta + E_\theta\cos\theta$$

$$E_y = \frac{1}{4\pi\varepsilon_0}\frac{3pxy}{r^5}$$

54. (b, c)

$$E = 2E_0\cos\theta$$



$$E = 2\frac{KQ}{r^2}\frac{x}{r}$$

$$E = \frac{2KQx}{\left(x^2+a^2\right)^{3/2}}$$

If x >> a

$$E = \frac{2KQ}{x^2}, \qquad \text{Hence } E \propto \frac{1}{x^2}$$

$$E = \frac{2KQx}{(x^2+a^2)^{3/2}}$$

$$\frac{dE}{dx} = \frac{2KQ(a^2-2x^2)}{(x^2+a^2)^{5/2}}$$

For E to be maximum, $\frac{dE}{dx} = 0$

$$x = \frac{a}{\sqrt{2}} \qquad (\text{for } x \ge 0)$$

55. (b, d)

$$i = \frac{B\ell v}{R}, \; F_m = i\ell B$$

$$\frac{mdv}{dt} = -Bi\ell$$

$$\frac{dv}{dt} = -\left(\frac{B^2\ell^2}{mR}\right)v$$

$$\int_{v_0}^{v} \frac{dv}{v} = -\int_0^t \frac{B^2\ell^2}{mR}dt$$

$$v = v_0 e^{-\left(\frac{B^2\ell^2}{mR}\right)t}$$

$$\int_0^x dx = v_0 \int_0^t e^{-\left(\frac{B^2\ell^2}{mR}\right)t} dt$$

$$x = \frac{mv_0R}{B^2\ell^2}\left(1 - e^{-\left(\frac{B^2\ell^2}{mR}\right)t}\right)$$

at $t \to \infty$, $x_{max} = \left(\frac{mv_0R}{B^2\ell^2}\right)$

Total heat dissipated in the resistance, $H = \frac{1}{2}mv_0^2$

Total charge that flows in the circuit, $q = \frac{\Delta\phi}{R} = \frac{B\ell x_{max}}{R} = \frac{mv_0}{B\ell}$

56. (a, d)

$$\vec{B} = 2\times10^{-5}\sin\left[\pi\left(0.5\times10^3x + 1.5\times10^{11}t\right)\right]\left(\hat{j}\right)T$$

$$K = 0.5\pi\times10^3 \Rightarrow \frac{2\pi}{\lambda} = \frac{\pi}{2}\times10^3$$

$$\lambda = 4mm$$

$$\omega = 1.5\pi\times10^{11} \Rightarrow 2\pi f = 1.5\pi\times10^{11}$$

$$f = 75\times10^9 Hz = 75 GHz.$$

Average energy density = $\frac{B_0^2}{2\mu_0} = \frac{4\times10^{-10}}{2\times4\pi\times10^{-7}} = \frac{1}{2\pi}\times10^{-3} = 159\mu J/m^3$

$$v = \frac{\omega}{k} = \frac{1.5\pi\times10^{11}}{0.5\pi\times10^3} = 3\times10^8 m/s$$

$$\vec{E} = \left(\vec{B}\times\vec{v}\right) = \left(2\times10^{-5}\times3\times10^8\right)\sin\left[\pi\left(0.5\times10^3x + 1.5\times10^{11}t\right)\right]\left(\hat{k}\right)Vm^{-1}$$

$$\vec{E} = 6000\sin\left[\pi\left(0.5\times10^3x + 1.5\times10^{11}t\right)\right]\left(\hat{k}\right)Vm^{-1}$$

(A, D) are correct.

57. (a, b, c, d)

$$V_A - 2\times\frac{5}{2} - 2\times\frac{3}{2} - 2\times\frac{1}{2} - 8\times\frac{1}{2} = V_H$$

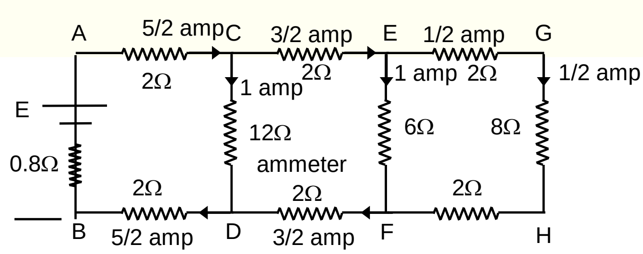
$V_A - V_H = 13$ V

$$V_c - 2\times\frac{3}{2} - 1\times6 = V_F$$

$V_c - V_F = 9V$

$$V_c - 2\times\frac{3}{2} - 1\times6 - 2\times\frac{3}{2} = V_D$$

$V_C - V_D = 12$



$-2\times\frac{5}{2}-1\times12-2\times\frac{5}{2}-0.8\times\frac{5}{2}+E=0$

$\Rightarrow$ E = 24V

58. (a, b, c)

Δx = 5000 nm

$n\lambda$ = 5000 nm

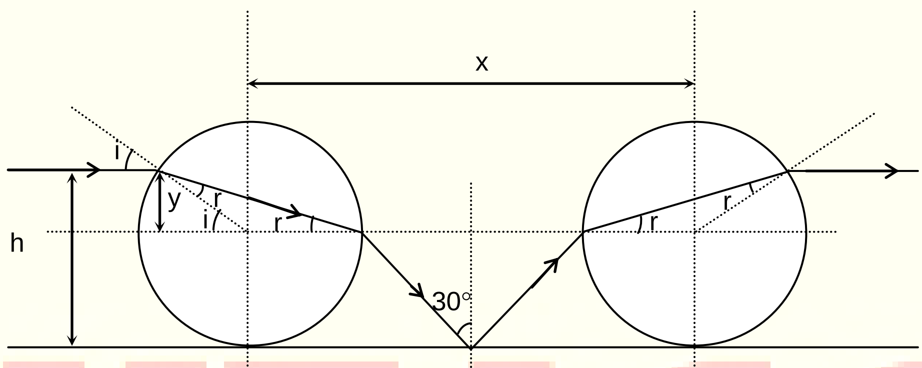
$\lambda = \frac{5000}{n}$

For n = 8, λ = 625 nm

n = 9, λ = 555.56 nm

n = 12, λ = 416.67 nm

59. (a, b, c, d)



$\sin i = \sqrt{3}\ \sin r$ and $i = 2r$

$y = R\sin(2r) = 2R\sin r\cos r$

$\sin 2r = \sqrt{3}\sin r$

$r = 30^0$ and $i = 60^0$

$y = 2(0.1)\frac{1}{2}\frac{\sqrt{3}}{2} = 0.087\text{m}$

$\Rightarrow$ h = 0.1 + 0.087 = 0.187 m

$x = 2R + 2R\tan 30^0$

$= (2)\ (0.1)\ \left(1+\frac{1}{\sqrt{3}}\right) = 0.3154$ m

60. (a, b, c)

Current flows from p type semiconductor to n-type semiconductor in for forward biased.

Current flows from n type semiconductor in reverse biased.

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