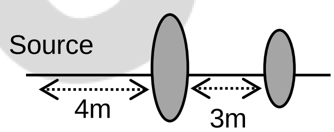
WB-JEE-2015 (Physics)

1. Two particles of mass m_1 and m_2 approach each other due to their mutual gravitational attraction only. Then
   a. accelerations of both the particles are equal
   b. acceleration of the particle of mass m_1 is proportional to m_1
   c. acceleration of the particle of mass m_1 is proportional to m_2
   d. acceleration of the particle of mass m_1 is inversely proportional to m_1

2. Three bodies of the same material and having masses m, m and 3m are at temperatures 40°C, 50°C and 60°C respectively. If the bodies are brought in thermal contact, the final temperature will be
   a. 45°C b. 54°C
   c. 52°C d. 48°C

3. A satellite has kinetic energy K, potential energy V and total energy E. Which of the following statements is true?
   a. $K = -V/2$ b. $K = V/2$
   c. $E = K/2$ d. $E = -K/2$

4. An object is located 4 m from the first of two thin converging lenses of focal lengths 2m and 1m respectively. The lenses are separated by 3 m. The final image formed by the second lens is located from the source at a distance of

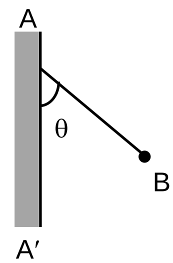


   a. 8.0 m b. 7.5 m
   c. 6.0 m d. 6.5 m

5. A simple pendulum of length L swings in a vertical plane. The tension of the string when it makes an angle θ with the vertical and the bob of mass m moves with a speed v is (g is the gravitational acceleration
   a. mv^2/L b. $mg\cos\theta + mv^2/L$
   c. $mg\cos\theta - mv2/L$ d. $mg\cos\theta$

6. The length of a metal wire is L_1 when the tension is T_1 and L_2 when the tension is T_2. The unstretched length of the wire is equilibrium, the final temperature becomes 19^oC. What is the specific heat of the metal in C.G.S. units?
   a. $\frac{L_2 + L_2}{2}$ b. $\sqrt{L_1 L_2}$
   c. $\frac{T_2 L_1 - T_1 L_2}{T_2 - T_1}$ d. $\frac{T_2 L_1 + T_1 L_2}{T_2 + T_1}$

7. The line AA′ is on a charged infinite conducting plane which is perpendicular to the plane of the paper. The plane has a surface density of charge σ and B is a ball of mass m with a like charge of magnitude q. B is connected by a string from a point on the line AA′. The tangent of the angle (θ) formed between the line AA′ and the string is



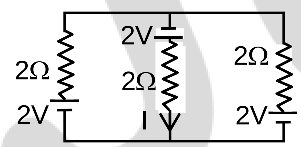
a. $\frac{q\sigma}{2\epsilon_0 mg}$

b. $\frac{q\sigma}{4\pi\epsilon_0 mg}$

c. $\frac{q\sigma}{3\pi\epsilon_0 mg}$

d. $\frac{q\sigma}{\epsilon_0 mg}$

8. The current I in the circuit shown is



a. 1.33A

b. zero

c. 2.00 A

d. 1.00 A

9. A hollow sphere of external radius R and thickness t (<< R) is made of a metal of density □, sphere will float in water if

a. $t \le \frac{R}{\rho}$

b. $t \le \frac{R}{3\rho}$

c. $t \le \frac{R}{2\rho}$

d. $t \ge \frac{R}{2\rho}$

10. A metal wire of circular cross-section has a resistance R_1. The wire is now stretched without breaking so that its length is doubled and the density is assumed to remain the same. If the resistance of the wire now becomes R_2 then $R_2 : R_1$ is

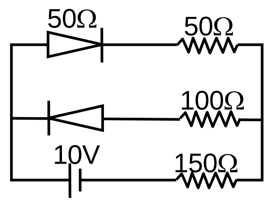
a. 1 : 1

b. 1 : 2

c. 4 : 1

d. 1 : 4

11. Assume that each diode shown in the figure has a forward bias resistance of 50Ω and an infinite reverse bias resistance. The current through the resistance 150Ω is



a. 0.66A
b. 0.05A
c. zero
d. 0.04A

12. The r.m.s speed of oxygen is v at a particular temperature. If the temperature is doubled and oxygen molecules dissociate into oxygen atoms, the r.m.s speed becomes

a. V
b. $\sqrt{2}v$
c. 2v
d. 4v

13. Two particles, A and B, having equal charges, after being accelerated through the same potential difference enter a region of uniform magnetic field and the particles describe circular paths of radii R_1 and R_2 respectively. The ratio of the masses of A and B is

a. $\sqrt{R_1 / R_2}$
b. R_1 / R_2
c. $(R_1 / R_2)^2$
d. $(R_2 / R_1)^2$

14. A large number of particles are placed around the origin, each at a distance R from the origin. The distance of the center of mass of the system from the origin is

a. = R
b. ≤ R
c. > R
d. ≥ R

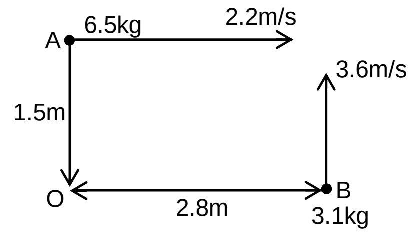
15. A straight conductor 0.1m long moves in a uniform magnetic field 0.1 T. The velocity of the conductor is 15 m/s and is directed perpendicular to the field. The e.m.f. induced between the two ends of the conductor is

a. 0.10 V
b. 0.15V
c. 1.50 V
d. 15.00V

16. A ray of light is incident at an angle i on a glass slab of refractive index μ. The angle between reflected and refracted light is 90°. Then the relationship between i and μ is

a. $i = \tan^{-1}\left(\frac{1}{\mu}\right)$
b. $\tan i = \mu$
c. $\sin i = \mu$
d. $\cos i = \mu$

17. Two particles A and B are moving as shown in the figure. Their total angular momentum about the point O is



a. 9.8 kg m^2/s
b. Zero.
c. 52.7 kg m^2/s.
d. 37.9 kg m2/s

18. A 20 cm long capillary tube is dipped vertically in water and the liquid rises upto 10 cm. If the entire system is kept in a freely falling platform, the length of water column in the tube will be

a. 5 cm
b. 10 cm
c. 15 cm
d. 20cm

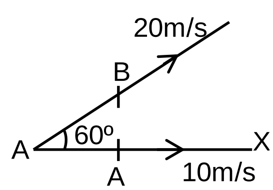
19. A train is moving with a uniform speed of 33 m/s and an observer is approaching the train with the same speed. If the train blows a whistle of frequency 1000 Hz and the velocity of sound is 333 m/s then the apparent frequency of the sound that the observer hears is

a. 1220 Hz
b. 1099 Hz
c. 1110 Hz
d. 1200 Hz

20. A photon of wavelength 300 nm interacts with a stationary hydrogen atom in ground state. During the interaction, whole energy of the photon is transferred to the electron of the atom. State which possibility is correct? (Consider, Planck's constant = 4×10^{-15} eVs, velocity of light = 3×10^{8} m/s, ionization energy of hydrogen = 13.6eV)

a. Electron will be knocked out of the atom
b. Electron will go to any excited state of the atom
c. Electron will go only to first excited state of the atom
d. Electron will keep orbiting in the ground state of atom

21. Particle A moves along X-axis with a uniform velocity of magnitude 10 m/s. Particle B moves with uniform velocity 20 m/s along a direction making an angle of 60° with the positive direction of X-axis as shown in the figure. The relative velocity of B with respect to that of A is



a. 10 m/s along X-axis
b. $10\sqrt{3}$ m/s along Y-axis (perpendicular to X-axis)
c. $10\sqrt{5}$ along the bisection of the velocities of A and B
d. 30 m/s along negative X-axis

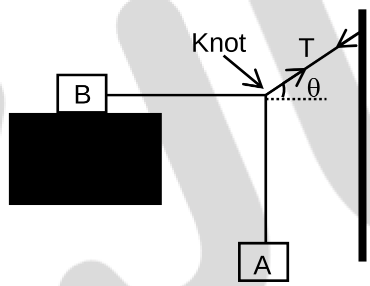
22. When light is refracted from a surface, which of its following physical parameters does not change?

a. velocity
b. amplitude
c. frequency
d. wavelength

23. A solid maintained at t_1° C is kept in an evacuated chamber at temperature t_2°C ($t_2 >> t_1$). The rate of heat absorbed by the body is proportional to

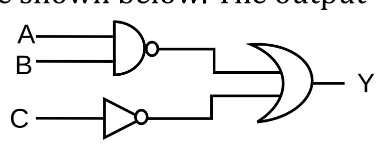
a. $t_2^4 - t_1^4$
b. $(t_2^4 + 273) - (t_1^4 + 273)$
c. $t_2 - t_1$
d. $t_2^2 - t_1^2$

24. Block B lying on a table weighs W. The coefficient of static friction between the block and the table is μ. Assume that the cord between B and the knot is horizontal. The maximum weight of the block A for which the system will be stationary is



a. $\frac{w \tan\theta}{\mu}$
b. $\mu w \tan\theta$
c. $\mu w \sqrt{1 + \tan^2 \theta}$
d. $\mu w \sin\theta$

25. The inputs to the digital circuit are shown below. The output Y is



a. $A + B + \overline{C}$
b. $(A + B)\overline{C}$
c. $\overline{A} + \overline{B} + \overline{C}$
d. $\overline{A} + \overline{B} + C$

26. Two particles A and B having different masses are projected from a tower with same speed. A is projected vertically upward and B vertically downward. On reaching the ground

a. velocity of A is greater than that of B
b. velocity of B is greater than that of A
c. both A and B attain the same velocity
d. the particle with the larger mass attains higher velocity

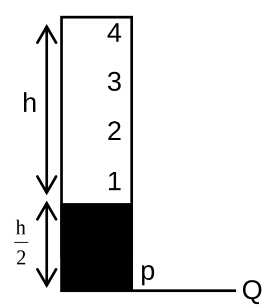
27. The work function of metals is in the range of 2 eV to 5eV. Find which of the following wavelength of light cannot be used for photoelectric effect. (Consider, Planck constant = 4×10^{-15}eVs, velocity of light = 3×10^{8}m/s)
    a. 510 nm
    b. 650 nm
    c. 400 nm
    d. 570nm

28. A thin plastic sheet of refractive index 1.6 is used to cover one of slits of a double slit arrangement. The central point on the screen is now occupied by what would have been the 7^{th} bright fringe before the plastic was used. If the wavelength of light is 600 nm, what is the thickness (in μm) of the plastic?
    a. 7
    b. 4
    c. 8
    d. 6

29. The length of an open organ pipe is twice the length of another closed organ pipe. The fundamental frequency of the open pipe is 100 Hz. The frequency of the third harmonic of the closed pipe is
    a. 100 Hz
    b. 200 Hz
    c. 300 Hz
    d. 150 Hz

30. A 5 μF capacitor is connected in series with a 10 μF capacitor. When a 300 Volt potential difference is applied across this combination, the energy stored in the capacitors is
    a. 15 J
    b. 1.5 J
    c. 0.15 J
    d. 0.10 J

31. A cylinder of height h is filled with water and is kept on a block of height h/2. The level of water in the cylinder is kept constant. Four holes numbered 1, 2, 3 and 4 are at the side of the cylinder and at heights 0, h/4 and 3h/4 respectively. When all four holes are opened together, the hole from which water will reach farthest distance on the plane PQ is the hole no.



    a. 1
    b. 2
    c. 3
    d. 4

32. The pressure p, volume v and temperature T for a certain gas are related by $p=\frac{AT-BT^2}{v}$, where A and B are constants. The work done by the gas when the temperature changes from T_1 to T_2 while the pressure remains constant, is given by

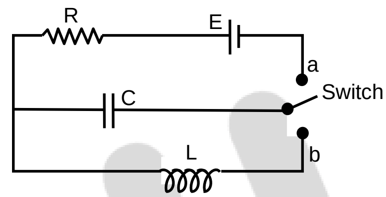
a. $A(T_2-T_1)+B(T_2^2-T_1^2)$

b. $\frac{A(T_2-T_1)}{v_2-v_1}-\frac{B(T_2^2-T_1^2)}{v_2-v_1}$

c. $A(T_2-T_1)-B(T)$

d. $\frac{A(T_2-T_2^2)}{v_2-v_1}$

33. In the circuit shown below, the switch is kept in position 'a' for a long time and is then thrown to position 'b'. The amplitude of the resulting oscillating current is given by



a. $F\sqrt{L/C}$

b. F/R

c. Infinity

d. $F\sqrt{C/L}$

34. A charge q is placed at one corner of a cube. The electric flux through any of the three faces adjacent to the charge is zero. The flux through any one of the other three faces is

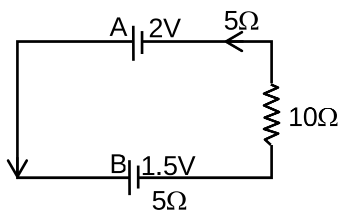
a. $q/3\epsilon_0$

b. $q/6\epsilon_0$

c. $q/12\epsilon_0$

d. $q/24\epsilon_0$

35. Two cells A and B of e.m.f 2V and 1.5V respectively, are connected as shown in figure through an external resistance 10Ω. The internal resistance of each cell is 5Ω. The potential difference E_A and E_B across the terminals of the cells A and B respectively are



a. $E_A = 2.0V, E_B = 1.5V$

b. $E_A = 2.12V, E_B = 1.375V$

c. $E_A = 1.875V, E_B = 1.625V$

d. $E_A = 1.875V, E_B = 1.375V$

36. Two charges +q and –q are placed at a distance 'a' in a uniform electric field. The dipole moment of the combination is $\left(\cos\theta\hat{i}+\sin\theta\hat{j}\right)$, where θ is the angle between the direction of the field and the line joining the two charges. Which of the following statement(s) is/are correct?
    a. The torque exerted by the field on the dipole vanishes
    b. The net force on the dipole vanishes
    c. The torque is independent of the choice of coordinates
    d. The net force is independent of 'd'.

37. Find the right condition(s) for Fraunhoffer diffraction due to a single slit.
    a. Source is at infinite distance and the incident beam has converged at the slit.
    b. Source is near to the slit and the incident beam is parallel.
    c. Source is at infinity and the incident beam is parallel.
    d. Source is near to the slit and the incident beam has converged at the slit.

38. A conducting loop in the form of a circle is placed in a uniform magnetic field with its plane perpendicular to the direction of the field. An e.m.f. will be induced in the loop if
    a. It is translated parallel to itself.
    b. It is rotated about one of its diameters.
    c. It is rotated about its own axis which is parallel to the field.
    d. The loop is deformed from the original shape.

39. A circular disc rolls on a horizontal floor without slipping and the centre of the disc moves with a uniform velocity v. Which of the following values the velocity at a point on the rim of the disc can have?
    a. v
    b. –v
    c. 2 v
    d. zero

40. Consider two particles of different masses. In which of the following situations the heavier of the two particles will have smaller de Broglie wavelength?
    a. Both have a free fall through the same height
    b. Both move with the same kinetic energy.
    c. Both move with the same linear momentum
    d. Both move with the same speed

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ANSWER KEYS

1. (c)	2. (b)	3. (a)	4. (b)	5. (b)	6. (c)	7. (d)	8. (a)	9. (b)	10. (c)
11. (d)	12. (c)	13. (c)	14. (b)	15. (b)	16. (b)	17. (a)	18. (d)	19. (a)	20. (d)
21. (b)	22. (c)	23. (G)	24. (b)	25. (c)	26. (c)	27. (b)	28. (a)	29. (c)	30. (c)
31. (b)	32. (c)	33. (d)	34. (d)	35. (c)	36. (b,c,d)	37. (b,c)	38. (b,d)	39. (c,d)	40. (a,b,d)

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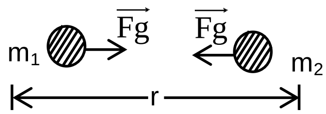
Solution

1. (c)

According to question



Two masses are approaching each other at that time distance b/w them is r.
Now according to Newton's law of gravitation,

$\vec{F}_g = \frac{Gm_1m_2}{r^2}$ (force of attraction)

(Equal and opposite)

Newton's 2nd law of motion -: $F = ma \Rightarrow a = \frac{f}{m}$

for $\vec{a}$ of mass $m_1 \Rightarrow \vec{a}_1 = \frac{\vec{F}_g}{m_1} = \frac{\frac{Gm_1m_2}{r^2}}{m_1} = \frac{Gm_2}{r^2}$

For $\vec{a}$ of mass $m_2 \Rightarrow \vec{a}_2 = \frac{\vec{F}_g}{m_2} = \frac{Gm_1}{r^2}$

$\therefore$ $G = 6.67 \times 10^{-11} \frac{N-m^2}{kg^2}$ and $r \rightarrow$ const. (at any time)

So, $\vec{a}_1 \propto m_2$

And $\vec{a}_2 \propto m_1$

2. (b)

According to law of conservation of energy,
Energy lost = Energy gained
Let the final temperature be T.
Let the specific heat capacity of the material be C.
Then,

$mcT_1 + mcT_2 + 3mcT_3 = (mc + mc + 3mc)\ T$

$\Rightarrow mT_1 + mT_2 + 3\ mT_3 = (m + m + 3m)\ T$

$\Rightarrow mT_1 + mT_2 + 3mT_3 = 5mT$

$\Rightarrow T_1 + T_2 + 3T_3 = 5T$

$\Rightarrow T = \frac{T_1 + T_2 + 3T_3}{5} \Rightarrow \frac{40 + 50 + 3 \times 60}{5}$

$\Rightarrow T = \frac{270}{5} = 54^{o}C$

3. (a)

The kinetic energy of satellite is given as:

$$K = \frac{GMm}{2r} \text{.............(i)}$$

Similarly, the potential energy is given as;

$$V = \frac{-GMm}{2r} \text{.............(ii)}$$

Total energy of satellite is given as:

$$E = K + V$$

$$E = \frac{GMm}{2r} - \frac{GMm}{r} \text{.............(iii)}$$

From equation, (i), (ii) and (iii)

$$K = -\frac{V}{2}$$

4. (b)

The image obtained by first lens will act as object for the second lens.

Here, for the first lens.

$u = -4$ m

$f_1 = 2$ m

According to lens formula

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

$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$$

$$\frac{1}{v_1} = \frac{1}{2} - \frac{1}{4} = \frac{1}{4}$$

$$\Rightarrow \quad \frac{1}{v_1} = \frac{1}{4}$$

$$\Rightarrow \quad v_1 = 4\text{m}$$

For the second lens,

$u_2 = 1$ m

And $f_2 = 1$m

Again apply lens formula,

$$\frac{1}{v_2} - \frac{1}{u_2} = \frac{1}{f_2}$$

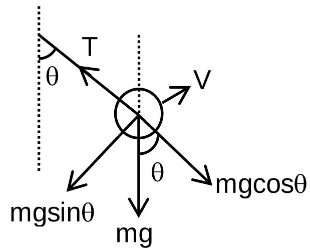
$$\Rightarrow \frac{1}{v_2} - \frac{1}{1} = \frac{1}{1}$$

$$\Rightarrow \frac{1}{v_2} = 2$$

$$\Rightarrow v_2 = \frac{1}{2} = 0.5$$

Therefore distance from the object = 4 + 3 + 0.5 = 7.5 m

5. (b)



From the diagram, we can see that

mg cos θ is the component of mg.

Also a centripetal force act on the pendulum which is $\frac{mv^2}{L}$

So, the tension in the string is mg cos θ + $\frac{mv^2}{L}$

6. (c)

Let the initial length of the metal wire is L

The strain at tension T_1 is $\Delta L_1 = L_1 - L$

The strain at tension T_2 is $\Delta L_2 = L_2 - L$

Suppose, the young's modulus of the wire is Y,

$$\frac{\frac{T_1}{A}}{\frac{\Delta L_1}{L}} = \frac{\frac{T_2}{A}}{\frac{\Delta L_2}{L}}$$

$\because$ young's modulus (Y) = $\frac{\text{stress}(\sigma)}{\text{strain}(\varepsilon)} = \frac{F/A}{\Delta L/L}$

Where, A is area of cross section of the wire assume to be same at all the situations.

$$\Rightarrow \frac{T_1}{A} \times \frac{L}{\Delta L_1} = \frac{T_2}{A} \times \frac{L}{\Delta L_2}$$

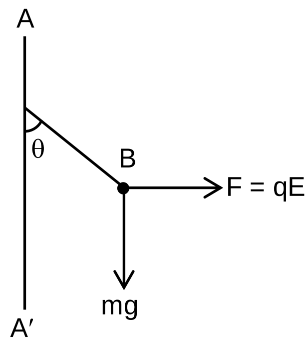
$$\Rightarrow \frac{T_1}{(L_1 - L)} = \frac{T_2}{(L_2 - L)}$$

$$\Rightarrow T_1 (L_2 - L) = T_2 (L_1 - L)$$

$$\Rightarrow L = \frac{T_2 L_1 - T_1 L_2}{T_2 - T_1}$$

7. (d)

The diagram is as follows



The electric field due to charged infinite conducting sheet is E = $\frac{\sigma}{\varepsilon_0}$

Now, force (electric force) on the charged ball is F = qE = $\frac{q\sigma}{\varepsilon_0}$

The resultant of electric force and mg balance the tension produced in the string.

So, $\tan\theta = \frac{F_e}{mg} = \frac{q\sigma/\varepsilon_0}{mg} = \frac{q\sigma}{\varepsilon_0 mg}$

8. (a)

We first try to find the equivalent emf and internal resistance of the two side branches.

$$E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

$$= \frac{\frac{2}{2} + \frac{2}{2}}{\frac{1}{2} + \frac{1}{2}}$$

$$= 2V$$

$\because r_{eq} = \frac{r_1 r_2}{r_1 + r_2} = 1\,\Omega$

This equivalent cell is in series with the central branch.

Hence current = $\frac{E_{eq} + E_3}{r_{eq} + r_3}$

$= \frac{2v + 2v}{1\Omega + 2\Omega} = \frac{4}{3}$ A = 1.33 A

9. (b)

The density of material is ρ.

The hollow sphere will float if its weight is less than the weight of the water displaced by the volume of the sphere. This implies mass of the sphere is less than that for the same volume of water. Now, mass of spherical shell,

$m_1 = 4\pi R^2 \times t \times \rho$

While the mass of water having same volume

$$m_2 = \frac{4}{3}\pi R^3 \times \rho_g = \frac{4}{3}\pi R^3$$

Where, ρ_g = density of water = 1 gm/cm^3

For the floatation of sphere,

$m_1 \le m_2$

$$4\pi R^2 \times t \times \rho \le \frac{4}{3}\pi R^3$$

$$\Rightarrow \quad t.\rho \le \frac{R}{3}$$

$$\Rightarrow \quad t \le \frac{R}{3\rho}$$

10. (c)

The wire is stretched to double its length.

$\Rightarrow \ell' = 2\ell$

The volume in the process remains the same. (Since mass is unchanged, and density remains same)

$\Rightarrow \ell'A' = \ell A$

$$\Rightarrow A' = \frac{\ell A}{\ell'} \Rightarrow \frac{A\ell}{2\ell}$$

$$\Rightarrow A' = \frac{A}{2}$$

If the initial resistance was, $R = \frac{\rho\ell}{A}$

Hence, $R' = \frac{\rho\ell'}{A'}$

$$\Rightarrow R' = \frac{\rho.(2\ell)}{(A/2)} = \frac{4\rho\ell}{A}$$

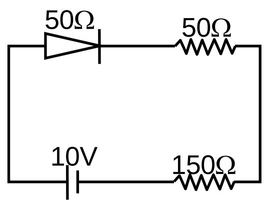
$\Rightarrow \therefore R' = 4R$

$$\Rightarrow \frac{R'}{R} = \frac{4}{1} \text{ or } 4:1$$

11. (d)

Since the positive terminal of battery is attached to positive terminal of the upper diode, it is forward bias, and hence conducts current offering 50Ω resistance.

Since the positive terminal of battery is attached to negative of the lower diode, it is reverse bias, and hence does not conduct current at all. Hence that branch can be ignored in the circuit.



Thus the current flowing in rest of the

Circuit = $\dfrac{10\text{v}}{150\Omega + 50\Omega + 50\Omega}$ = 0.04 A

12. (c)

The root mean square speed of a gas is given by $\sqrt{\dfrac{3RT}{M}}$

Where T is the temperature of gas

M is the molecular weight of gas.

When oxygen molecules dissociate into oxygen atoms, the molecular weight of gas halves.

Hence, $T' = 2T$

$M' = \dfrac{M}{2}$

$$\frac{V'}{V} = \sqrt{\frac{T'/M'}{T/M}} = \sqrt{\frac{2T/M/2}{\frac{T}{M}}}$$

$$\Rightarrow \quad \frac{V'}{V} = \sqrt{\frac{4}{1}} \Rightarrow 2$$

$$\Rightarrow \quad V' = 2V$$

13. (c)

Since charge on both particles is same and they are accelerated through the same voltage, work done by electric field will be same for both the charges so the increase in kinetic energy will be same. Assuming that charges started from rest, we have :

$$\frac{1}{2}m_1v_1^2 = qv = \frac{1}{2}m_2v_2^2 \Rightarrow \frac{v_1^2}{v_2^2} = \frac{m_2}{m_1}$$

Where V is the potential difference through which the charges are accelerated.
The magnetic force only provides the necessary centripetal force for circular motion :

$$\frac{m_1v_1^2}{R_1} = Bqv_1$$

$$\frac{m_2v_2^2}{R_2} = Bqv_2$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{m_1v_1}{m_2v_2} = \frac{\sqrt{m_1}}{\sqrt{m_2}} \Rightarrow \frac{m_1}{m_2} = \frac{R_1^2}{R_2^2}$$

14. (b)
As large number of particles are situated at a distance R from the origin. If particles are uniformly distributed and make a circular boundary around the origin, then centre of mass will be at the origin.
While, if the particles are not uniformly distributed then center of mass will lie between particle and origin. This implies that the distance between centre of mass and origin is always less than or equal to R.
So, Answer will be $\le$ R.

15. (b)
The EMF induced across a conductor of length ℓ, moving perpendicular to a magnetic field B with velocity V is equal to $BV\ell$
EMF induced in given problem = $BV\ell$
= 0.1 T × 15 m/s × 0.1 m
= 0.15 V

16. (b)
Let the angle of reflection and refraction be r_1, r_2 respectively.
Since angle between reflected and refracted ray is 90°,

$$r_1 + r_2 = 90°$$

From law of reflection, $r_1 = i$
From snell's law,
sin i = $\mu \sin r_2$
= $\mu \sin(90° - r_1)$
sin i = $\mu \cos r_1 = \mu \cos i$
$\Rightarrow$ tan i = μ

17. (a)

Total angular momentum about 0 is given as,

$L = L_1 + L_2$

$= m_1v_1r_1 + m_2v_2r_2$

= – 6.5 × 2.2 × 1.5 + 3.1 × 3.6 × 2.8

(Considering anticlockwise direction as negative angular momentum)

= – 21.45 + 31 .24

$L = 9.8 \text{ kg} - \frac{m^2}{sec}$

18. (d)

The height raised by liquid in capillary tube,

$$H = \frac{2\ell \cos\theta}{\rho g h}$$

Where, H is rise in the capillary tube.

As in freely falling platform, a body experience weightlessness.

$g_{eff} = 0$

So, the liquid will rise upto length of the capillary. i.e. height raised by the liquid will be 20 cm.

19. (a)

Doppler shifted frequency of sound radiation from a source is given as

$f = f_0 \left(\frac{c - v_0}{c - v_s}\right)$

$c \rightarrow$ velocity of sound

$v_0 \rightarrow$ velocity of observer

$v_s \rightarrow$ velocity of source

Following the sign convention of velocity of observer and source

$f = 1000 \left(\frac{333 + 33}{333 - 33}\right)$ Hz

f = 1220 Hz

20. (d)

$\because$ Energy of photon, $E_{ph} = h\nu$

$$E_{ph} = \frac{hc}{\lambda}$$

$$\because [c = \nu\lambda]$$

Now put the given values,

$$E_{ph} = \frac{4\times10^{-15}\times3\times10^{8}}{300\times10^{-9}}$$

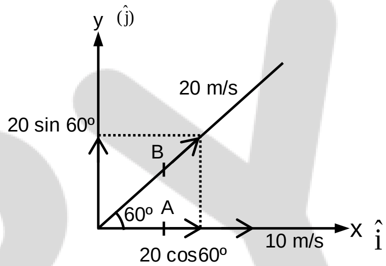
$$E_{ph} = 4ev$$

$\because$ Ionisation energy of hydrogen = 13.6 eV

$$E_{Ionisation} = 13.6 \text{ eV}$$

The ionization energy is 13.6 eV which is greater than energy of photon
13.6 eV > 4 eV, Hence no excitation takes place and electron will keep orbiting in ground state of atom.

21. (b)
Resolving the velocity in horizontal and vertical components



The relative velocity of B with respect to that of A is given as $\vec{V}_{BA}$,

$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

$= (20\cos 60°\ \hat{i} + 20\sin 60°\ \hat{j}) - 10\hat{i}$

$= 20 \times \frac{1}{2}\hat{i} + 20\ \frac{\sqrt{3}}{2}\hat{j} - 10\hat{i}$

$= 10\ \hat{i} + 10\sqrt{3}\ \hat{j} - 10\hat{i}$

$= \vec{v}_{BA} = 10\sqrt{3}\ \hat{j}$

So, the relative velocity of B with respect to that of A is $10\sqrt{3}\,m/s$ along Y – axis and it is perpendicular to x – axis.

22. (c)
Frequency of the light depends upon the source so it doesn't change in case of reflection or refraction or polarization.

23. (G) Bonus
According to Stefan-Boltzman law

$\mu = \sigma AT^4$

Where, $\sigma \rightarrow$ Stefan – Boltzman constant

$\because$ $t_{solid} < t_{surrounding\ (given)}$

Now, temperature of solid increase and, solid and surrounding will be at equilibrium.

So, the rate of emission in case of solid will be proportional at,

$R_{solid} \propto T_1^4$ R→ rate of emission

$\because$ $T_1 = (t_1 + 273)^4$

$\Rightarrow$ $R_{solid} \propto (t_1 + 273)^4$

Similarly, $R_{surrounding}$ & T

$R_{surrounding} \propto T_2^4$

$\because$ $T_2 = (t_2 + 273)^4$

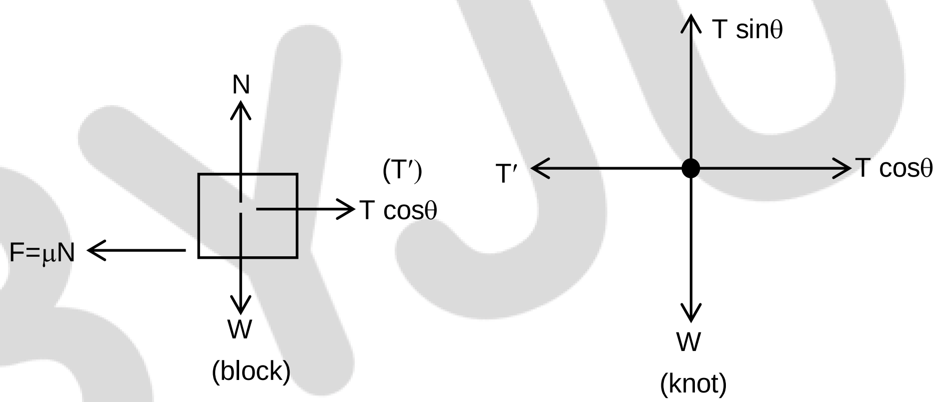
$\Rightarrow$ $R_{surrounding} \propto (t_2 + 273)^4$

$\therefore$ Net Rate $\propto T_2^4 - T_1^4$

$\Rightarrow$ Net Rate $\propto (t_2 + 273)^4 - (t_1 + 273)^4$

So, the correct option is this

24. (b)



The block B is under equilibrium by action of tension force on it leftwards (say T′), and force of static friction on it left wards (f).

Hence, $f = \mu N = \mu W = T'$

Consider the force acting on the knot

Balancing the forces on knot horizontally,

$T' = T\cos\theta$

Also balancing the forces on knot vertically,

$T\sin\theta = w$

$\Rightarrow$ $w = \dfrac{T'}{\cos\theta}.\sin\theta$

$w = T'\tan\theta$

$w = \mu w \tan\theta$

25. (c)

Here, A, B and C are inputs and Y is output

A and B are inputs to the NAND gate. The output of that gate is

$\overline{(A.B)} = \overline{A} + \overline{B}$

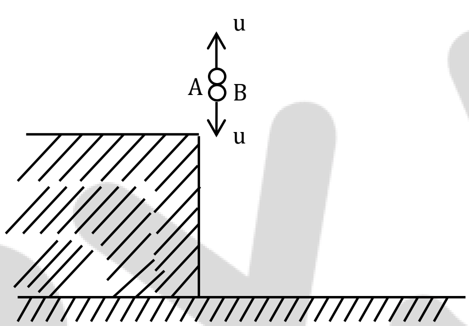
The output of c being input to the NOT gate is $\overline{C}$.

These two $\left[\left(\overline{A}+\overline{B}\right),\overline{C}\right]$ are inputs of OR gate.

Hence, $Y = \left(\overline{A}+\overline{B}\right)+\overline{C}$

$Y = \overline{A}+\overline{B}+\overline{C}$

26. (c)



Let v_A and v_B be the final velocities of A and B respectively since initial velocity of both particles is same.

So, using third equation of motion i.e,

$v^2 = u^2 + 2as$

$\therefore \quad v_A^2 = u^2 - 2g(-h) = u^2 + 2gh$ ....(1)

and $\quad v_B^2 = u^2 + 2gh$ ....(2)

$\therefore$ from (1) and (ii)

$v_A = v_B$

27. (b)

The work function of metal is given as:

$E = \frac{hc}{\lambda}$

So, $\lambda = \frac{hc}{E}$

Now,

$\lambda_{max} = \frac{hc}{E_{min}}$

And, $\lambda_{min} = \frac{hc}{E_{max}}$

$\lambda_{min} = \frac{4\times10^{-15}\times3\times10^{8}}{5} = \frac{12\times10^{-7}}{5} = 2.4\times10^{-7}\,m$

$\Rightarrow \quad \lambda_{min} = 240$ nm

$\lambda_{max} = \frac{4\times10^{-15}\times3\times10^{8}}{2} = \frac{12\times10^{-7}}{2} = 6\times10^{-7}\,m$

$\Rightarrow \quad \lambda_{max} = 600$ nm

So, the wavelength of light that cannot be used for photo electric effect is 650 nm.

28. (a)

If the central fringe shifts to 'm'th bright fringe,

$(\mu - 1)\, t = m\lambda$

$\because \quad \mu = 1.6, \quad m = 7$

$\lambda = 600$ nm

t = thickness

$\therefore \quad (1.6 - 1)\, t = 7 \times 600$

$\Rightarrow \quad t = \frac{7\times600}{0.6}$

$\Rightarrow \quad t = 7000$ nm

$\because$ 1000 nm = 1μm

$\Rightarrow \quad t = 7\ \mu m$

29. (c)

The fundamental frequency of the organ open pipe is given as:-

$$f_0 = \frac{v}{2\ell_0} = 100 Hz$$

Similarly, the third harmonic of the closed pipe is given as:

$$f_c = \frac{3}{4}\frac{v}{\ell_c}$$

It is given that, $\ell_0 = 2\ell_c$

$$f_c = \frac{3}{4}\left(\frac{v}{\frac{\ell_0}{2}}\right) \Rightarrow \frac{3}{2}\left(\frac{v}{\ell_0}\right)$$

$$f_0 = 3\left(\frac{v}{2\ell_0}\right)$$

$= 3 \times 100$

$f_0 = 300$ Hz

30. (c)

Let us assume that,

$C_1 = 5\mu F$

$C_2 = 10\mu F$

Equivalent capacitances are given as:

$$C_{eq} = \frac{C_1C_2}{C_1 + C_2}$$

$$C_{eq} = \frac{5\times10}{5+10} = \frac{50}{15} = \frac{10}{3}\mu F$$

Hence,

Energy stored in the capacitor is given as:

$$U = \frac{1}{2} C_{eq} V^2$$

$$= \frac{1}{2}\left(\frac{10}{3}\times10^{-6}\right)(300)^2$$

U = 0.15 J

31. (b)

We know from torricelli's theorem, that the range of the liquid falling from a certain height is given by,

$R = 2\times\sqrt{h(H-h)}$

Where H is the total height of the container and h is the height where the hole is,

For $R = R_{max}$;

$$\frac{dR}{dh} = 0$$

$$\frac{dR}{dh} = 2\times\left(\frac{1}{2\sqrt{h}}\sqrt{H-h} + \sqrt{h}\frac{-1}{2\sqrt{H-h}}\right)$$

$$\frac{dR}{dh} = \left(\frac{\sqrt{H-h}}{\sqrt{h}} + \frac{-\sqrt{h}}{\sqrt{H-h}}\right)$$

$$\frac{dR}{dh} = \frac{H-h-h}{\sqrt{h(H-h)}} = 0$$

$\Rightarrow$ H–h–h = 0

$\Rightarrow$ H = 2h

For $R = R_{max}$

$h = \frac{H}{2}$

Taking PQ as the reference,

$H = h + \frac{h}{2} = \frac{3h}{2}$

So hole must be at height,

$$\frac{H}{2} = \frac{\left(\frac{3h}{2}\right)}{2} = \frac{3h}{4}$$

For hole 1,

$h_1 = \frac{h}{2} + 0 = \frac{h}{2}$

For hole 2,

$h_2 = \frac{h}{2} + \frac{h}{4} = \frac{3h}{4}$

For hole 3,

$h_3 = \frac{h}{2} + \frac{h}{2} = h$

For hole 4,

$h_4 = \frac{h}{2} + \frac{3h}{4} = \frac{5h}{4}$

Since, hole 2 is at the $\frac{H}{2}$ height required for longest range.

$\therefore$ Hole 2 is from which water will reach farthest distance on the plane PQ.

32. (c)

We have, $P = \dfrac{AT - BT^2}{V}$

$\Rightarrow \quad V = \dfrac{AT - BT^2}{p}$

Work done is given as:-

$W = p\Delta V = p\,[V_2 - V_1]$

Now,

$V_2 = \dfrac{AT_2 - BT_2^2}{P}$

$V_1 = \dfrac{AT_1 - BT_1^2}{p}$

So,

$$W = P\left[\frac{AT_2 - BT_2^2}{p} - \left(\frac{AT_1 - BT_1^2}{p}\right)\right]$$

$$= P\left[\frac{AT_2 - BT_2^2 - AT_1 + BT_1^2}{p}\right]$$

$$w = \left[A(T_2 - T_1) - B\left(T_2^2 - T_1^2\right)\right]$$

33. (d)

The charge through the capacitor is given as :

$q_0 = CE$

Where, C is capacitance and E is potential difference.

Now by conservation of energy,

Energy stored by capacitor = Energy stored by inductor

$$\frac{q_0^2}{2c} = \frac{1}{2} L I_0^2$$

$$\Rightarrow \frac{C^2E^2}{2C} = \frac{1}{2} L I_0^2$$

$$\Rightarrow I_0 = E\sqrt{\frac{C}{L}}$$

34. (d)

Consider a cube as this charge is at centre so, this cube for which the charge is at the corner becomes $\frac{1}{8}$. As we know from Gauss Law, the total flux produced by a charge is,

$$\phi_0 = \frac{Q_{encl}}{\varepsilon_0}$$

In this amount $\frac{1}{8^{th}}$ part goes from the cube we are considering. So, flux from the given cube is

$$\phi = \frac{Q_{enclosed}}{8\varepsilon_0} = \frac{q}{8\varepsilon_0}$$

Therefore, flux passing from the three surfaces in contact with the charges is zero and the flux passes only from the remaining faces. Because of the symmetry, the flux from the remaining three faces will be equal. Therefore, flux passing from each of these faces is

$$\phi = \frac{q}{24\varepsilon_0}$$

35. (c)

Let i be the current flowing through the circuit on applying KVL,

$$i = \frac{2-1.5}{20} = \frac{1}{40}\text{A}$$

The potential difference through battery A is given as,

$$E_A = 2 - ir = 2 - \frac{1}{40}\times 5 = 1.875 \text{ V}$$

Similarly potential difference through B is given as,

$$E_B = 1.5 + ir = 1.625 \text{ v}$$

36. (b, c, d)

The net force on a dipole in a uniform electric field is zero because opposite and equal forces on both charges of dipole cancels each other but the torque is given as,

$T = PE \sin\theta$

Where, θ is angle between electric field and dipole.

Now, torque is only zero when dipole is kept along electric field.

37. (b, c)

In fraunhoffer diffraction, the source has to be kept at infinite distance effectively from the slit because then only the incident rays are parallel. This can be achieved if

(i) Point source is kept at the focus of a converging lens

(ii) Point source is at infinite distance

38. (b, d)

Emf will be induced in the loop only when flux changes. Now, if the loop is translated parallel to itself then there is no flux change.

Hence option A is not correct.

If the loop is rotated about one of its diameters then the flux passing through loop changes so, B is correct option.

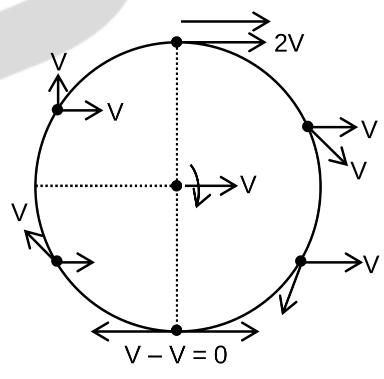
If the axis is parallel to field then again there will be no change in flux and hence no emf will be induced in the loop.

If the loop is deformed then obviously its area will change and hence the flux flowing through it will also change.

So, the correct option is (B) and (D)

39. (c, d)

At each point on the rim, the velocity is tangent due to circular motion and horizontal to the ground due to linear motion of the centre of mass of the disc. So, the resultant velocity will never be v or –v.



It is clear from the figure that at topmost position on the rim, the velocity is 2v and at lower most position, the velocity is 0.

So, the correct options are C and D.

40. (a, b, d)

De Broglie wave length (λ), it can be given as;

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

If both particles fall freely from the same height, then

$$v = \sqrt{2gh}$$

So, De Broglie wavelength

$$\lambda = \frac{h}{m\sqrt{2gh}}$$

So, $\lambda \propto \frac{1}{m}$ for same v

From the formula of De Broglie wave length, it can be seen that option B and option D are correct.