PHYSICS (312)

SECTION—A

Note : For Question Nos. 1 to 16, an internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.

1.

Pressure due to a liquid column does not depend on

(A) its density

(B) its viscosity

(C) its height

(D) acceleration due to gravity at the place

Answer: (B) its viscosity

Explanation**:**
P=hρg
where:

i. P is the pressure,
ii. h is the height of the liquid column,
iii. ρ is the density of the liquid, and
iv. g is the acceleration due to gravity.

From this formula, **pressure does not depend on viscosity**, which is a measure of a fluid's resistance to flow, not a factor in the calculation of pressure in a static column.

2.

In the sky after rains, rainbow is formed due to the phenomenon of

(A) interference (B) diffraction

(C) polarization (D) dispersion

Answer: (D) dispersion.

Explanation:
The formation of a rainbow after rain is due to the phenomenon of **dispersion**. When light passes through raindrops, it is dispersed into its constituent colors, creating a spectrum.

3.

When a constant net external force acts on a body, which of the following physical quantities may not change?

(A) Position (B) Speed

(C) Velocity (D) Acceleration

Answer: (B) Speed.

Explanation:
It is understood that when a constant net external force acts on a body, the body experiences constant **acceleration** according to Newton's Second Law of Motion. This constant acceleration implies that both the velocity and position of the body will change over time. However, **speed** may remain unchanged if the direction of motion changes but the magnitude of velocity (i.e., speed) remains constant.

4.

A body of mass m is thrown vertically upwards in air with an initial velocity v. Its kinetic energy at a height h will be

(A) equal to $\frac{1}{2}mv^2$ (B) more than $\frac{1}{2}mv^2$

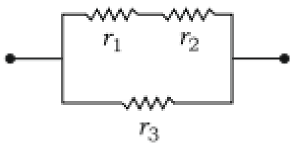
(C) less than $\frac{1}{2}mv^2$ (D) $mgh - \frac{1}{2}mv^2$

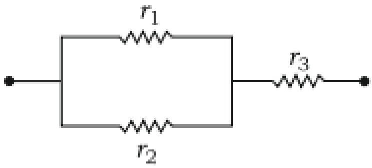
Answer: (C) less than ½ mv2.

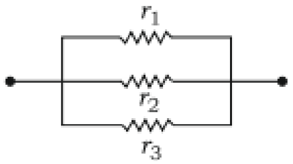
Explanation:
The kinetic energy of a body at a height h can be derived using the principle of conservation of mechanical energy. The total mechanical energy (kinetic + potential) remains constant, neglecting air resistance. At the height h, part of the body's initial kinetic energy is converted into potential energy.
The initial kinetic energy is ½ mv^2. At height h, the kinetic energy will be less than the initial kinetic energy because some of it is converted into potential energy, mgh.

9.

To obtain the maximum resistance, three resistors r_1, r_2 and r_3 should be connected as

(A) 

(B) 

(C) 

(D) 

Answer:

(D) 

Explanation:

To obtain the **maximum resistance**, resistors should be connected in **series**. When resistors are connected in series, the total resistance is the sum of the individual resistances:

$$R_{\text{total}} = r_1 + r_2 + r_3$$

10.

The light waves from two coherent sources of intensity I interfere. In interference pattern, if the intensity of light at minima is zero, the intensity of light at maxima is

(A) I^2

(B) I

(C) $2I$

(D) $4I$

Answer: (D) 4I.

Explanation:

The principles of interference, when two coherent sources interfere constructively, the intensity at the maxima is given by:

$$I_{\text{max}} = 4I$$

This occurs because, in constructive interference, the amplitudes of the waves add up, and the intensity, which is proportional to the square of the amplitude, becomes four times the individual intensity.

16.

Which of the following devices has its *I-V* characteristics in the fourth quadrant of Cartesian coordinate system?

(A) Zener diode (B) Photodiode

(C) LED (D) Solar cell

Answer: (B) Photodiode**.**

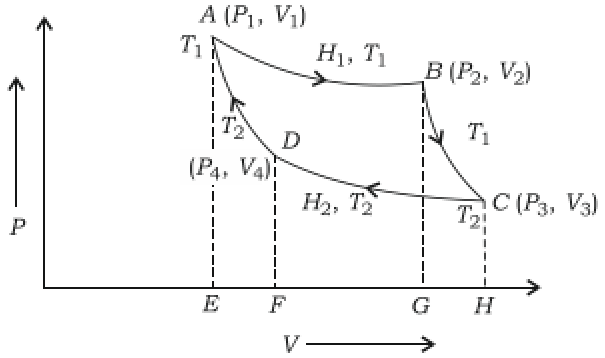
Explanation:
A **photodiode** operates in reverse bias and generates a current when exposed to light. In reverse bias mode, the current flows when the voltage is negative, which places its I-V characteristics in the fourth quadrant of the Cartesian coordinate system.

Note : Question Nos. 17 to 28 are objective type questions of 2 marks each. Some of these questions have 4 sub-parts. You have to attempt any 2 sub-parts out of the 4 sub-parts in such questions.

17. Read the passage given below and answer any two of the four questions that follow it :

Sadi Carnot visualized an ideal engine consisting of an ideal cylinder fitted with a piston of perfectly frictionless and insulating material and filled with a perfect gas, and there was an ideal heat source maintained at a constant temperature T1, an ideal heat sink at a constant lower temperature T2, and a lid of perfectly insulating material. Carnot showed that even this ideal engine cannot convert 100% of heat into work and its efficiency does not depend on the working substance.

Each cycle of a Carnot engine involves two isothermal strokes and two adiabatic strokes. The indicator diagram of Carnot cycle is shown in the figure below.



(a) In a Carnot cycle

(A) an isothermal expansion stroke is followed by an adiabatic expansion stroke

(B) an isothermal compression stroke is followed by an isothermal expansion stroke

(C) an isothermal expansion stroke is followed by an adiabatic compression stroke

(D) an isothermal expansion stroke is followed by an isothermal compression stroke

Answer: (C) An isothermal expansion stroke is followed by an adiabatic compression stroke.

This is consistent with the sequence of strokes in the Carnot cycle, which includes isothermal expansion, adiabatic expansion, isothermal compression, and adiabatic compression.

(b) In a Carnot engine, heat is

(A) absorbed during isothermal expansion and released during isothermal compression

(B) absorbed during isothermal expansion and released during adiabatic compression

(C) absorbed during adiabatic expansion and released during isothermal compression

(D) absorbed during adiabatic compression and released during isothermal expansion

Answer: (B) absorbed during isothermal expansion and released during adiabatic compression.

This follows the basic principles of heat absorption and release in a Carnot engine.

(c) The amount of heat converted into work in each cycle is equal to

(A) heat absorbed

(B) heat released

(C) (heat absorbed − heat released)

(D) (heat absorbed + heat released)

Answer: (C) (heat absorbed - heat released).

(d) Working substance for a heat engine can be

(A) necessarily steam

(B) necessarily petrol

(C) necessarily a perfect gas

(D) any gas

Answer: (D) any gas.

19. Read the passage given below and answer any two of the four questions that follow it :

To find the net force acting on a body, we consider only the external forces. Because, all internal forces between its molecules will add to zero as per the Newton's third law of motion. The same law also tells us that to find the various external forces acting on the body, we will have to take into account the various bodies in the surroundings of the body which interact with it.

The net force acting on the body is determined geometrically by applying the law of polygon or algebraically by applying the method of resolution of vectors.

The body is in translational equilibrium if the net force acting on the body is zero.

(a) While calculating the resultant force acting on a body, why do we not take into account the interaction forces between its molecules?
(b) What is the condition under which a body stays in equilibrium under two forces?
(c) What are the conditions under which a body stays in equilibrium under three forces?
(d) A book is placed on a table. What are the various forces acting on the book?

Answer:

- **(a)** We do not take the interaction forces between its molecules into account because, according to Newton's third law, these internal forces cancel out and add to zero.
- **(b)** A body stays in equilibrium under two forces if the two forces are equal in magnitude, opposite in direction, and act along the same line.
- **(c)** A body stays in equilibrium under three forces if the forces are concurrent (acting at a common point), and the vector sum of the forces is zero.
- **(d)** The forces acting on the book are:

    i. The gravitational force (weight) acting downward.
    ii. The normal force exerted by the table acting upward.

22.

Match the concept given in Column—I with the law given in Column—II (any *two*) : 1×2=2

Column—I	*Column—II*
(a) Temperature	*(i)* Clausius statement of second law of thermodynamics
(b) Conservation of energy	*(ii)* Kelvin-Planck statement of second law of thermodynamics
(c) Non-attainability of 100% efficiency by a heat engine	*(iii)* First law of thermodynamics
(d) Impossibility of self-transfer of heat from a body at lower temperature to a body at higher temperature	*(iv)* Zeroth law of thermodynamics

Answer:

Column–I	Column–II
(a) Temperature	(iv) Zeroth law of thermodynamics
(b) Conservation of energy	(iii) First law of thermodynamics
(c) Non-attainability of 100% efficiency by a heat engine	(ii) Kelvin-Planck statement of second law of thermodynamics
(d) Impossibility of self-transfer of heat from a body at lower temperature to a body at higher temperature	(i) Clausius statement of second law of thermodynamics

23.

Fill in the blanks : 1×2=2

(a) When two waves of frequency ν and (ν + Δν) superpose, the number of beats produced will be _____.

(b) The intensity ratio of two waves is 1 : 16. Their amplitude ratio will be _____.

Answer:

(a) When two waves of frequency v and $(v + \Delta v)$ superpose, the number of beats produced will be ***Δv***.

(b) The intensity ratio of two waves is 1:16. Their amplitude ratio will be ***1:4***.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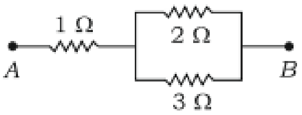
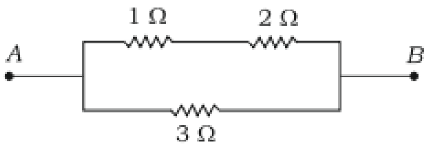
28.

Match the circuit given in Column—I with its resistance given in Column—II : 1×2=2

Column—I

(a) 

(b) 

Column—II

(i) 6·0 Ω

(ii) 0·5 Ω

(iii) 1·5 Ω

(iv) 2·2 Ω

Answer:

Column–I	Column–II
(a)	(iii) 1.5 Ω
(b)	(iv) 2.2 Ω

SECTION—B

29. A boy throws a ball vertically upwards with a velocity v0 and catches it when it returns. What will be the change in the linear momentum of the ball?

Answer: The change in linear momentum of the ball can be calculated using the principle of momentum, which is given by:

$$\Delta p = p_{\text{final}} - p_{\text{initial}}$$

- When the ball is thrown upwards, its initial momentum is mv_0 (where m is the mass of the ball and v_0 is the initial velocity).
- When the ball returns and is caught, its velocity will be $-v_0$ (since it is moving in the opposite direction).

Thus, the final momentum will be $m(-v_0)$.

The change in linear momentum is:

$$\Delta p = m(-v_0) - mv_0 = -2mv_0$$

Hence, the change in the linear momentum of the ball is $-2mv_0$.

30. . Name any two phenomena based on scattering of light.

Answer:

1. **Tyndall effect:** The scattering of light by colloidal particles in a medium, making the path of the light beam visible.
2. **Rayleigh scattering:** The scattering of light by particles much smaller than the wavelength of light, which is responsible for the blue color of the sky.

31. Write the symbol of (a) p-n junction and (b) p-n-p transistor

Answer:

(a) **p-n junction**:

The symbol for a p-n junction (diode) is:

```
        |
----|>|----
        |
```

(b) **p-n-p transistor**:

The symbol for a p-n-p transistor is:

```
   C
   |
----|<----
   |
   B
   |
----|<----
   |
   E
```

32. In Young's double-slit experiment, how is a dark fringe produced on the screen?

Answer: In Young's double-slit experiment, a **dark fringe** is produced on the screen due to **destructive interference**. This occurs when the path difference between the two waves from the slits is an odd multiple of half the wavelength, i.e.,

$$\Delta x = \quad n + \frac{1}{2} \quad \lambda$$

where Δx is the path difference, n is an integer (0, 1, 2,...), and λ is the wavelength of the light. At these points, the waves cancel each other out, resulting in a dark fringe.

33. Out of X-rays and microwaves, which radiation is more likely to produce photo-emission from a given material? Explain.

Answer: X-rays are more likely to produce photo-emission from a given material compared to microwaves.

This is because the ability of radiation to produce photo-emission depends on its energy, which is directly proportional to its frequency, according to the equation:

$$E = h\nu$$

Where:

- E is the energy,
- h is Planck's constant, and
- ν is the frequency of the radiation.

X-rays have a much higher frequency than microwaves, and thus, higher energy. This higher energy is more likely to overcome the work function of a material and cause the emission of electrons, resulting in photo-emission.

39. Two large charged plane sheets of charge densities σ and –2σ are arranged vertically and parallel with a seperation d between them. Deduce the expression for the electric field at a point (a) to the left of the first sheet, (b) to the right of the second sheet and (c) between the two sheets.

Answer: We can use **Gauss's law** to calculate the electric field due to an infinite charged plane sheet. The electric field EEE due to a plane sheet with surface charge density σ is given by:

$$E = \frac{\sigma}{2\epsilon_0}$$

Where ϵ_0 is the permittivity of free space.

Now, let's analyze the electric field in the three regions mentioned.

(a) To the left of the first sheet:

The first sheet has a charge density σ, and since the second sheet is far enough to the right, it doesn't affect the electric field in this region. The electric field due to the first sheet alone will be:

$$E = \frac{\sigma}{2\epsilon_0}$$

So, the electric field to the left of the first sheet is directed **away** from the positively charged sheet and is:

$$E = \frac{\sigma}{2\epsilon_0}$$

(b) To the right of the second sheet:

The second sheet has a charge density of -2σ, and since the first sheet is far away on the left, the electric field in this region is only due to the second sheet. The electric field due to a negatively charged sheet is directed **toward** the sheet and is given by:

$$E = \frac{-2\sigma}{2\epsilon_0} = \frac{-\sigma}{\epsilon_0}$$

Thus, the electric field to the right of the second sheet is:

$$E = \frac{-\sigma}{\epsilon_0}$$

(c) Between the two sheets:

In this region, the electric fields due to both sheets will add because the field due to the positively charged sheet is directed **away** from it, and the field due to the negatively charged sheet is directed **toward** it. The electric field between the two sheets is:

- Field due to the first sheet: $\frac{\sigma}{2\epsilon_0}$ (away from the sheet).
- Field due to the second sheet: $\frac{2\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$ (toward the second sheet).

Thus, the total electric field between the two sheets is:

$$E = \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{\epsilon_0} = \frac{3\sigma}{2\epsilon_0}$$

Summary of Electric Fields:

- (a) To the left of the first sheet: $E = \frac{\sigma}{2\epsilon_0}$
- (b) To the right of the second sheet: $E = \frac{-\sigma}{\epsilon_0}$
- (c) Between the two sheets: $E = \frac{3\sigma}{2\epsilon_0}$

These expressions follow from the application of Gauss's law and the superposition principle for electric fields.

40. State Faraday's laws of electromagnetic induction and explain them with the help of an example.

Answer:

Faraday's First Law:

Whenever there is a change in the magnetic flux linked with a closed circuit, an electromotive force (EMF) is induced in the circuit. If the circuit is closed, a current will flow due to this induced EMF.

Faraday's Second Law:

The magnitude of the induced EMF is directly proportional to the rate of change of magnetic flux linked with the circuit. Mathematically, this can be expressed as:

$$\text{EMF} = -\frac{d\Phi_B}{dt}$$

Where:

- Φ_B is the magnetic flux,
- $\frac{d\Phi_B}{dt}$ is the rate of change of magnetic flux,
- The negative sign indicates the direction of the induced EMF as per **Lenz's law**.

Explanation with an Example:

Example: Moving a Magnet through a Coil

Consider a coil of wire connected to a galvanometer. When a bar magnet is moved towards the coil, the magnetic flux linked with the coil changes, and an EMF is induced in the coil. This causes a current to flow, which is indicated by a deflection in the galvanometer.

- **When the magnet is moved closer to the coil:** The magnetic flux increases, and an EMF is induced.
- **When the magnet is moved away from the coil:** The magnetic flux decreases, and an EMF of opposite polarity is induced.
- **When the magnet is held stationary near the coil:** No EMF is induced because there is no change in magnetic flux.

This example illustrates both of Faraday's laws:

- The EMF is induced when there is a change in magnetic flux (First Law).
- The magnitude of the induced EMF depends on how quickly the magnetic flux changes (Second Law).

41. Convert the following :

(a) 7460 watt into hp
(b) 360 kJ into kWh

Answer:

(a) 7460 watts into horsepower (hp):

We know that 1 hp = 746 watts. To convert 7460 watts to hp:

$$\text{hp} = \frac{7460\,\text{watts}}{746\,\text{watts/hp}} = 10\,\text{hp}$$

So, 7460 watts is equivalent to **10 hp**.

(b) 360 kJ into kWh:

We know that 1 kWh = 3.6 × 10^6 joules (J), and 1 kJ = 1000 J.

First, convert 360 kJ to joules:

$$360\,\text{kJ} = 360 \times 1000 = 360,000\,\text{J}$$

Now, convert joules to kWh:

$$\text{kWh} = \frac{360,000\,\text{J}}{3.6 \times 10^6\,\text{J/kWh}} = 0.1\,\text{kWh}$$

So, 360 kJ is equivalent to **0.1 kWh**.

Final Answers:

- (a) 7460 watts = **10 hp**.
- (b) 360 kJ = **0.1 kWh**.

42. A metallic rod of length l is rotated with a frequency ν. One end of the rod is hinged at the centre and the other end at the circumference of a circular metallic ring. It is rotating about an axis passing through the centre and normal to the plane of the ring. A constant and uniform magnetic field B ρ parallel to the axis is present everywhere. (a) Obtain an expression for the e.m.f. induced between the centre and the ring. (b) Given that the rod has resistance R, how much power will be generated?

Answer:

(a) Expression for the induced EMF:

For a rod rotating in a uniform magnetic field, the EMF ε induced between the center and the ring can be found using the formula:

$$\varepsilon = \frac{1}{2}Bl^2\omega$$

Where:

- B is the magnetic field strength,
- l is the length of the rod,
- ω is the angular velocity of the rod, which is related to the frequency ν by $\omega = 2\pi\nu$.

Substituting $\omega = 2\pi\nu$ into the equation:

$$\varepsilon = \frac{1}{2}Bl^2(2\pi\nu)$$

$$\varepsilon = \pi Bl^2\nu$$

Thus, the expression for the induced EMF is:

$$\varepsilon = \pi Bl^2\nu$$

(b) Power generated:

The power generated can be found using the formula for power P in terms of EMF ε and resistance R:

$$P = \frac{\varepsilon^2}{R}$$

Substitute the expression for ε from part (a):

$$P = \frac{(\pi Bl^2\nu)^2}{R}$$

$$P = \frac{\pi^2B^2l^4\nu^2}{R}$$

Thus, the power generated is:

$$P = \frac{\pi^2 B^2 l^4 \nu^2}{R}$$

Final Answers:

- (a) The induced EMF between the center and the ring is $\varepsilon = \pi B l^2 \nu$.
- (b) The power generated is $P = \frac{\pi^2 B^2 l^4 \nu^2}{R}$.

43. Give the Boolean expression, logic symbol, truth table and implementation circuit of NOT gate.

Answer:

Boolean Expression:

The Boolean expression for a NOT gate is:

$$Y = \overline{A}$$

Where:

- A is the input,
- Y is the output, which is the complement (inverse) of A.

Logic Symbol:

The logic symbol for a NOT gate is:

A ----|>o---- Y

The symbol consists of a triangle pointing to the right with a small circle at the output, which represents inversion.

Truth Table:

The truth table for a NOT gate is as follows:

Input A	Output $Y = \overline{A}$
0	1
1	0

Implementation Circuit:

A NOT gate can be implemented using a transistor or integrated circuit. For simplicity, in an implementation using logic gates:

- A single input is provided to the NOT gate, and the output is the inverted form of the input.

Summary:

- Boolean Expression: $Y = \overline{A}$
- Logic Symbol: $A - - - -| > o - - - - Y$
- Truth Table:

Input A	Output $Y = \overline{A}$
0	1
1	0

- Implementation Circuit: The NOT gate inverts the input signal, and a basic circuit can be designed with logic gates or transistors to achieve this functionality.