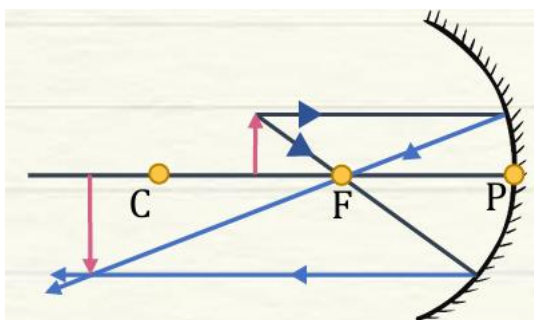


SOLUTION OF QUESTIONS CAT FOR WAVES AND OPTICS

SECTION A:

1. The Gauss law for the electric field (First Maxwell Equation which states that $\nabla \times \vec{E} = -\frac{\delta}{\epsilon_0}$, where E is the Electric field and δ is the charge density, ϵ_0 is the permeability in the vacuum means that the presence of charges imply the presence of electric field. In power transmission this case show up when there is high voltage conductor of transformer. Electrical power can have impact nearby, because of electrical field. That is why we some time see the sign of danger, telling people not to approach.
2. The **current density** (j) is the quantity of charges passing in the unity of time from the unity of area (A). Based on the definition $j = \frac{I}{A}$ and the unity is $[A/m^2]$.
The **charge density** (δ) is the quantity of charges present in the unity of area. Baed on that definition, $\delta = \frac{Q}{A}$ and the unity $[C/m^2]$

3.



The image is real, inverted, and greater than the object.

SECTION B:

1.

$$y_1 = a \sin(\omega t - \theta) \text{ and } y_2 = a \sin(\omega t + \theta)$$

$$y_2 + y_2 = a \sin(\omega t - \theta) + a \sin(\omega t + \theta)$$

Using the formula from trigonometry $\sin a + b + \sin a - b = 2 \sin a \cos b$, we get

$$y_2 + y_2 = 2a \cos \theta \sin \omega t. \text{ The amplitude } A \text{ is now } 2a \cos \theta.$$

If $A = 0$, then $2a \cos \theta$. But $2a \neq 0$.

So, $\cos \theta = 0$,

$$\theta = \frac{\pi}{2} + n\pi$$

$$n = 1, 3, 5, 7, \dots$$

2.

Radius of curvature, $R = + 3.00 \text{ m}$;

Object-distance, $u = - 5.00 \text{ m}$;

Image-distance, $v = ?$

Height of the image, $h' = ?$

Focal length, $f = R/2 = + \frac{3.00 \text{ m}}{2} = + 1.50 \text{ m}$ (as the principal focus of a convex mirror is behind the mirror)

Since $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\text{or, } \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = + \frac{1}{1.50} - \frac{1}{(-5.00)} = \frac{1}{1.50} + \frac{1}{5.00}$$

$$= \frac{5.00 + 1.50}{7.50}$$

$$v = \frac{+7.50}{6.50} = + 1.15 \text{ m}$$

The image is 1.15 m at the back of the mirror.

$$\text{Magnification, } m = \frac{h'}{h} = - \frac{v}{u} = - \frac{1.15 \text{ m}}{-5.00 \text{ m}}$$

$$= + 0.23$$

The image is virtual, erect and smaller in size by a factor of 0.23.

3. $i = \frac{dQ}{dt}$ (1), and $Q = \epsilon_0 \phi_E$ (2), ϕ_E is the charge flux i is the current, Q is the charge, t is the time ϵ_0 is the permittivity in the vacuum and A is the area.

Putting equation (2) in equation (1) gives: $i = d \frac{(\epsilon_0 \phi_E)}{dt}$.

But ϵ_0 is a constant. It can be outside the derivative: $i = \epsilon_0 d \frac{\phi_E}{dt}$.

Multiplying both sides with μ_0 gives

$\mu_0 i = \mu_0 \epsilon_0 d \frac{\phi_E}{dt}$. μ_0 is the permeability in vacuum. This expression shows that charge flux generates the current. It is applied in charging the capacitor to store the current.

SECTION C

1. Four Maxwell equations in differentiation form:

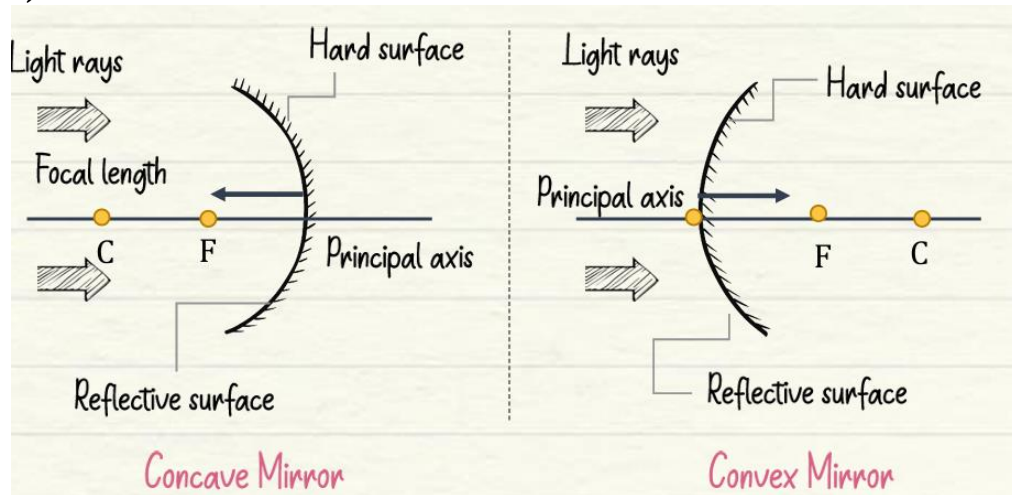
1) $\nabla \vec{E} = \frac{\delta}{\epsilon_0}$, where E is the Electric field and δ is the charge density, ϵ_0 is the permittivity in the vacuum. (This is Gauss's law for the electric field)

2) $\nabla \vec{B} = 0$, where B is the Magnetic field (This is Gauss's law for the magnetic field)

3) $\nabla \times \vec{E} = - \frac{\partial \vec{B}}{\partial t}$, where t is the time. (This is Faraday's law)

4) $\nabla \times \vec{B} = \mu_0 j = \mu_0 \epsilon_0 d \frac{\partial \vec{E}}{\partial t}$ where all letter are as defined previously (This is Ampere law).

2. A)



B)

$$\text{or, } \frac{1}{v} = \frac{-5.0 + 3.0}{75.0} = \frac{-2.0}{75.0} \quad \text{or, } v = -37.5 \text{ cm}$$

The screen should be placed at 37.5 cm in front of the mirror. The image is real.

$$\text{Also, magnification, } m = \frac{h'}{h} = -\frac{v}{u}$$

$$\text{or, } h' = -\frac{vh}{u} = -\frac{(-37.5 \text{ cm})(+4.0 \text{ cm})}{(-25.0 \text{ cm})}$$

Height of the image, $h' = -6.0 \text{ cm}$

The image is inverted and enlarged.

Object-size, $h = +4.0 \text{ cm}$;

Object-distance, $u = -25.0 \text{ cm}$;

Focal length, $f = -15.0 \text{ cm}$;

Image-distance, $v = ?$

Image-size, $h' = ?$

From Eq. (10.1):

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

$$\text{or, } \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{-15.0} - \frac{1}{-25.0} = -\frac{1}{15.0} + \frac{1}{25.0}$$