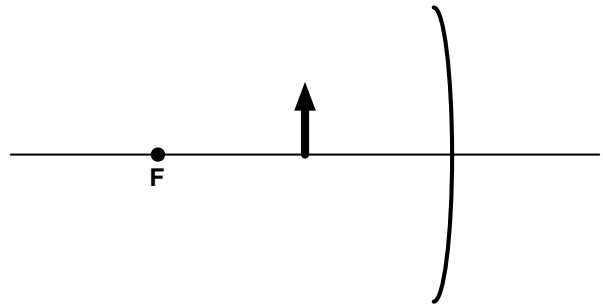
1. An object is placed in front of a concave mirror, as shown. The image is



   (a) real, upright, and larger than the object.
   (b) real, inverted, and smaller than the object.
   (c) virtual, upright, and smaller than the object.
   (d) virtual, inverted, and larger than the object.
   (e) $\boxed{\text{virtual, upright, and larger than the object.}}$

   Solution

   For concave mirrors, objects placed inside the focal length will produce images that are virtual, upright, and larger than the object, corresponding to choice $\boxed{\text{e}}$.

2. A diver shines a light upward from beneath the surface of a swimming pool. If he shines the light at an angle of 29° to the vertical, the angle at which the light leaves the water (n=1.33) is

   (a) 49°.
   (b) 25°.
   (c) 34°.
   (d) $\boxed{40°.}$
   (e) 28°.

   Solution

   We find

$$\begin{aligned}\theta_2 &= \sin^{-1}\left(\frac{n_1}{n_2}\sin\theta_1\right)\\ &= \sin^{-1}\left(\frac{1.33}{1.00}\sin 29°\right)\\ &= 40°,\end{aligned}$$

   or choice $\boxed{\text{d}}$.

3. Once again, a diver shines a light upward from beneath the surface of a swimming pool. The minimum angle at which the diver would need to shine the light so that *no* light leaves the water is

(a) 25°.
(b) 34°.
(c) 40°.
(d) $\boxed{49°.}$
(e) 28°.

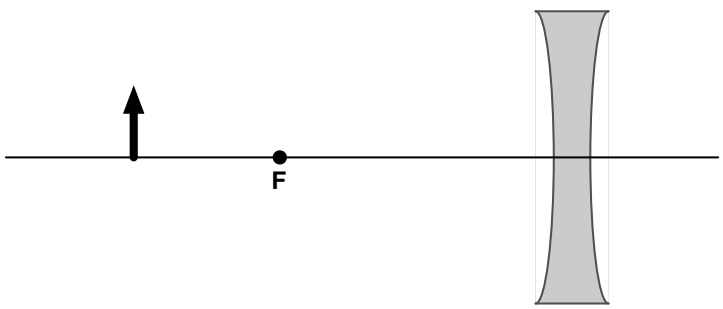
Solution

We find

$$\begin{aligned}\theta_c &= \sin^{-1}\left(\frac{n_2}{n_1}\sin\frac{\pi}{2}\right)\\ &= \sin^{-1}\left(\frac{1.00}{1.33}\right)\\ &= 49°,\end{aligned}$$

or choice $\boxed{\text{d}}$.

4. An object is placed 30 cm to the left of a diverging lens with a focal length of −20 cm. The image is



(a) real, upright, and 12 cm to the left of the lens.
(b) real, inverted, and 10 cm to the right of the lens.
(c) $\boxed{\text{virtual, upright, and 12 cm to the left of the lens.}}$
(d) virtual, inverted, and 10 cm to the right of the lens.
(e) virtual, upright, and 10 cm to the left of the lens.

Solution

We find

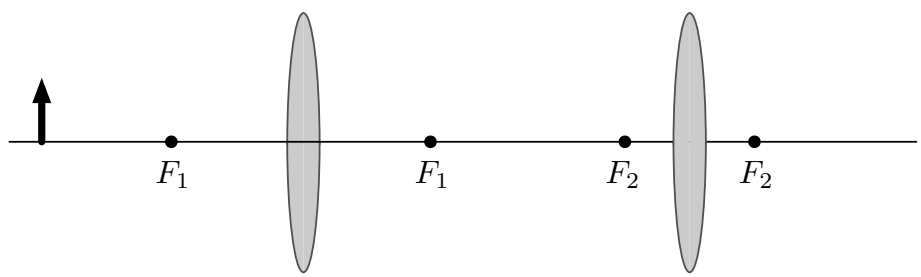
$$\begin{aligned}q &= \frac{pf}{p-f}\\ &= \frac{(30)(-20)}{30+20}\\ &= -12,\end{aligned}$$

and

$$\begin{aligned} M &= -\frac{q}{p} \\ &= \frac{12}{30} \\ &= 0.4, \end{aligned}$$

indicating an image that is virtual, upright, and 12 cm to the left of the lens, or choice $\boxed{\text{c}}$.

5. Two converging lenses are placed 60 cm apart. The focal length of the first lens is 20 cm, and the focal length of the second lens is 10 cm. An object is placed 40 cm to the left of the first lens, as shown. The final image is



(a) $\boxed{\text{upright and 20 cm to the right of lens 2.}}$
(b) inverted and 25 cm to the left of lens 2.
(c) upright and 25 cm to the right of lens 2.
(d) inverted and 20 cm to the right of lens 1.
(e) upright and 20 cm to the right of lens 1.

Solution

Letting d be the distance between the lenses, we write

$$\begin{aligned} q_2 &= \frac{p_2 f_2}{p_2 - f_2} \\ &= \frac{(d - q_1) f_2}{d - q_1 - f_2} \\ &= \frac{\left(d - \dfrac{p_1 f_1}{p_1 - f_1}\right) f_2}{d - \dfrac{p_1 f_1}{p_1 - f_1} - f_2} \\ &= \frac{\left(60 - \dfrac{(40)(20)}{40 - 20}\right) 10}{60 - \dfrac{(40)(20)}{40 - 20} - 10} \\ &= 20 \end{aligned}$$

and since both M_1 and M_2 are less than zero, the image will be "flipped" twice, resulting in an upright image 20 cm to the right of lens 2, or choice $\boxed{\text{a}}$.

Extra Credit (1 point)

Once again, write Maxwell's Equations.

$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q}{\epsilon_0}$$

$$\oint \mathbf{B} \cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$

$$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I + \epsilon_0 \mu_0 \frac{d\Phi_E}{dt}$$