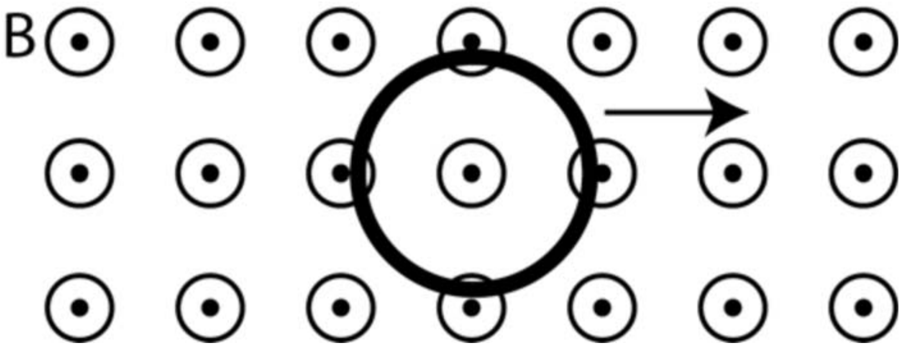
The next two questions pertain to the situation described below.

A metal ring, in the page, is in a region of uniform magnetic field pointing out of the page as shown in the figure below.



1) If the ring moves to the right (in the direction shown by the arrow) at a constant speed, what is the direction of the induced current in the ring?

a. No current is induced.
b. Clockwise
c. Counterclockwise

No magnetic flux change -> no emf due to Faraday

2) If we now decrease the magnetic field at a constant rate, what is the direction of the induced current in the loop?

a. Counterclockwise
b. No current is induced
c. Clockwise

Lenz tells us that the system opposes the change.

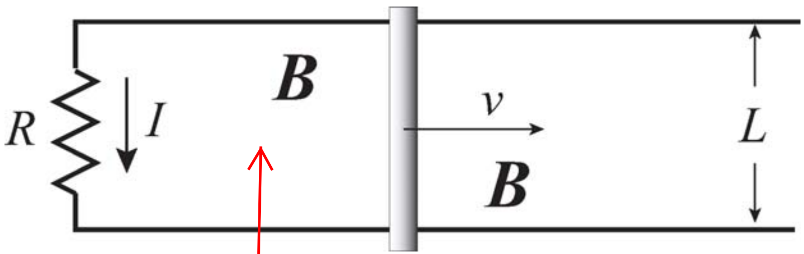
The magnetic flux out of the page through the ring decreases, so the ring compensates the decreasing flux. The ring must create an outgoing magnetic field. The right-hand screw rule tells us the answer.

The next two questions pertain to the situation described below.

On the horizontal plane is a pair of parallel, conducting wires separated by a distance L. The left ends are connected to a resistor R as shown in the figure.

Sliding frictionlessly on the wires is a conducting bar. The resistances of the wires and bar are negligible.

A uniform magnetic field $\mathbf{B}$ of magnitude B is applied perpendicular to the page.



$L = 1.2$ m
$R = 34\ \Omega$

3) The conducting bar is pulled to the right at a constant speed $v = 12$ m/s.

As the bar moves, a constant current $I = 0.2$ A flows in the direction indicated by the arrow.

What is the magnitude B of the magnetic field?

Faraday or the moving emf formula BLv = emf

Ohm's law I = emf/R

BLv/R = I, so
B = IR/Lv= 0.2x34/1.2x12 =0.47 T

a. $B = 3.2$ T
b. $B = 0.66$ T
c. $B = 0.47$ T
d. $B = 0.94$ T
e. $B = 0.31$ T

4) The direction of the magnetic field

The area, so the flux increases.

Lenz

The induced current creates B out of the page (the right-hand screw rule), so the original field must be in the opposite direction.

a. is into the page.
b. is out of the page.
c. cannot be determined.

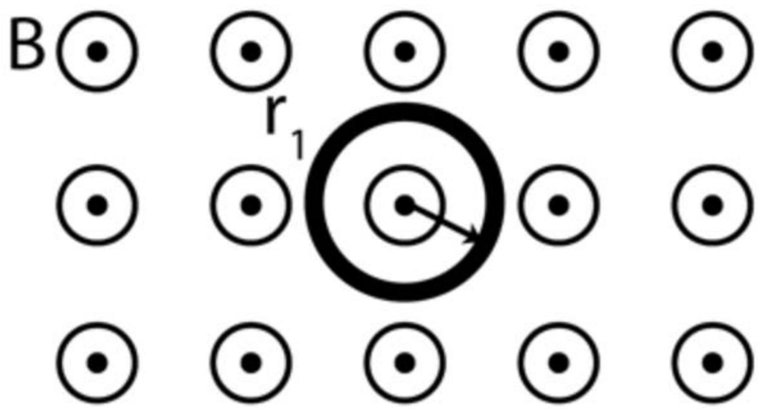
5) A ring is placed on the page and in a uniform magnetic field of strength $B = 1$ T pointing out of the page (see figure).

At time zero the ring has a radius $r_1 = 2$ cm. The ring expands at a constant rate for 10 seconds until it reaches a radius of $r_2 = 12$ cm.

Always read the problem well before jumping into calculation.

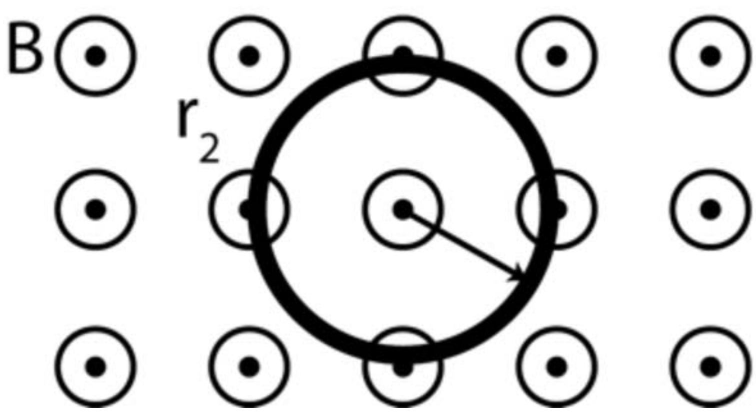
Notice that all numbers except two (the B value and one of r) are unrelated to answering the problem.

We need only r1 or r2 other than B.



$t = 0$s

This is a bad question not to have been asked.



$t = 10$s

We have only to calculate Phi1.

What is flux through the loop at $t = 0$s and $t = 10$ s?

```
Phi1 = pi r1^2 B
     = pi (0.02)^2 x 1
     = 0.001256  Wb
```

a. $\Phi_1 = 0.00126 \ \mathrm{T \cdot m^2}$ and $\Phi_2 = 0.0452 \ \mathrm{T \cdot m^2}$

b. $\Phi_1 = 4 \times 10^{-4} \ \mathrm{T \cdot m^2}$ and $\Phi_2 = 0.0144 \ \mathrm{T \cdot m^2}$

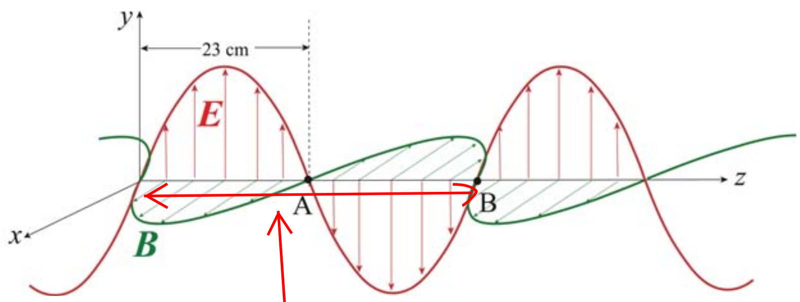
c. $\Phi_1 = 0.126 \ \mathrm{T \cdot m^2}$ and $\Phi_2 = 0.754 \ \mathrm{T \cdot m^2}$

The next three questions pertain to the situation described below.

Consider the electromagnetic wave shown in the diagram.

The wave is propagating through a vacuum along the z-axis.

The electric field of the wave is parallel to the y-axis. It is a sine wave of amplitude 15 V/m. The accompanying magnetic field is parallel to the x-axis. See Figure (which is a snapshot at a particular instant).



6) What is the frequency f of this electromagnetic wave?

c = f lambda

```
lambda = 2 x 0.23 = 0.46 m.
f = c/lambda = 3x10^8/0.46
  = 6.52 x 10^8 Hz
```

a. f = 0.138 GHz
b. f = 1.304 GHz
c. f = 0.652 GHz
d. f = 0.435 GHz
e. f = 0.326 GHz

7) How much energy W goes through a square of area 5 m^2 perpendicular to the z-axis (parallel to the xy-plane) in one second?

energy flux
= cu
u = epsilon_0 Emax^2/2

a. W = 1.49 J
b. W = 0.2 J
c. W = 2.11 J
d. W = 2.99 J
e. W = 0.1 J

```
W = cuA
  = (3x10^8) x (8.85x10^{-12} x 15^2/2) x 5
  = 14934 x 10^{8-12} = 1.49 J
```

8) This electromagnetic wave enters a medium with the index of refraction n = 2.55 for this frequency. What is the wavelength, λ_n, of the wave in this medium?

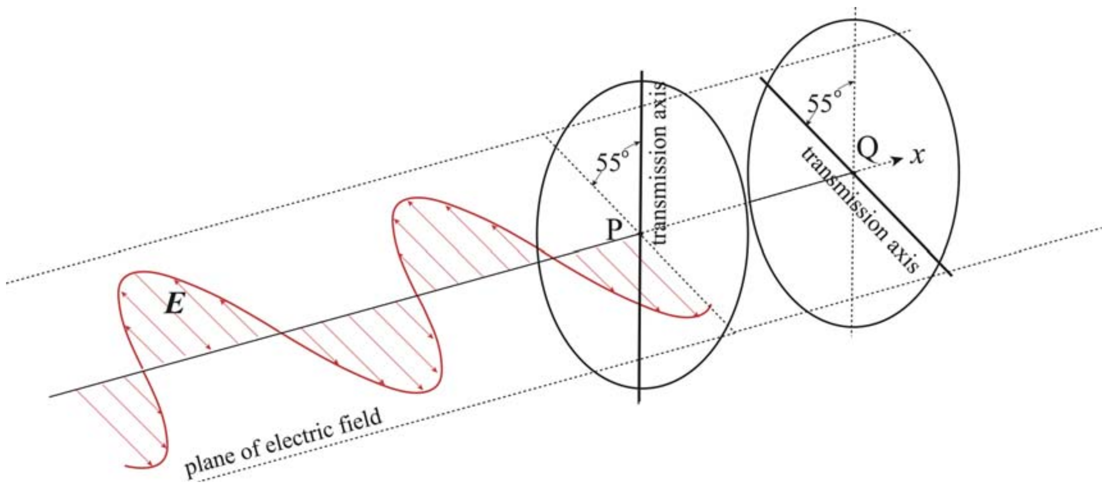
lambda -> lambda/n

```
23/2.55 = 9 cm
```

a. λ_n = 234.6 cm
b. λ_n = 117.3 cm
c. λ_n = 4.5 cm
d. λ_n = 18 cm
e. λ_n = 9 cm

The next two questions pertain to the situation described below.

A plane electromagnetic wave with electric field amplitude (E_{max} = 5.5 V/m) is incident on a polarizer as depicted in the figure. The **plane of electric field** indicates the plane in which the electric field lies. It makes an angle of 55 degrees with the transmission axis of the polarizer at *P*. The whole system is in a vacuum.



9) What is the amplitude of the electric field E_P immediately after passing through the first linear polarizer at *P*?

E = E0 x cos theta

a. E_p = 1.8 V/m

E = 5.5 cos 55 = 3.15 V/m

b. E_p = 3.7 V/m

c. E_p = 10 V/m

d. E_p = 3.2 V/m

e. E_p = 4.5 V/m

10) What is the intensity *I* of the light beyond the second polarizer at *Q* in terms of the intensity I_0 of the incident light?

Malus' law: I = I0 cos^2 theta

a. $I = 0.57 I_0$

b. $I = 0.33 I_0$

I = I0 cos^4 55 = 0.108 x I0

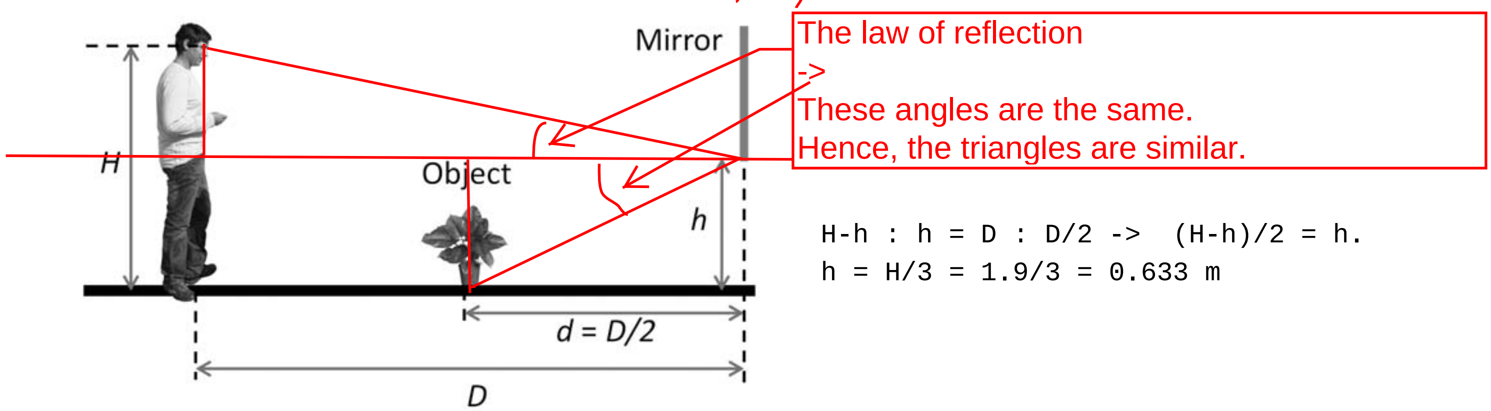
c. $I = 0.82 I_0$

d. $I = 0.19 I_0$

e. $I = 0.11 I_0$

11) A person is standing a distance D = 7 m in front of a flat, vertical mirror. The distance from the ground to his eyes is H = 1.9 m.

An object is placed on the ground a distance d = D/2 = 3.5 m in front of the mirror.



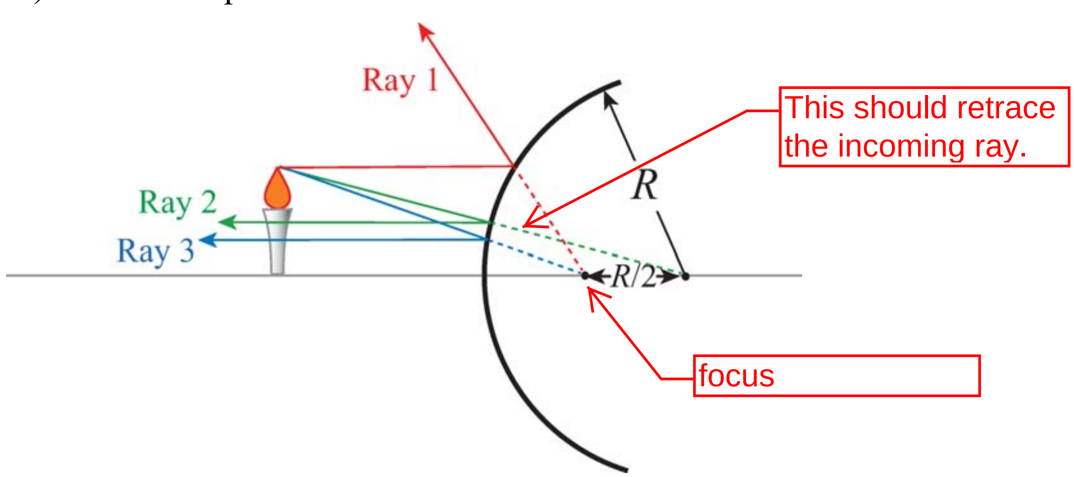
H-h : h = D : D/2 -> (H-h)/2 = h.

h = H/3 = 1.9/3 = 0.633 m

At what height h should the **bottom** of the mirror be so that the person can see the bottom of the object?

a. h = 3.68 m
b. h = 0.633 m
c. h = 0.317 m

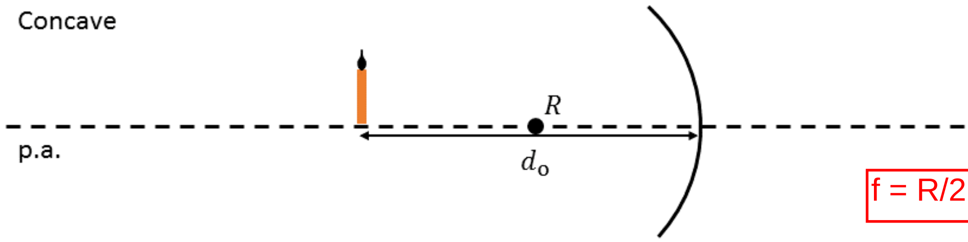
12) A candle is placed in front of a convex mirror with radius *R* as shown in the figure.



Which ray trace is ***incorrect*** for a ~~principle~~ ray?
principal

a. Ray 1
b. Ray 2
c. Ray 3

13) A candle, with height $h_o = 10$ cm, is placed $d_o = 60$ cm in front of a concave mirror with radius of curvature $R = 30$ cm, as shown.



f = R/2

What is the magnification, m, of the image in the **concave** mirror?

a. $m = -1$
b. $m = -0.2$
c. $m = -0.33$

```
f = 15 cm
do = 60 cm
1/di = 1/f - 1/do = 1/15 - 1/60
     = 3/60 = 1/20.
m = -20/60 = -1/3
```

1/f = 1/do + 1/di
m = -di/do

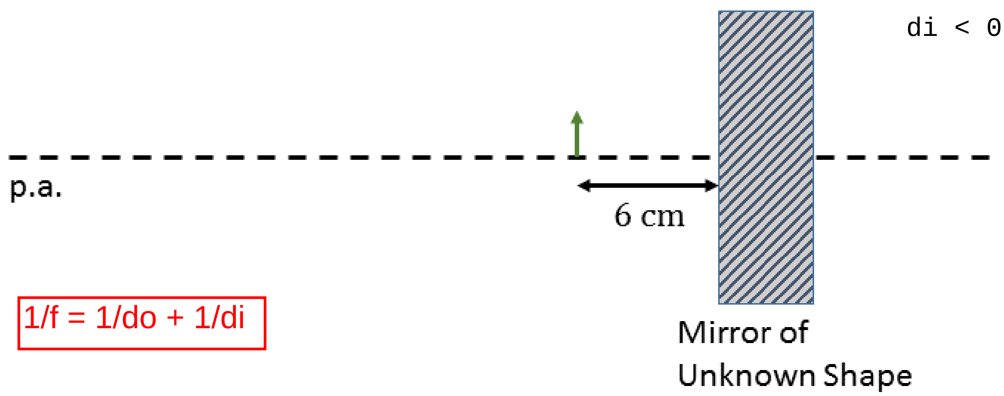
14) A real object sits 6 cm in front of a mirror.

The object height is $h_o = 3$ cm.

An upright image is produced $|d_i| = 18$ cm away from the mirror.

m > 0 upright

```
Since m > 0 and do > 0 (real),
di < 0.
```



1/f = 1/do + 1/di

What is the mirror?

```
1/f = 1/6 - 1/18 = 1/9
converging mirror.
```

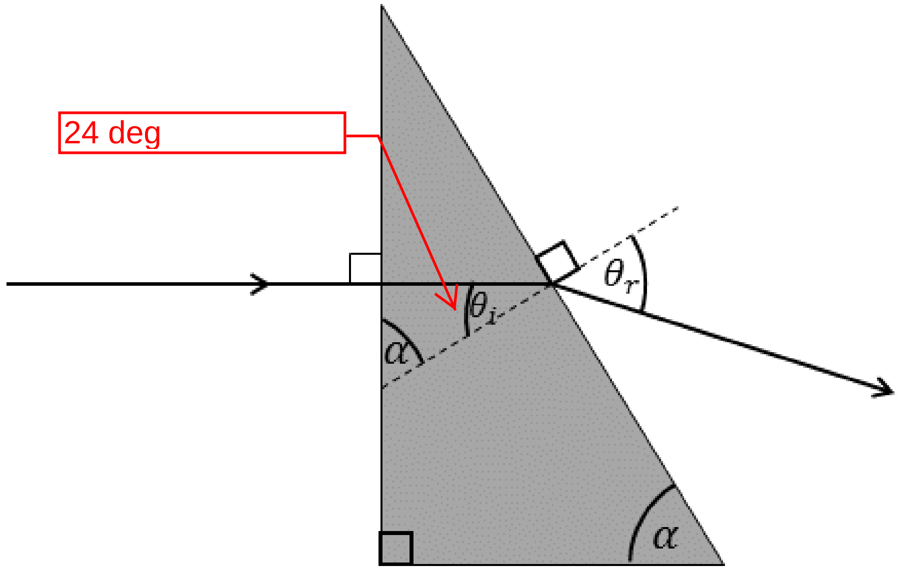
a. A convex mirror with the focal length (absolute value) 12 cm
b. A convex mirror with the focal length (absolute value) 4.5 cm.
c. A concave mirror with the focal length (absolute value) 12 cm
d. A concave mirror with the focal length (absolute value) 4.5 cm
e. A concave mirror with the focal length (absolute value) 9 cm

The next two questions pertain to the situation described below.

Consider a glass prism in the shape of a right triangle that makes an angle $\alpha = 66^\circ$, as shown.

The glass has index of refraction $n_{red} = 1.5$ and $n_{blue} = 1.53$ for red and blue light, respectively.

Snell's law
n sin theta = n' sin theta'



15) A ray of red, monochromatic light travelling in air to the right hits the surface of the prism at 90°, as shown in the figure. What is the angle θ_r at which the light emerges?

```
1.5 sin 24 = sin thetar -? thetar = 37.597 deg
```

a. $\theta = 54.78^\circ$

b. $\theta = 42.87^\circ$

c. $\theta = 24^\circ$

d. $\theta = 37.6^\circ$

e. $\theta = 66^\circ$

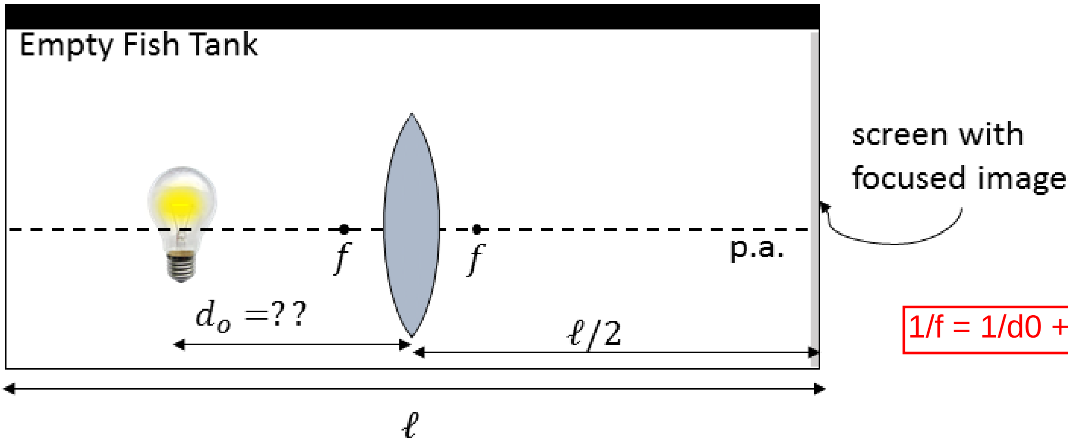
16) Now, a ray of white light hits the surface of the prism at 90°. In what order, from top to bottom do the different colored rays emerge?

a. Blue ray at the top, red ray at the bottom
b. Red and blue rays at the same angle
c. Red ray at the top, blue ray at the bottom

larger n implies
large thetar

The next three questions pertain to the situation described below.

A converging lens of focal length f = 12.5 cm, in air (n = 1), is placed at the center of a fish tank ℓ = 122 cm long. The right-hand end of the fish tank is painted to make a screen.



1/f = 1/d0 + 1/di

17) Where should a light bulb be placed to produce a focused, real image on the screen inside the fish tank?

```
f = 12.5 cm
di = 61 cm

1/do = 1/f - 1/61 = 1/15.72
```

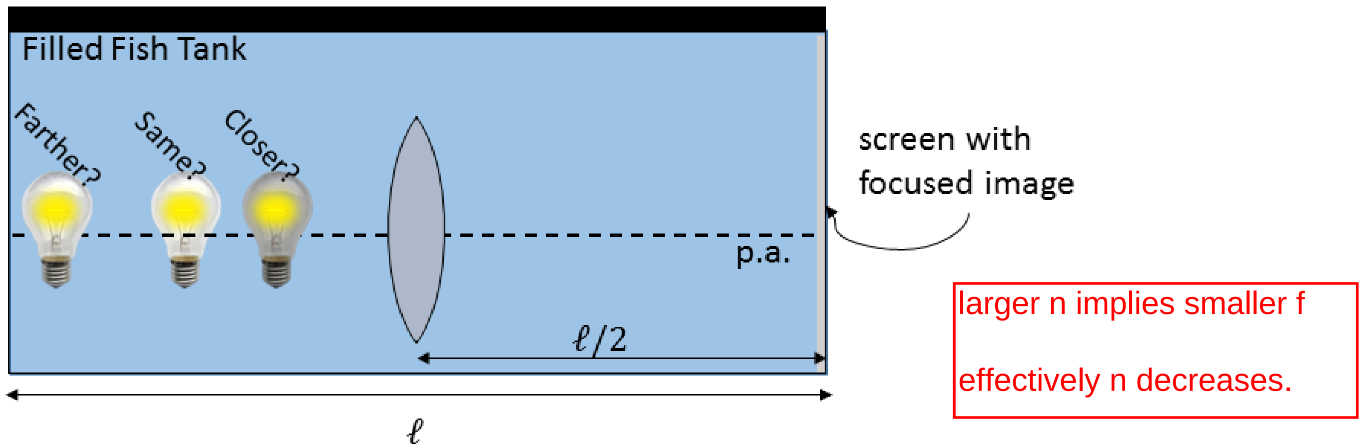
a. d_o = 12.5 cm
b. d_o = 15.72 cm
c. d_o = 10.37 cm
d. d_o = 1.26 cm
e. d_o = 0.83 cm

18) The image on the screen is

```
m = -di/do < 0
```

a. none of these.
b. inverted.
c. upright.

19) The fish tank is filled with water.



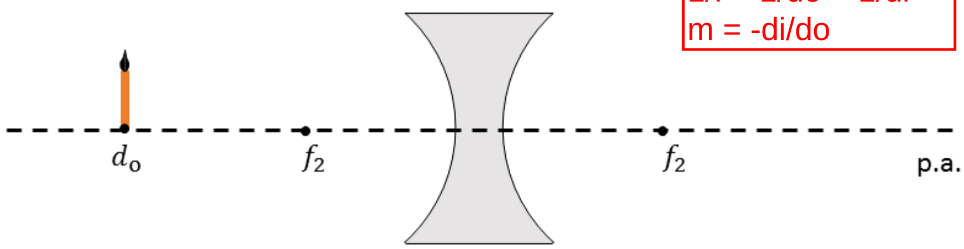
To obtain a focused image of the light bulb on the screen you must

a. increase the distance between the light bulb and the lens.
b. decrease the distance between the light bulb and the lens.
c. leave the light bulb in the same location as when the fish tank was empty.

The next two questions pertain to the situation described below.

Consider the following candle-lens case:

A candle is placed $d_o = 11$ cm to the left of a diverging lens of focal length $f_2 = -5.5$ cm as shown.



1/f = 1/do + 1/di
m = -di/do

20) Which of the following statements is true about the image formed by this lens:

- Statement A: Virtual, Upright
- Statement B: Real, Inverted
- Statement C: Virtual, inverted

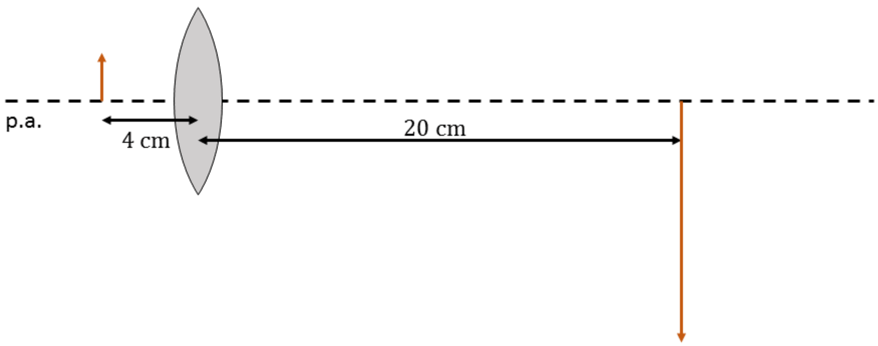
```
1/di = 1/f - 1/do = -1/5.5 -1/11 = -3/11

m = -(-11/3)/11 = 1/3
```

a. *Statement B*
b. *Statement C*
c. *Statement A*

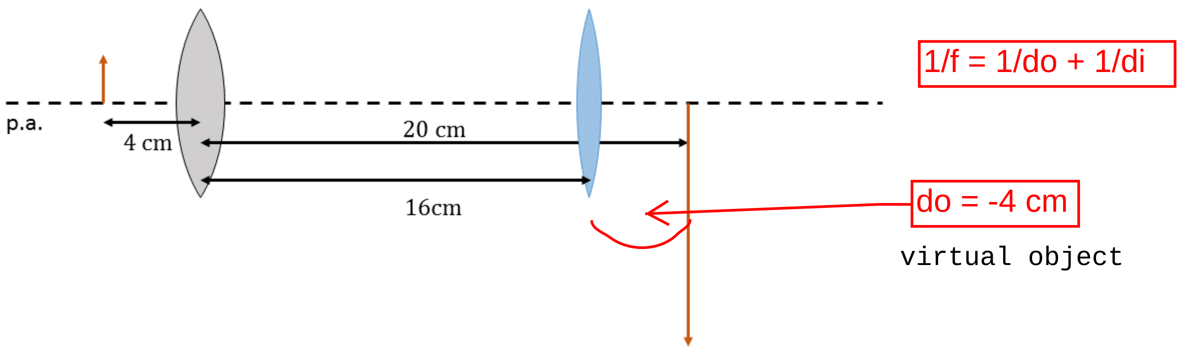
21) The image distance is

a. $d_i = -11$ cm
b. $d_i = -3.67$ cm
c. $d_i = -16.5$ cm
d. $d_i = 3.67$ cm
e. $d_i = 11$ cm

22) Initially, there is a converging lens alone. The real image of an object placed 4 cm in front of it makes a real image 20 cm behind this convex lens.



Now, a converging lens of focal length 6 cm is placed 16 cm from the lens as shown below.

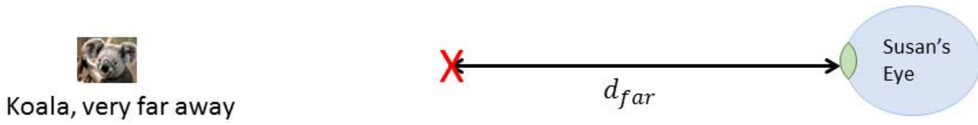


The final image produced by this two-lens system is located:

a. 2.4 cm to the right of the second lens.
b. 2.4 cm to the left of the second lens.
c. 12 cm to the left of the second lens.
d. 6 cm to the right of the second lens.
e. 12 cm to the right of the second lens.

1/do = 1/6 - 1/(-4) = 5/12 = 1/2.4

23) Susan has difficulty seeing distant objects. She requires corrective contact lenses.



Susan's far-point is d_{far} = 45 cm.

What should her corrective lens prescription be to see a koala very far away?

Remember: a diopter is $P = 1/f$ where f is measured in meters.

a. 2.2 diopters
b. −0.45 diopters
c. 0.45 diopters
d. −4.4 diopters
e. −2.2 diopters

Make the illusion where it can be seen well by the uncorrected eye.

```
di = -45 cm
do = infty

  1/f = 1/di = -1/0.45 = -2.22 D
```