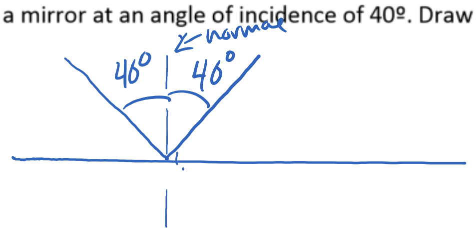
Name: ______________________________ Block: ______________

Physics 11

Unit 6 Review – Optics

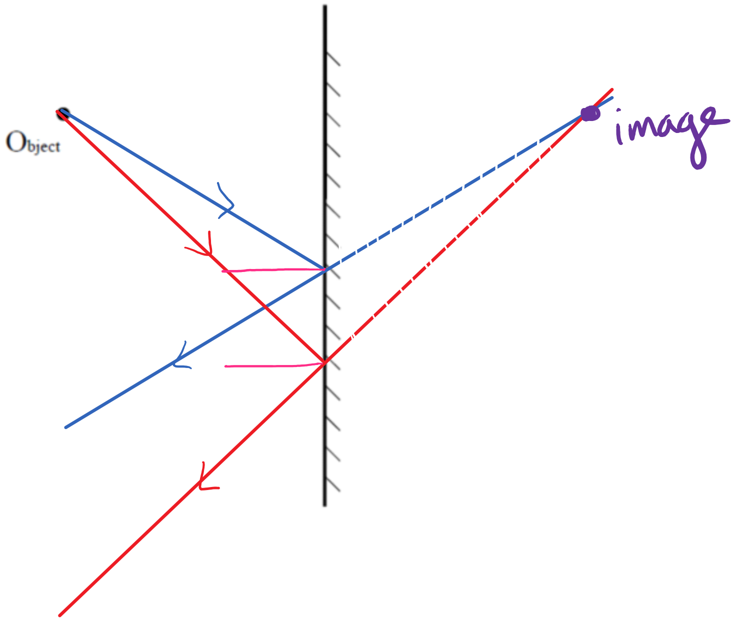
1) A beam of light strikes a mirror at an angle of incidence of 40º. Draw a diagram and show the angle of reflection of the reflected ray.



2) What happens to the size of the image as a plane mirror is moved away from an object?

stays the same.

3) Draw a ray diagram to locate the image in the plane mirror:



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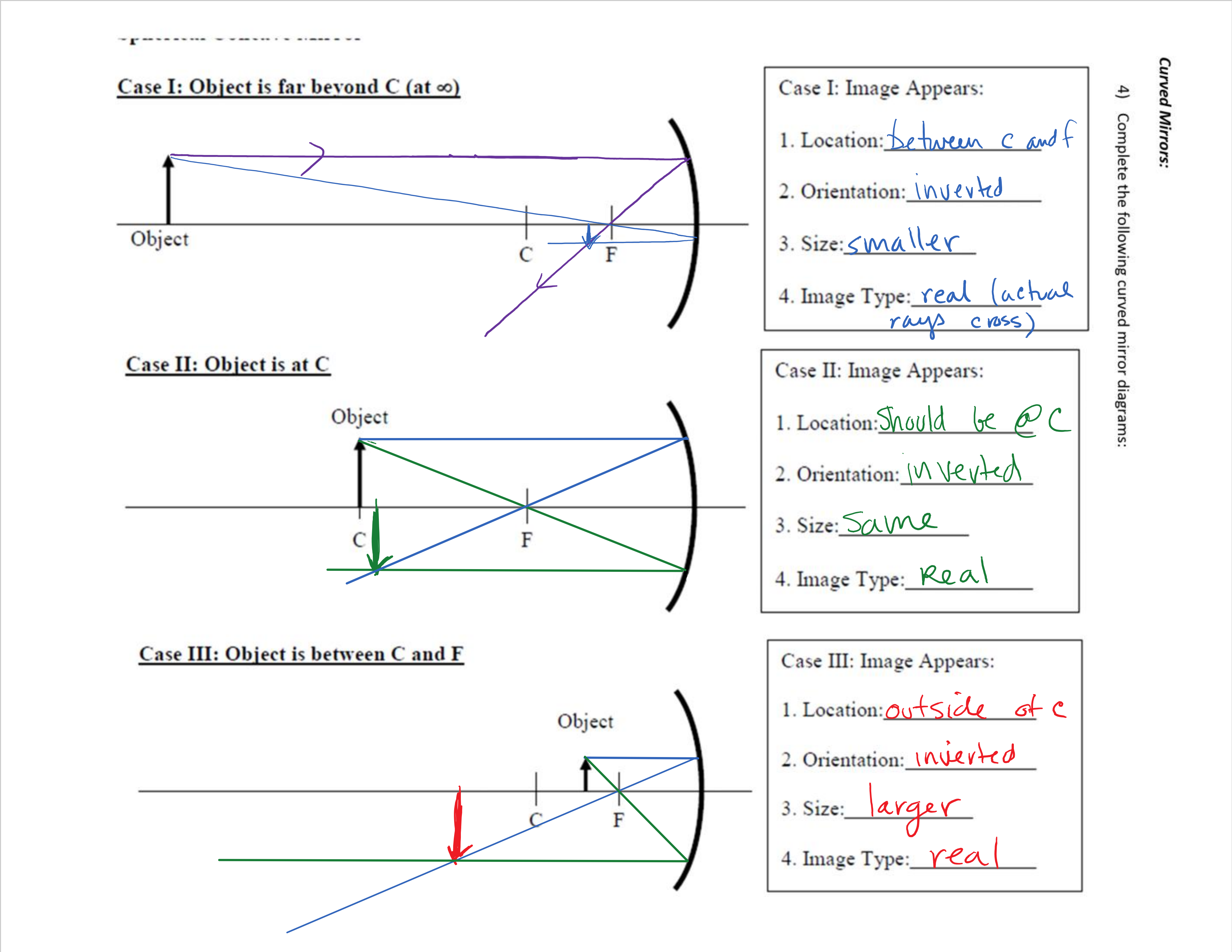

Curved Mirrors:

4) Complete the following curved mirror diagrams:

Case I: Object is far beyond C (at ∞)

Case I: Image Appears:

1. Location: between c and f
2. Orientation: inverted
3. Size: smaller
4. Image Type: real (actual rays cross)

Case II: Object is at C

Case II: Image Appears:

1. Location: Should be @ C
2. Orientation: inverted
3. Size: Same
4. Image Type: Real

Case III: Object is between C and F

Case III: Image Appears:

1. Location: outside of c
2. Orientation: inverted
3. Size: larger
4. Image Type: real

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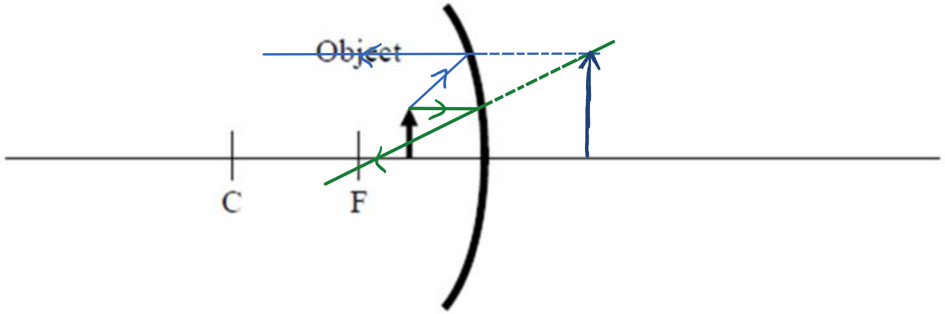
Case IV: Object is inside F (between F and Mirror)



Case IV: Image Appears:

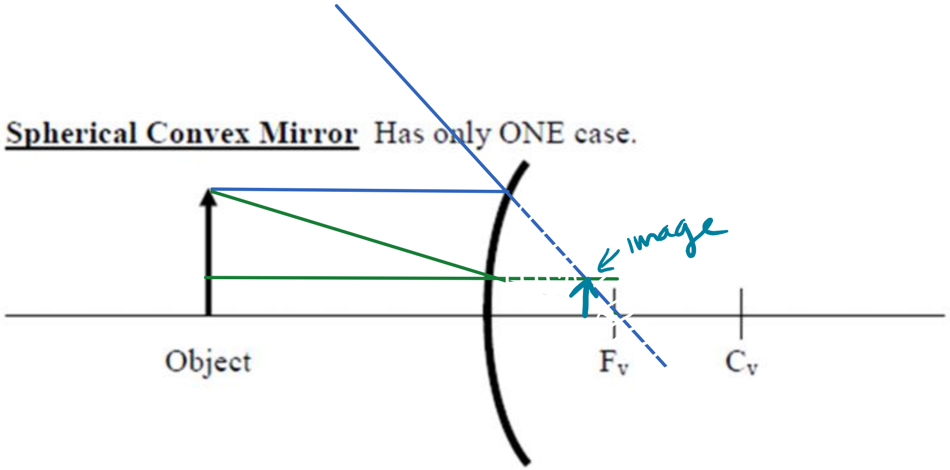
1. Location: behind mirror

2. Orientation: Upright

3. Size: larger

4. Image Type: virtual

Spherical Convex Mirror Has only ONE case.



Convex Mirror's Image Appears:

1. Location: behind mirror

2. Orientation: upright

3. Size: smaller

4. Image Type: Virtual

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5) A concave mirror has a focal length of 5cm. An object 2cm high is 11cm from the mirror. Calculate the image height and image distance.

$f = 5.0\text{ cm}$

$d_o = 11.0\text{ cm}$

$d_i = ?$

$h_i = ?$

$$\frac{1}{f}\cancel{-\frac{1}{d_o}} = \frac{1}{d_o}\cancel{-\frac{1}{d_o}} + \frac{1}{d_i}$$

$$\frac{1}{f}\cdot\frac{d_o}{d_o} - \frac{1}{d_o}\cdot\frac{f}{f} = \frac{1}{d_i}$$

$$\frac{d_o}{d_o f} - \frac{f}{d_o f} = \frac{1}{d_i}$$

$$\frac{d_o - f}{d_o f} = \frac{1}{d_i}$$

$$\Rightarrow \boxed{d_i = \frac{d_o f}{d_o - f}}$$

$$d_i = \frac{(11.0\text{cm})(5.0\text{cm})}{(11\text{cm} - 5\text{cm})}$$

$$d_i = 9.17\text{cm}$$

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = \frac{-d_i \bullet h_o}{d_o}$$

$$h_i = \frac{-(9.17\text{cm})(2\text{cm})}{11.0\text{cm}}$$

$$h_i = -1.67\text{cm}$$

inverted

6) A convex mirror has a focal length of -0.90m. An object with a height of 0.40m is 2.5m from the mirror.
a) Calculate the image distance.

$f = -0.90\text{m}$

$d_o = 2.5\text{m}$

$h = 0.40\text{m}$

$d_i = ?$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

from # 5:

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{(2.5\text{m})(-0.90\text{m})}{(2.5\text{m} - 0.90\text{m})} = -1.40\text{m}$$

behind mirror

b) Calculate the image height.

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$h_i = \frac{-d_i \bullet h}{d_o} = \frac{-(-1.40\text{m}) \bullet 0.40\text{m}}{2.5} = \boxed{0.225\text{m}}$$

(+) ← means upright

Refraction:

7) What is an index of refraction?

$$n = \frac{V_{vacuum}}{V_{medium}}$$

← ratio of speed of light in vacuum to material

→ higher index

⇒ more bending

8) State Snell's law and define the variables

$$n_1 \sin\theta_i = n_2 \sin\theta_r$$

* look in your notes!

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9) A laser beam with a frequency of 6.09 x 10^{14} Hz is incident from air onto a transparent medium. The angle of incidence is 51.0 deg. The angle of refraction is 25.0 deg.

a. What is the index of refraction of the medium?

$n_1 = \text{air} = 1.0003$ $\theta_i = 51°$

$n_2 = ?$ $\theta_r = 25°$

Snell's law

$$n_1 \sin\theta_i = n_2 \sin\theta_r$$

$$\Rightarrow n_2 = \frac{n_1 \sin\theta_i}{\sin\theta_r} = \frac{1.0003 \sin(51°)}{\sin(25°)}$$

$$\boxed{n_2 = 1.839}$$

b. What is the speed of light in the medium?

$$n_2 = \frac{V_{vacuum}}{V_{med}}$$

$$V_{med} = \frac{V_{vacuum}}{n_2} = \frac{3.00\times10^8 \text{ m/s}}{1.839}$$

$$V_{med} = 1.630 \times 10^8 \text{ m/s}$$

c. What is the wavelength of light in the medium?

$$V = \lambda \cdot f$$

$$\Rightarrow \lambda = \frac{V}{f} = \frac{1.630\times10^8}{6.09\times10^{14}} \leftarrow$$

from Question (read above)

$$= 2.67 \times 10^{-7} \text{ m}$$

~~10~~) An unknown substance is submerged in water (n_w = 1.33). A ray of light passes from the unknown into the water and refracts at an angle of 67°. If the speed of light in the unknown is 1.75 x 10^8 m/s, what is the incident angle of the light?

DON'T DO

① find index of refraction of medium

$$n_{med} = \frac{V_{vacuum}}{V_{med}} = \frac{3.00\times10^8 \text{ m/s}}{1.75\times10^8 \text{ m/s}}$$

$$n_{med} = 1.714$$

② Snell's law:

$$\frac{\cancel{n_1}\sin\theta_i}{\cancel{n_1}} = \frac{n_2\sin\theta_r}{n_1}$$

$$\cancel{\sin^{-1}}(\cancel{\sin}\,\theta_i) = \sin^{-1}\left(\frac{n_2\sin\theta_r}{n_1}\right)$$

$$\theta_i = \sin^{-1}\left(\frac{n_2\sin\theta_r}{n_1}\right)$$

$$\rightarrow \theta_i = \sin^{-1}\left(\frac{1.685\cdot\sin(67°)}{1.33}\right)$$

n of water

θ_i = Domain error!

→ Poorly written Question!

☹

-> would refract towards normal

-> refracted angle must be less than 45° !

→ assuming 2

11) The critical angle for a medium is 55 degrees. What is the speed of light in that medium?

① find n using snell's law

$n_1 \sin\overset{\text{critical angle}}{\theta_i} = \underset{\text{air}}{n_2} \sin\overset{\text{must be }90°}{\theta_r}$

$$n_1 = \frac{n_2 \sin\theta_r}{\sin\theta_i}$$

$$n_1 = \frac{1.0003 \sin(90°)}{\sin(55°)}$$

$$\boxed{n_1 \ 1.22}$$

$$n = \frac{V_{vacuum}}{V_{med}} \Rightarrow V_{med} = \frac{V_{vacuum}}{n} = \frac{3.00\times10^8 m/s}{1.22} = 2.45\times10^8 m/s$$

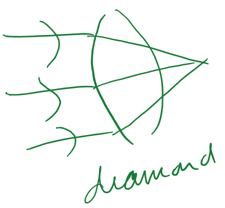
12) You have just managed to mix up two converging (convex) lenses. One of these lenses is made from crown glass and the other is made from a diamond. You know that because they have different indices of refraction, they will have different focal lengths. Which lens will have the longer focal length, the glass or the diamond? Draw a sketch:

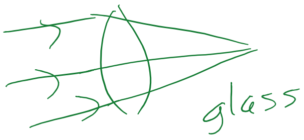
Diamonds have higher index of refraction

→ bends light more

→ smaller focal length.

∴ glass will have larger focal length





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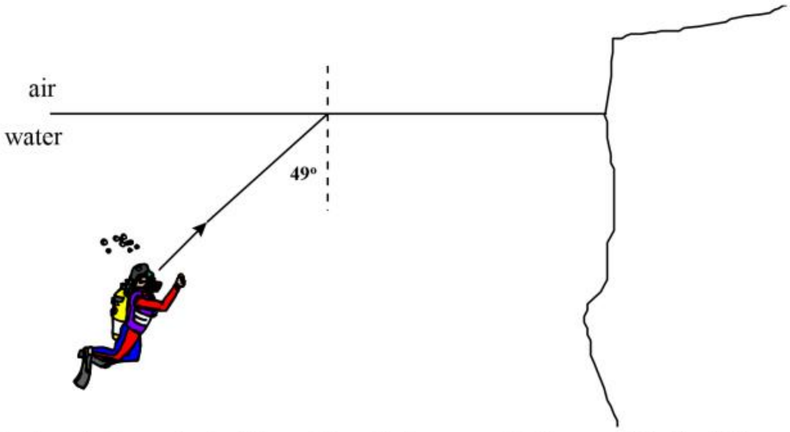
13) A ray of light is travelling from water to air.



a) If the critical angle for water is 49°, explain what happens to the ray of light at this angle.

it only reflects ⇒ total internal reflection

b) What would you expect to see if you look towards the water at an angle greater than the critical angle?

only reflections

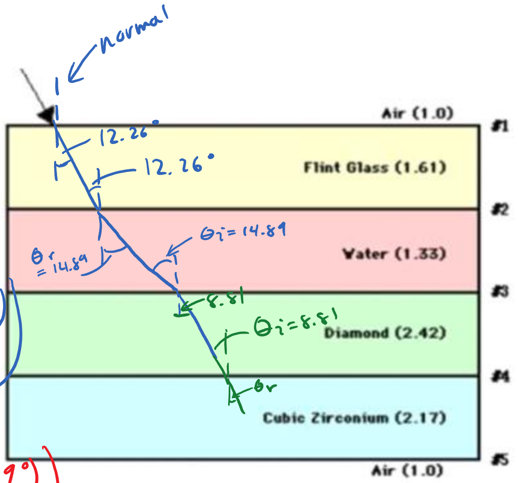
14) If the incoming angle from the air is 20° from the normal.

a. What angle is light traveling through each of the mediums below:

$$\frac{n_1 \sin\theta_i}{n_2} = \frac{\cancel{n_2} \sin\theta_r}{\cancel{n_2}}$$

$$\frac{n_1 \sin\theta_i}{n_2} = \sin\theta_r$$

$$\Rightarrow \boxed{\theta_r = \sin^{-1}\left(\frac{n_1 \sin\theta_i}{n_2}\right)}$$



i. Flint glass:

$$\theta_r = \sin^{-1}\left(\frac{1.0 \sin(20°)}{1.61}\right)$$

$$\boxed{\theta_r = 12.26°}$$

ii. Water:

$$\theta_r = \sin^{-1}\left(\frac{1.61 \sin(12.26°)}{1.33}\right)$$

$$\theta_r = 14.89°$$

iii. Diamond:

$$\theta_r = \sin^{-1}\left(\frac{1.33 \sin(14.89°)}{2.42}\right)$$

$$\theta_r = 8.81°$$

iv. Cubic Zirconium:

$$\theta_r = \sin^{-1}\left(\frac{2.42 \sin(8.81°)}{2.17}\right)$$

$$\theta_r = 9.83°$$

v. Air:

Kubic Z to air:

$$\theta_r = \sin^{-1}\left(\frac{2.17 \sin(9.83)}{1.0}\right)$$

$$\boxed{\theta_r = 21.7°}$$

b. How does the final angle of the light in air compare to the initial angle of light in air?

close → would prob be same with correct rounding!

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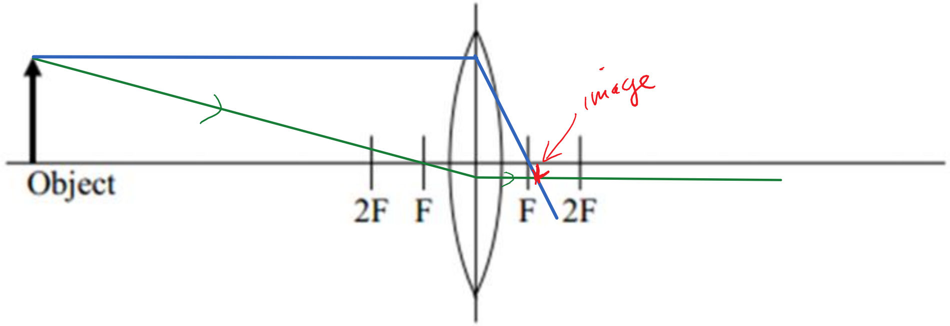
Lenses:

15) Draw the following ray diagrams:

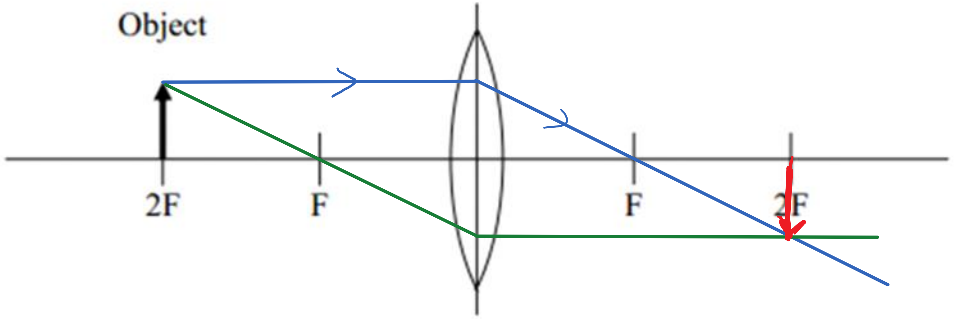
Case I: Object is far beyond 2F (at ∞)



Case I: Image Appears:

1. Location: Between f and 2f.
2. Orientation: inverted
3. Size: smaller
4. Image Type: real

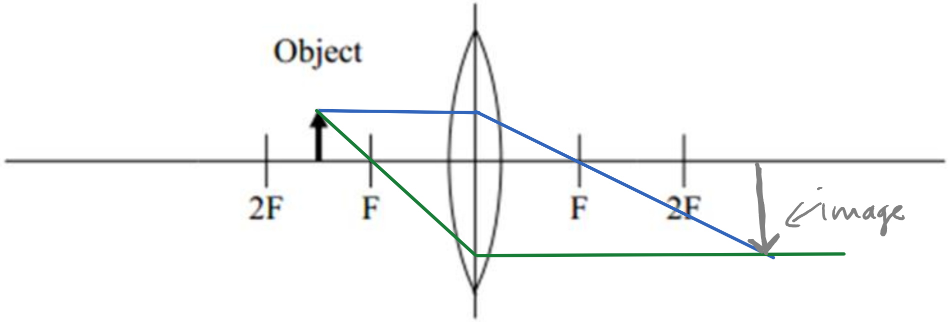
Case II: Object is at 2F



Case II: Image Appears:

1. Location: @ 2F
2. Orientation: inverted
3. Size: same
4. Image Type: real

Case III: Object is between 2F and F



Case III: Image Appears:

1. Location: outside 2F
2. Orientation: inverted
3. Size: larger
4. Image Type: real

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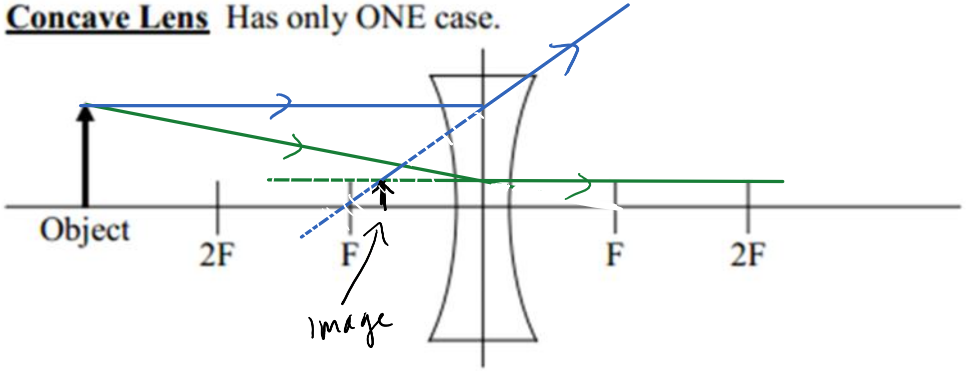
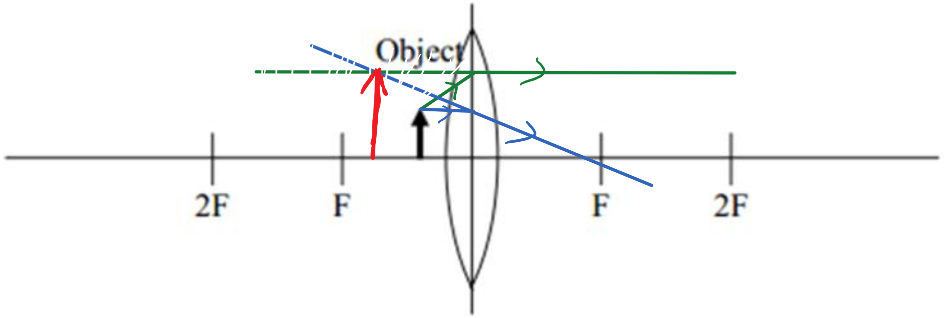
Concave Lens Has only ONE case.



Convex Mirror's Image Appears:

1. Location: on other side of lens
2. Orientation: upright
3. Size: smaller
4. Image Type: Virtual

Case IV: Object is inside F (between F and Lens)



Case IV: Image Appears:

1. Location: behind lens
2. Orientation: upright
3. Size: larger
4. Image Type: Virtual

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16) Fill in the following tables:

Mirrors:

Type of mirror	**Shape of mirror (concave or convex)**	**Focal Length (positive/negative)**	**Image type (real, virtual, both)**
Converging	concave	+	both
Diverging	convex	−	virtual

Lenses:

Type of lens	**Shape of lens(concave or convex)**	**Focal Length (positive/negative)**	**Image type (real, virtual, both)**
Converging	convex	+	both
Diverging	concave	−	virtual

17) A diverging lens has a focal length of 20 cm and a 5.0 cm high object is placed 15 cm in front of it. Determine the size and location of the image, use calculations.

$f = -20\text{ cm}$

$d_o = 15\text{cm}$

$d_i = ?$

$h = ?$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

from #5

$$d_i = \frac{d_o f}{(d_o - f)} = \frac{15(-20\text{cm})}{(15-(-20))}$$

$$= -8.57\text{ cm}$$

$$\frac{h_i}{h_o} = -\frac{d_i'}{d_o}$$

$$h_i = -\frac{d_i}{d_o} \cdot h_o$$

$$= -\frac{(-8.57\text{cm})(5.0\text{cm})}{(15\text{cm})}$$

$$\boxed{h_i = 2.857\text{cm}}$$

18) The focal length of a mirror does not depend on the material but the focal length of a lens does depend on the material. Explain.

mirrors just reflect → law of reflection applies to all

lenses refract → depends on index of refraction → that depends on material.