PH202-1G
Spring 2014

# Mock exam III

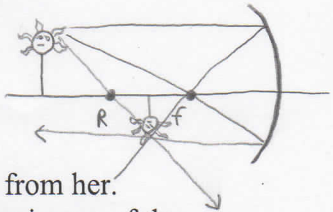
Print off your own copy of the mock exam and do your best to complete it before the mock exam session. We will not take any time during the mock exam session to complete the mock exam.

This mock exam will be most beneficial to you if you complete it under testing conditions. It should take you about 1 hour and 30 minutes to complete, but keep in mind that your class exam will be only 50 minutes. Use the equation sheet provided by Dr. Wenger on Blackboard and the same calculator that you plan to use during the actual exam. If you get stuck, try to use the strategy in the document called "How to solve a physics problem" to help you. Do not use your book or notes from class until you have attempted the problems in the mock exam on your own at least once.

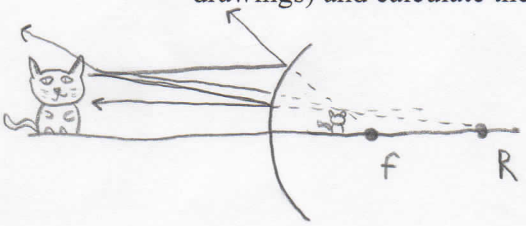
1. The terrible monster Medusa has a petrifying gaze that will turn anyone who meets her eye into stone. The hero Perseus cleverly decides to use the polished interior of his shield, which acts like a concave mirror, to avoid looking at Medusa directly. If Perseus sees a real image of Medusa that is smaller than the actual Medusa, where is Medusa standing?

Real, smaller
Real, larger
Virtual, larger
No image

A. Farther away than the radius of curvature of the shield
B. In between the radius of curvature and the focal point of the shield
C. In between the focal point of the shield and the shield itself
D. On the other side of the shield from Perseus
E. It is impossible to form a smaller real image using a concave mirror




2. A curious cat stares at the back side of a spoon so that the spoon curves away from her. When the cat's face is 10 cm from the spoon, the magnification of the resulting image of the cat's face is ~~3.1~~ 0.31. Draw a ray diagram representing the situation (bonus points for adorable cat drawings) and calculate the focal length of the mirror.




Convex mirrors produce smaller, upright virtual images.

$$M = -\frac{d_i}{d_o} \Rightarrow d_i = -M d_o$$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{d_o} - \frac{1}{M d_o} = \frac{1}{d_o}\left(1 - \frac{1}{M}\right)$$

$$f = \frac{d_o}{1 - \frac{1}{M}} = \frac{0.10\text{ m}}{1 - \frac{1}{0.31}} = -0.045\text{ m} = -4.5\text{ cm}$$

Focal length is negative for a convex lens.

3. T (T / F) For both mirrors and thin lenses, a negative magnification indicates that an inverted image will be formed.

$$M = \frac{h_i}{h_o}$$

$h_o$ is always positive, so $M < 0 \Rightarrow h_i < 0$

4. Light traveling through air strikes a leaf and enters the leaf's cells, whose internal environment has a refractive index of 1.35. Some of the light is absorbed by the leaf for photosynthesis, but the rest passes through the other side of the leaf and back into the air. The light will experience total internal reflection when it travels from the ________ into the ________ at angles greater than ________.

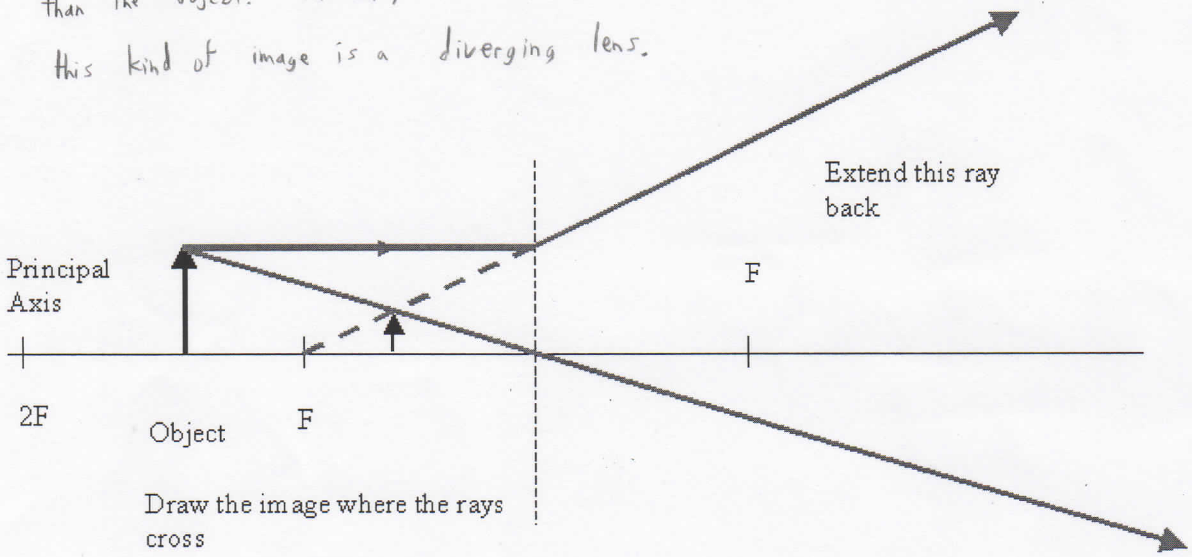
   A. Air; cells; 20°
   B. Cells; air; 20°
   C. Air; cells; 48°
   D. Cells; air; 48°
   E. The light will always be refracted

Must travel from medium with higher index to medium with lower index for total internal reflection to occur. Thus, light must travel from the cells to the air.

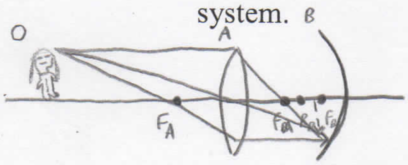
$$\theta_c = \arcsin\left(\frac{n_2}{n_1}\right) = \arcsin\left(\frac{1.00}{1.35}\right) = 47.8°$$

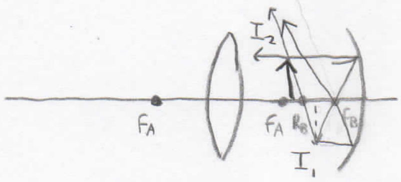
5. F (T / F) The lens depicted in the diagram below is a converging lens.

The image is upright and virtual, and it is smaller than the object. The only lens that can produce this kind of image is a diverging lens.



6. A converging lens with a focal length of 10 cm and a concave mirror with a radius of curvature of 8.0 cm are located 20 cm apart. A creepy doll is placed 30 cm in front of the lens. Find the location of the image formed and the total magnification of the lens-mirror system.




$$d_{i-A} = \left[\frac{1}{f_A} - \frac{1}{d_{o-A}}\right]^{-1} = \left[\frac{1}{10\text{ cm}} - \frac{1}{30\text{ cm}}\right]^{-1} = 15\text{ cm}$$

$$d_{o-B} = L - d_{i-A} = 20\text{ cm} - 15\text{ cm} = 5\text{ cm}$$

$$d_{i-B} = \left[\frac{1}{f_B} - \frac{1}{d_{o-B}}\right]^{-1} = \left[\frac{1}{4.0\text{ cm}} - \frac{1}{5.0\text{ cm}}\right]^{-1} = 20\text{ cm}$$

$$M_T = M_A M_B = \frac{d_{i-A}}{d_{o-A}} \cdot \frac{d_{i-B}}{d_{o-B}} = \frac{15\text{ cm}}{30\text{ cm}} \cdot \frac{20\text{ cm}}{5\text{ cm}} = 2$$

7. Which of the following accurately describes the physical systems that produce the interference patterns shown to the right?

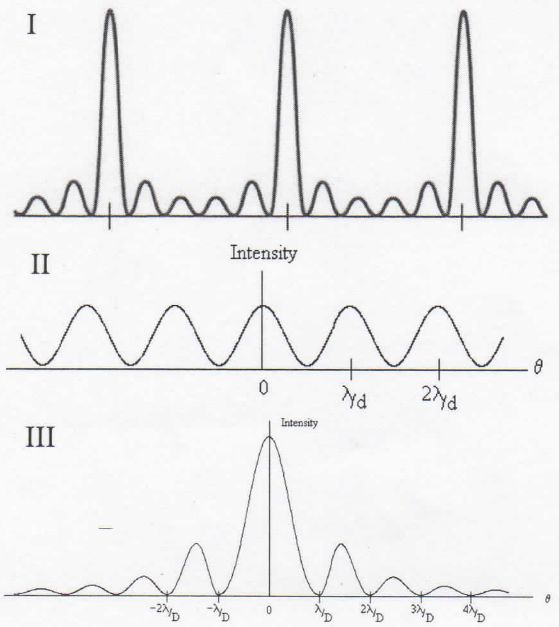
A. (I) Two slits
(II) Diffraction grating
(III) One slit

B. (I) Diffraction grating
(II) Two slits
(III) One slit

C. (I) One slit
(II) Two slits
(III) Diffraction grating

D. (I) Diffraction grating
(II) One slit
(III) Two slits

E. (I) One slit
(II) Diffraction grating
(III) Two slits



8. If you look directly down onto a 357 nm film of gasoline (refractive index 1.40) on a layer of water (refractive index 1.33), what wavelengths of light within the visible spectrum (400 nm to 700 nm) exhibit constructive interference? What wavelengths exhibit destructive interference?

There is a phase shift of $\frac{1}{2}\lambda$ at the air-gasoline barrier but not the gasoline-water barrier.

$\lambda_{vacuum} = n\lambda_{Film} = n\frac{2t}{m}$ or $n\frac{2t}{m+\frac{1}{2}}$ $\qquad 2nt = 2 \cdot 1.40 \cdot 357 \text{ nm} = 999.6 \text{ nm}$

| m | constructive $\frac{2nt}{m+\frac{1}{2}}$ | destructive $\frac{2nt}{m}$ |
|---|---|---|
| 0 | 1.999 µm | — |
| 1 | 666.4 nm | 999.6 nm |
| 2 | 399.8 nm | 499.8 nm |
| 3 | 285.6 nm | 333.2 nm |

Within the visible spectrum, 666.4 nm exhibits constructive interference and 499.8 nm exhibits destructive interference.

9. F (T / F) Increasing the width of the opening will increase the width of the bright central fringe in single-slit diffraction.

$\sin\theta = m\frac{\lambda}{W}$

$\tan\theta = \frac{y}{L}$

Width of the central bright Fringe $\qquad 2y = 2L\tan\theta$
$\qquad\qquad\qquad = 2L\tan\left[\arcsin\left(\frac{\lambda}{W}\right)\right]$

m = 1 for bounding dark fringes

Using $\tan\theta \approx \sin\theta \approx \theta$, $2y = 2L\theta = \frac{2L\lambda}{W}$

10. F (T / F) A photon undergoes Compton scattering by an electron. The electron will have the maximum kinetic energy when the angle at which the photon scatters is 90°.

Maximum kinetic energy is transferred to the electron when the photon is scattered straight back at 180°.

PH202-1G
Spring 2014

11. A metal plate connected to another metal plate by a wire with a potential difference is illuminated by a light source. If the wavelength of the incident light is greater than $\lambda_0$, no current is measured in the wire. If the wavelength of the incident light is equal to or less than $\lambda_0$, a current is measured, and the electrons emitted from the plate have a speed $v_0$. Give an algebraic expression for the work function of the metal in terms of $\lambda_0$ and $v_0$.

To displace electrons, and give them enough energy to cross the potential barrier the photons must have energy

$$E = KE + W_0$$

$$hf = \frac{1}{2}mv_0^2 + W_0$$

$$\frac{hc}{\lambda_0} = \frac{1}{2}mv_0^2 + W_0$$

Thus, $W_0 = \frac{hc}{\lambda_0} - \frac{1}{2}mv_0^2$

12. Which is the largest of the following slits that will cause an 18 g bullet with a kinetic energy of 2.25 kJ to exhibit diffraction behavior?

A. $10^{-5}$ m
B. $10^{-10}$ m
C. $10^{-20}$ m
D. $10^{-35}$ m
E. $10^{-50}$ m

$$KE = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

$$p = \sqrt{2m\,KE}$$

To exhibit diffraction, the slit must be on the same order of magnitude as the de Broglie wavelength

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m\,KE}} = \frac{6.626 \cdot 10^{-34}\ J \cdot s}{\sqrt{2 \cdot 0.018kg \cdot 2.25\,kJ}} = 7.3 \cdot 10^{-35}\ m$$

$$\lambda \approx 10^{-35}\ m$$

This slit would have to be smaller than the radius of an atom $(10^{-10}\ m)$ by a factor of $10^{25}$. This is not feasible, explaining why bullets do not diffract.