General Physics II - Spring 2019
Second Exam

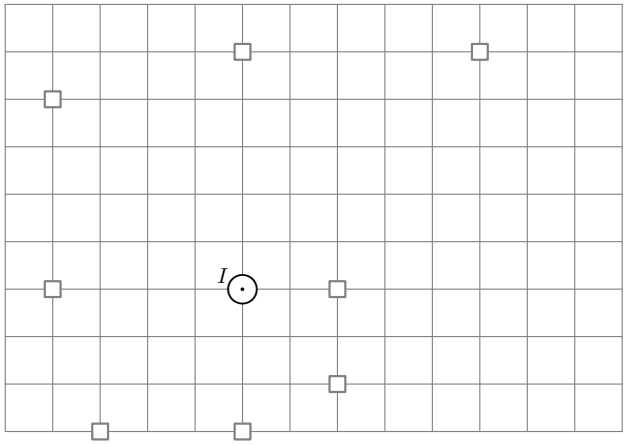
Show your work. Answers alone get no credit.

$$c = 3.0 \times 10^8 \ \frac{\text{m}}{\text{s}}$$

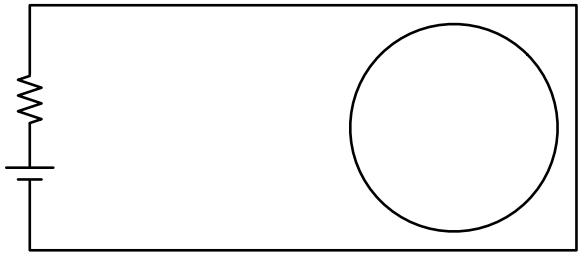
$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\text{C}^2 \cdot \text{J}}{\text{N}^2 \cdot \text{m}^3}$$

{10} **1** A magnetic field of 0.02 Tesla is pointed north. A current is going upward in a wire on a vertical pole.
(a) What is the direction of the magnetic force on the wire?
(b) The wire is 5 meters long and carrying a current of 120 amps. What is the strength of the magnetic force on the wire?

{10} **2** There is a current coming straight out of the paper at the location indicated. Draw the direction of the magnetic field at the eight location marked with squares.



{5} **3** The voltage of the battery in the rectangular loop is decreasing. What is the direction of the current in the circular loop?



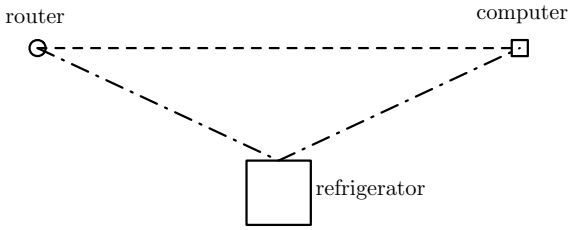
{10} **4** A magnetic field is passing through a loop of wire. The loop has a resistance of 10 Ohms. The area of the loop is 0.41m^2. Initially the field is 2 Tesla, over a time of 0.1 seconds the field increases to 5 Tesla.
(a) What is the current in the loop when the field is a constant 2 Tesla?
(b) What is the current in the loop when the field is increasing.

{5} **5** An electromangetic wave has an electric field amplitude of $5.2722 \times 10^6 \frac{\text{N}}{\text{C}}$ what is the energy per volume (energy density) of the electromagnetic wave.

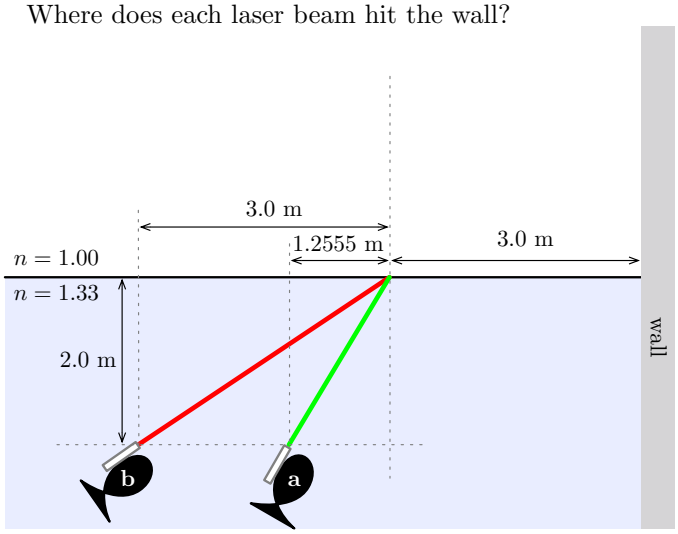
{5} **6** An electromagnetic wave has an energy per volume of $4.1 \times 10^{-7} \frac{\text{J}}{\text{m}^3}$, what is the power per area (intensity) of the light?

{10} **7** A wave is at a maximum at $x = 0$ and $t = 0$. The wavelength is 300 meters and the period is 15 seconds, and the amplitude is 3 meters.
(a) What is the speed of the wave?
(b) Write a function $y(x, t)$ that gives the height of the wave at any position x and time t.

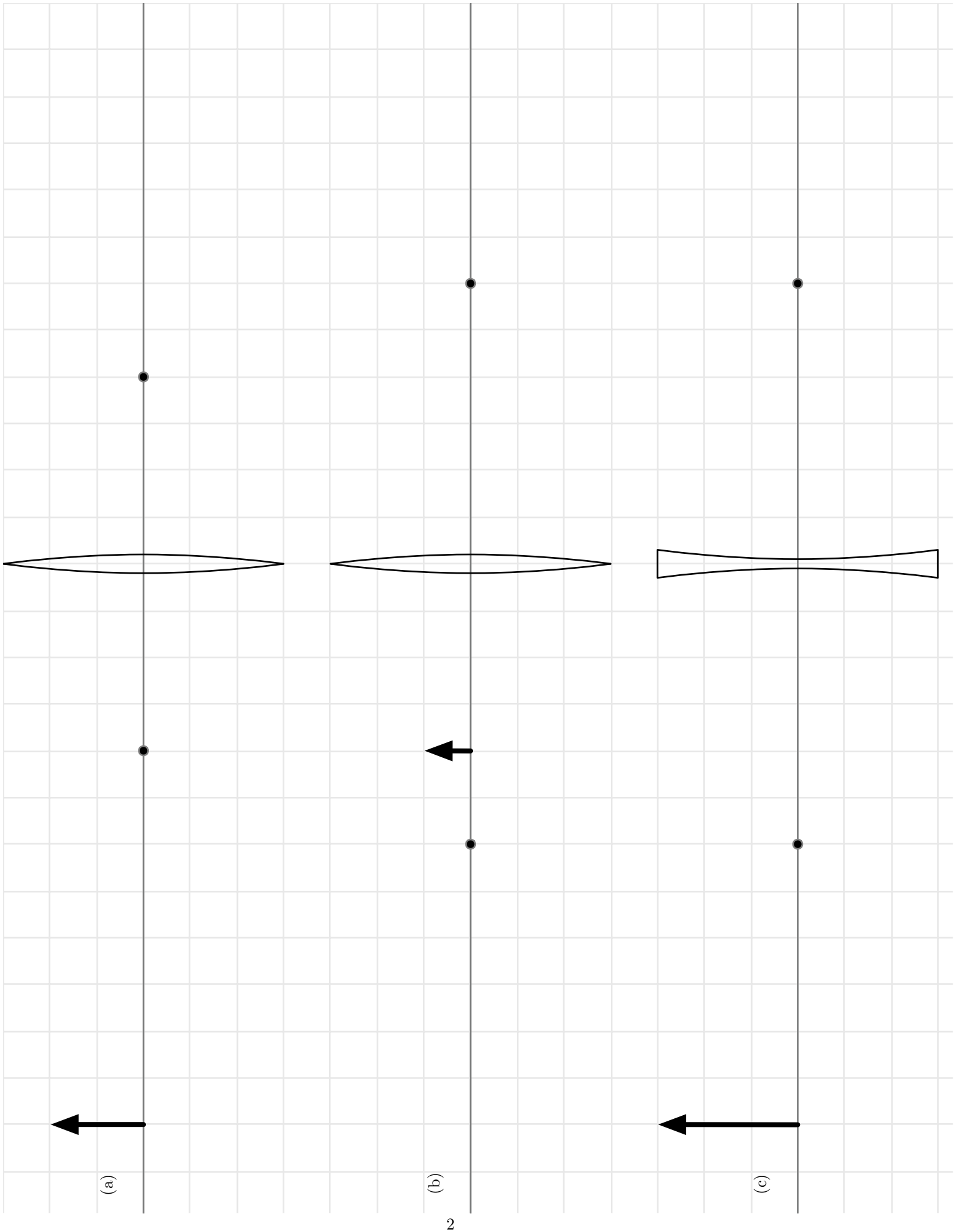
{15} **8** Your computer is receiving a signal from your WIFI router, the wavelength is 0.2705 meters. The signal arrives at the computer by the direct path (3.0 meters), but also by another path (5.0 meters) bouncing off of the refrigerator, as shown in the diagram. The signal strength by the direct path is $8\frac{\text{N}}{\text{C}}$ and the signal strength by the reflected path is $7\frac{\text{N}}{\text{C}}$. What is the signal strength when both signals combine.



{15} **9** Fish **a** and fish **b** are in the water near a wall playing with green and red lasers. They each aim their laser at the water surface at a point 3 meters from the wall. Where does each laser beam hit the wall?



{15} **10** For the three lens and object configurations shown on the back of this sheet,
(a) Construct the image using a ray diagram. Use a ruler.
(b) Find the location of the image using the thin lens equation. The grid on which the object and lens are draw has a spacing of 1 cm.


(a)
(b)
(c)

Instructions:
Do your work on separate blank paper.
Put this sheet on top and staple them all together.
Use only this exam sheet and a calculator.

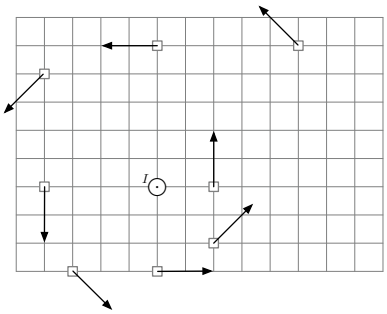
Solutions:

{10} **1**

(a) The current is up and the field north so using the right hand rule the force is west.

(b) $F = ILB = (120)(5)(0.02)\text{N} = 12\text{N}$.

{10} **2**



{5} **3** The existing field is into the paper, and the flux is decreasing so the induced field will also be into the paper. So the induced field must be clockwise around the loop.

{10} **4** $I = \frac{1}{R}\mathcal{E} = \frac{1}{R}\frac{d\Phi_B}{dt} = \frac{1}{R}\frac{\Delta B}{\Delta t}A = \frac{A\Delta B}{R\Delta t}$

(a) $\Delta B = 0$ so $I = 0$.

(b) $I = \frac{A\Delta B}{R\Delta t} = \frac{(0.41)(5-2)}{(10)(0.01)}\text{A} = 1.23\text{A}$

{5} **5** $\bar{u} = \frac{1}{2}\epsilon_0 E^2 = 123\ \text{J/m}^3$.

{5} **6** $I = c\bar{u} = 123\ \text{W/m}^2$.

{10} **7**

(a) $v = \frac{\lambda}{T} = \frac{300\text{m}}{15\text{s}} = 20\frac{\text{m}}{\text{s}}$.

(b) $y(x,t) = (3.0\text{m})\cos\left(2\pi\frac{x}{(300\text{m})} - 2\pi\frac{t}{(15\text{s})}\right)$.

{15} **8** $\Delta\phi = 2\pi\frac{\Delta x}{\lambda} = 2\pi\frac{2}{0.2705}$ so $\cos\Delta\phi = -0.78518$.

$E^2 = E_1^2 + E_2^2 + 2E_1E_2\cos\Delta\phi$

$E = \sqrt{7^2 + 8^2 + 2(7)(8)(-0.78518)}\ \text{N/C} = 5.0\ \text{N/C}$

{15} **9** $n_2\sin\theta_2 = n_1\sin\theta_1 \longrightarrow \sin\theta_2 = 1.33\sin\theta_1$.

(a) $\tan\theta_1 = \frac{1.2555}{2} \longrightarrow \sin\theta_2 = 1.33\sin\theta_1 = 0.7071$ so $\theta_2 = 45^\circ$ and the beam strikes 3 meters above the surface.

(b) $\tan\theta_1 = \frac{3}{2} \longrightarrow \sin\theta_2 = 1.33\sin\theta_1 = 1.1066 > 1$ So it is internally reflected, and the beam strikes the wall 2 meters below the surface.

{15} **10** $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \longrightarrow \frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{d_o - f}{fd_o} \longrightarrow d_i = \frac{fd_o}{d_o - f}$

(a) $d_i = \frac{fd_o}{d_o - f} = \frac{(4)(12)}{12-4}\text{cm} = 6\text{cm}$.

(b) $d_i = \frac{fd_o}{d_o - f} = \frac{(6)(4)}{4-6}\text{cm} = -12\text{cm}$.

(c) $d_i = \frac{fd_o}{d_o - f} = \frac{(-6)(12)}{12-(-6)}\text{cm} = -4\text{cm}$.

{15} **11**