Final Exam (Fall 2025)

PHYS 205B: UNIVERSITY PHYSICS

School of Physics and Applied Physics, Southern Illinois University–Carbondale

Date: 2025 Dec 9

(Name) (Signature)

Instructions

1. Seating direction: In alternate rows, B, D, F, . . . , on even-numbered seats.
2. Total time = 120 minutes.
3. There are 4 short questions and 3 homework-style problems in this exam.
4. Equation sheet is provided separately.
5. For partial credit you need to present your work in detail and organize it clearly.
6. A simple calculator (with trigonometric functions) is allowed.
7. Use of smart devices, including smart watches, is strictly prohibited. They should stay out of reach during the exam.
8. Academic misconduct will lead to a failing grade in the course.

1. (**5 points.**) The electric field due to a uniformly charged spherical shell of radius R at a distance $r > R$ from the center of the sphere is given by

$$\mathbf{E} = \hat{\mathbf{r}} \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}, \qquad r > R, \tag{1}$$

where Q is the total charge on the spherical shell and $\hat{\mathbf{r}}$ specifies the direction of the electric field to be pointing radially outwards. How does this electric field outside the shell change if the radius of the shell is halved with total charge on the shell kept the same.

2. (**5 points.**) The electric potentials at the two ends of a $R = 1.5\,\mathrm{k}\Omega$ resistor in a circuit is measured to be $V_a = 6.0\,\mathrm{V}$ and $V_b = 1.5\,\mathrm{V}$. Refer Figure 1. Determine the current passing through the resistor.

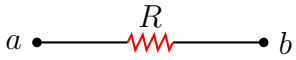

Figure 1: Problem 2

3. (**5 points.**) Two infinitely long straight wires parallel to each other carry steady currents I_1 and I_2 in opposite directions as shown in Figure 2. What are the directions of the magnetic force exerted by the wires on each other?

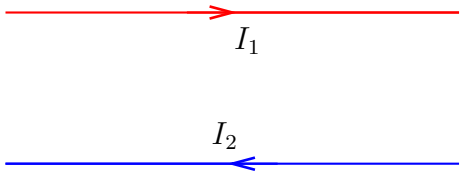

Figure 2: Problem 3

4. (**5 points.**) The index of refraction of diamond is 2.4. Determine the critical angle for total internal reflection at a diamond-air interface.

5. (**10 points.**) A charge $q = +8.0\,\text{nC}$ is placed on the y-axis a distance $a = 3.0\,\text{cm}$ below the origin. Find the electric potential difference between the point marked $\times$ in Figure 3, on the x-axis a distance $b = 4a/3$ to the left of the origin, and a point infinitely far away from charge q.

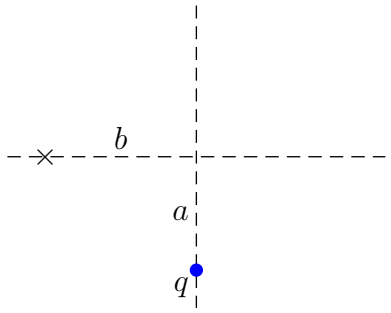

Figure 3: Problem 5

6. (**10 points.**) A 1.0 cm object is placed upright at a distance 5.0 cm away from a convex mirror. The mirror's focal length is 10. cm.

   (a) What is the radius of curvature of the mirror?

   (b) Calculate the image distance. Is the image real or virtual?

   (c) What is the magnification? Determine the height of the image.

   (d) Is the image upright or inverted?

   (e) Confirm your results by drawing a ray diagram for the above case. Choose the scale for the two relevant directions appropriately so that the relevant features are illustrated well. Points will be awarded for clarity and accuracy.

7. (**10 points.**) A 1.0 cm object is placed upright at a distance 30. cm away from a convex lens. The focal length of the lens is 10. cm.

   (a) Calculate the image distance. Is the image real or virtual?

   (b) What is the magnification? Determine the height of the image.

   (c) Is the image upright or inverted?

   (d) Confirm your results by drawing a ray diagram for the above case. Choose the scale for the two relevant directions appropriately so that the relevant features are illustrated well. Points will be awarded for clarity and accuracy.