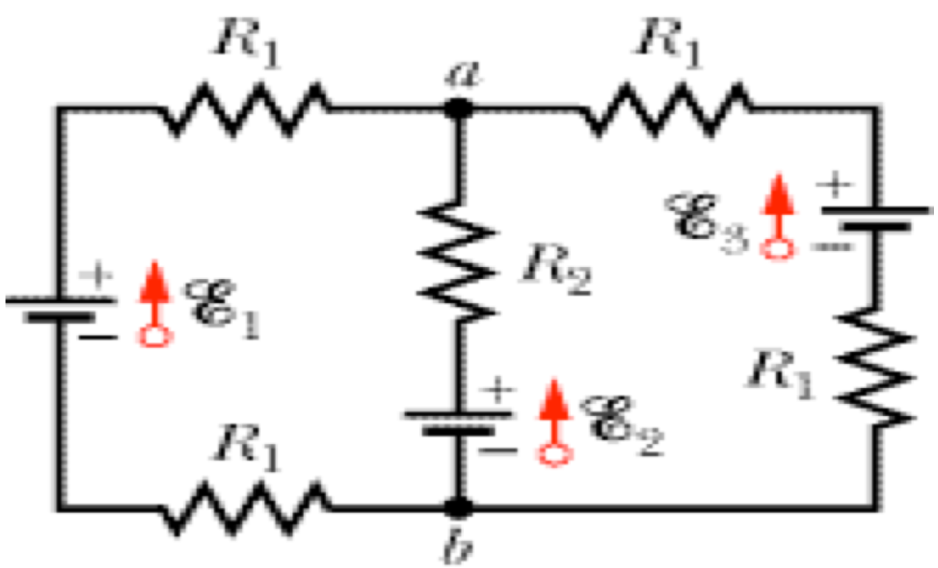
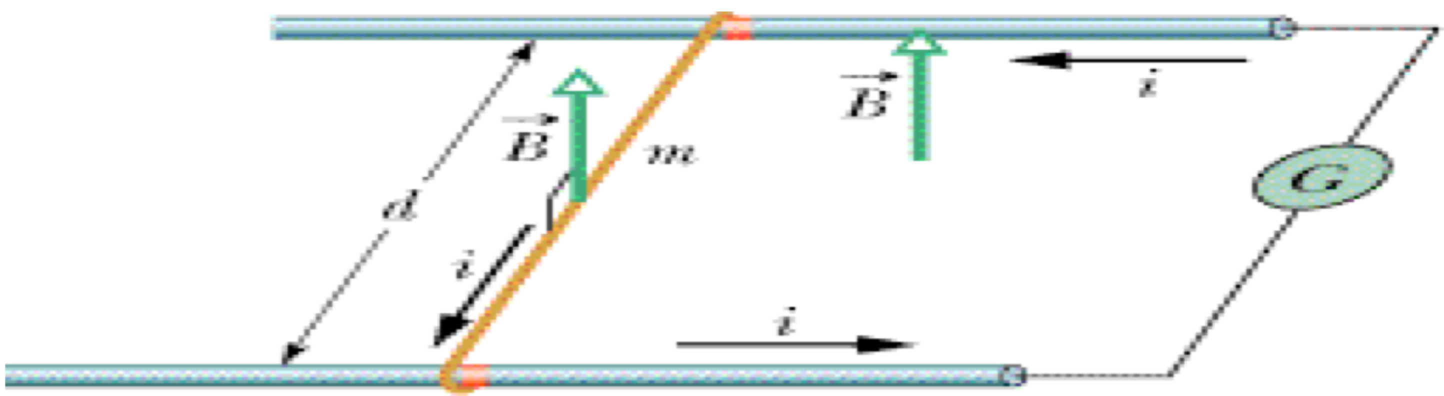
1. What is the *escape speed* for an electron initially at rest on the surface of a sphere with a radius of 1.4 cm and a uniformly distributed charge of $1.6 \times 10^{-15}$ C?

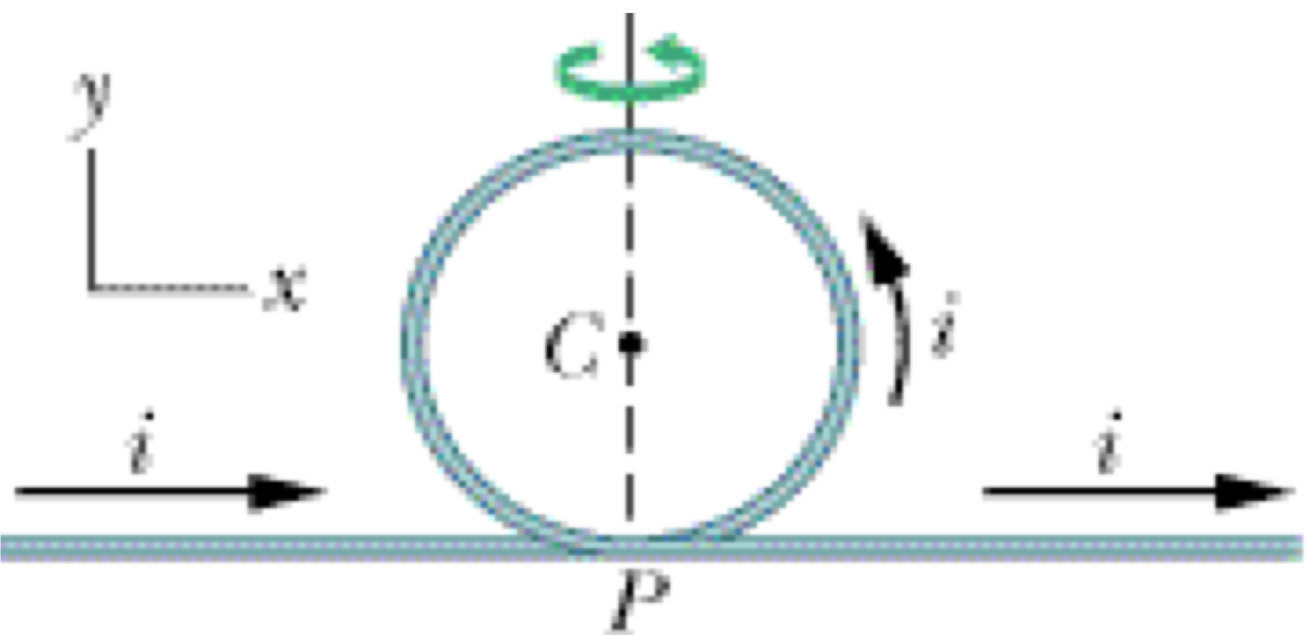
2. In the circuit the resistances are $R_1 = 1.0\ \Omega$ and $R_2 = 2.0\ \Omega$, and the ideal batteries have emfs $\varepsilon_1 = 2.0$ V, and $\varepsilon_2 = \varepsilon_3 = 6.0$ V. What are the **(a)** size and **(b)** direction (up or down) of the current in battery 1, the **(c)** size and **(d)** direction of the current in battery 2, and the **(e)** size and **(f)** direction of the current in battery 3? **(g)** What is the potential difference $V_a - V_b$?



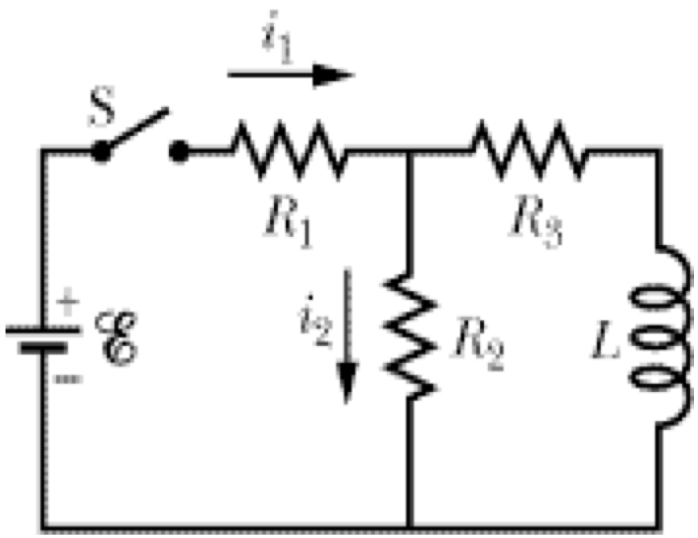
3. A metal wire of mass $m = 30.0$ mg can slide with negligible friction on two horizontal parallel rails separated by distance $d = 3.0$ cm. The track lies in a vertical uniform magnetic field of magnitude 50.0 mT. At time $t = 0$ s, device $G$ is connected to the rails, producing a constant current $i = 10.0$ mA in the wire and rails (even as the wire moves). At $t = 70.0$ ms, what are the wire's **(a)** speed and **(b)** direction of motion?



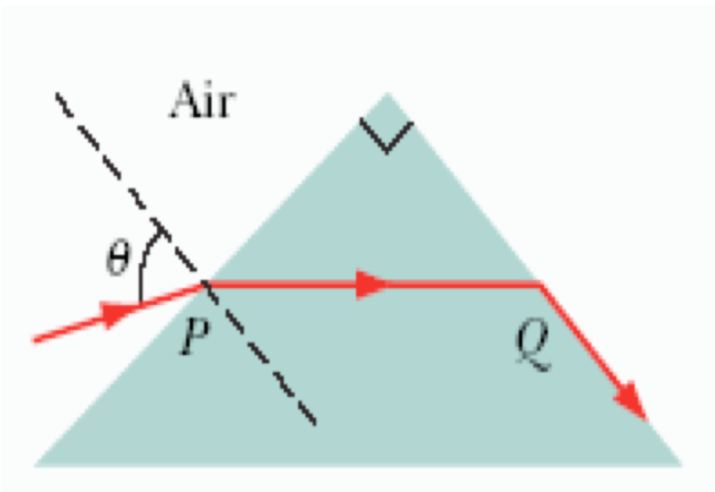
4. Part of a long insulated wire carrying current $i = 6.0$ mA is bent into a circular section of radius $R = 8.0$ cm. What are **(a)** the $x$-component, **(b)** the $y$-component, and **(c)** the $z$-component of the magnetic field at the center of curvature $C$ if the circular section lies in the plane of the page as shown? What are **(d)** the $x$-component, **(e)** the $y$-component, and **(f)** the $z$-component of the magnetic field at the center of curvature $C$ if the circular section is perpendicular to the plane of the page after being rotated 90° counterclockwise as indicated?



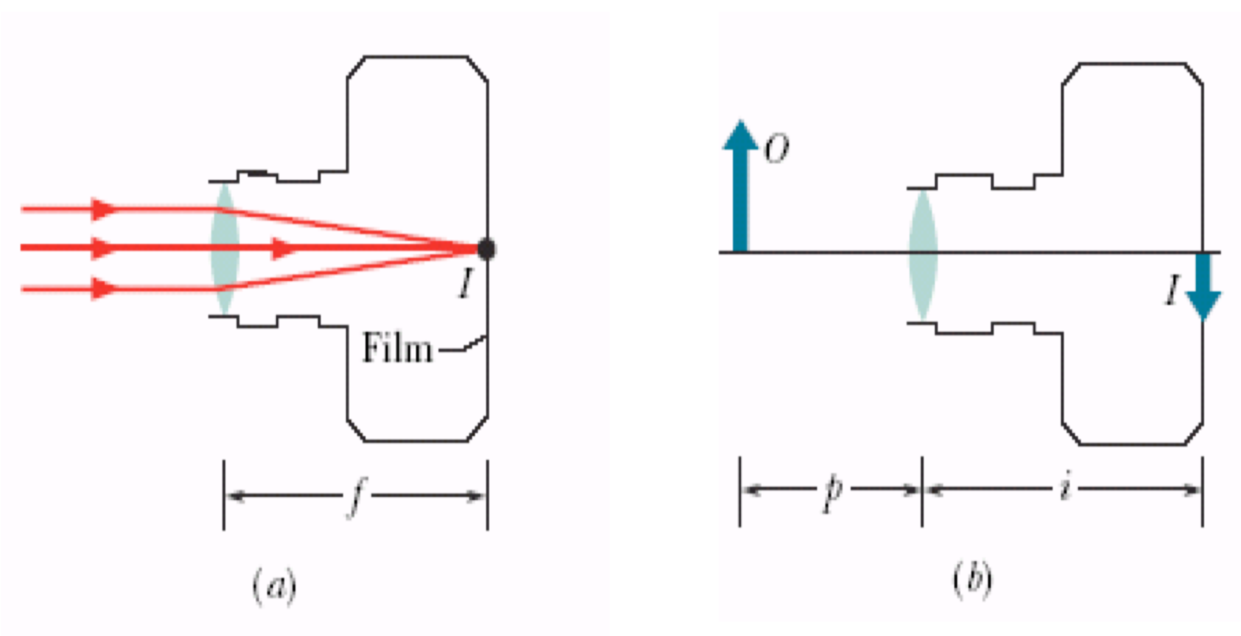
5. In the circuit, ε = 100 V, $R_1$ = 8.0 Ω, $R_2$ = 20.0 Ω, $R_3$ = 25.0 Ω, and $L$ = 2.0 H. Immediately after switch S is closed, what are **(a)** $i_1$ and **(b)** $i_2$? (Let currents in the indicated directions have positive values and currents in the opposite directions have negative values.) A long time later, what are **(c)** $i_1$ and **(d)** $i_2$? The switch is then reopened. Just then, what are **(e)** $i_1$ and **(f)** $i_2$? A long time later, what are **(g)** $i_1$ and **(h)** $i_2$?



6. Light enters a 90º triangular prism at point *P* with incident angle $\theta$, and then some of it refracts at point *Q* with an angle of refraction of 90º. **(a)** What is the index of refraction of the prism in terms of $\theta$? **(b)** What, numerically, is the maximum value that the index of refraction can have? Does light emerge at *Q* if the incident angle at *P* is **(c)** increased slightly and **(d)** decreased slightly?



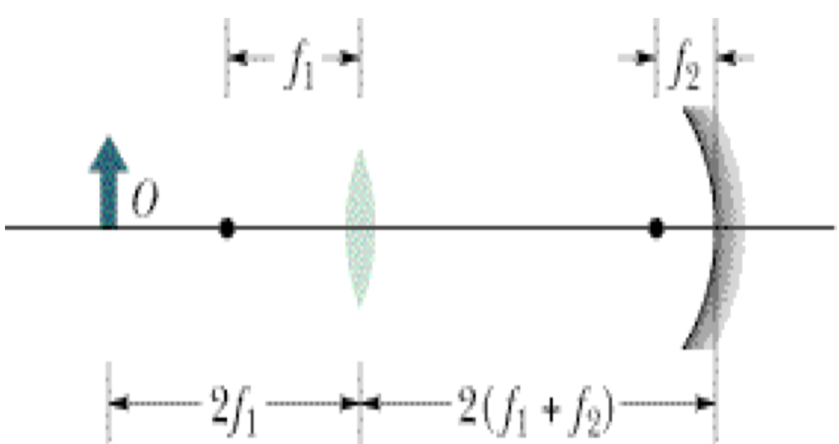
7. Figure (*a*) shows the basic structure of a camera. A lens can be moved forward or back to produce an image on film at the back of the camera. For a certain camera, with the distance $i$ between the lens and the film set at $f = 6.0$ cm, parallel light rays from a very distant object $O$ converge to a point image on the film, as shown. The object is now brought closer, to a distance of $p = 180$ cm, and the lens–film distance is adjusted so that an inverted real image forms on the film (Figure (*b*)). **(a)** What is the lens–film distance $i$ now (in cm)? **(b)** By how much (in cm) was distance $i$ changed?



8. A lens is made of a transparent material having an index of refraction of 2.0. One side of the lens is flat, and the other convex with a radius of curvature of 40.0 cm. **(a)** Find the focal length of the lens. **(b)** If an object is placed 32 cm in front of the lens, where will be the image and its orientation with respect to the opbject?

9. A 710-nm-thick soap film ($n = 1.50$) in air is illuminated with white light in a direction perpendicular to the film. For how many different wavelengths in the 400 to 700 nm range is there **(a)** fully constructive interference and **(b)** fully destructive interference in the reflected light?

10. An object is placed in front of a converging lens at a distance equal to twice the focal length $f_1$ of the lens. On the other side of the lens is a concave mirror of focal length $f_2$ separated from the lens by a distance $2(f_1 + f_2)$. Light from the object passes rightward through the lens, reflects from the mirror, passes leftward through the lens, and forms a final image of the object. Take $f_1 = 7.0$ cm and $f_2 = 3.0$ cm. What are **(a)** the distance between the lens and the final image and **(b)** the overall lateral magnification $M$ of the object? Is the image **(c)** real or virtual (if it is virtual, it requires someone looking through the lens toward the mirror), **(d)** to the left or right of the lens, and **(e)** inverted or non-inverted relative to the object?



11. The α particle from Am-241 has a kinetic energy of 5.486 MeV. Assume a disk source of a diameter of 2 mm, like the one in a smoke detector. Using static field (magnetic or electric, or both) and sketch a setup that may focus the α particles coming from such a source, and estimate the field strength if a focusing path of 80 mm is used.

12. The trajectory of charged particles such as the muons from atmospheric cosmic rays is detected through the ionization of gas (one commonly used gas is Ar) the particle left behind. Can you describe a few kind of such detectors and the principles they based on for the detection? Can you make a connection of these highly specialized detectors to the physics we learned in this course?

13. A switching power supply is now very common but quite a recent invention and a large industry has been built for it. Do you know how it works? If you were to invent it, would have enough knowledge from this course to support you? What part is still missing?