Part I: Review from Midterm I. Correct answers on questions 1-5 will count on Midterm II, and also be added to your score on Midterm I

---

1. Corrections to electric forces do to the apparent relativistic contraction of moving electric charges are too small to observe unless their speeds are very close to the speed of light.

   (a) True
   (b) False

2. When the astronaut Edwin Aldrin returned from his Apollo 11 walk on the moon, his height was slightly less because of the relativistic length contraction that occurred during the journey.

   (a) True
   (b) False

3. An unstable particle has an average decay time of 1.5×10^{-8}s (in the rest frame of the particle). If these particles are formed in the laboratory with a speed of 2.4×10^{8} m/s (80% of c, where $c = 3 \times 10^{8}$m/s), approximately how far do they travel in the lab during one average decay time?

   (a) 2 meters
   (b) 4 meters
   (c) 6 meters
   (d) 8 meters
   (e) 10 meters

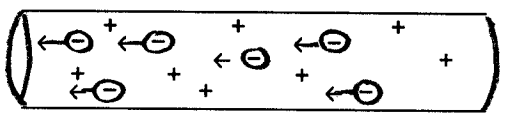
$$\Delta x = \frac{vt}{\sqrt{1 - v^2/c^2}} = \frac{(2.4\times10^{8})(1.5\times10^{-8})}{\sqrt{1-(0.8)^2}} = \frac{3.6}{0.6}$$

$$= 6\ m$$

4. An electric current of about one ampere flows through copper about one millimeter in radius. To a rough order of magnitude, the drift speed of electrons in the wire is such that the charge moves about

   (a) about one millimeter every 100 years
   (b) about one millimeter every 10 seconds
   (c) about one millimeter every one-billionth of a second.
   (d) approximately 100 times the speed of light in vacuum.

5. A positive charge Q moves parallel to and in the same direction as the drift of electrons in a current carrying wire, as shown below. The force on the charge Q is



Moves faster relative to + charge, therefore repulsive

   (a) toward the wire, up the page on the diagram.
   (b) away from the wire, down the page on the diagram.
   (c) inward, into the page on the diagram.
   (d) outward, out of the page on the diagram.

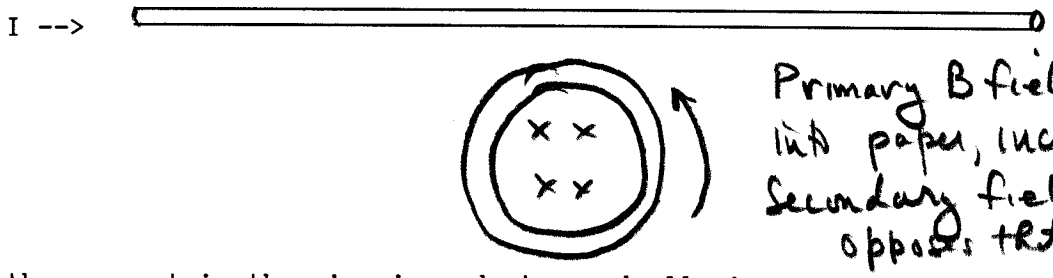
6. A metal rod 0.5 meters long is pulled through a magnetic field of strength 4 Teslas with a velocity 2 meters/second. The direction of the velocity is perpendicular to that of the magnetic field. What is the emf induced between the two ends of the rod?

(a) 2 Volts
(b) 4 Volts
(c) 6 Volts
(d) 8 Volts

$\mathcal{E} = BL\upsilon = (4T)(0.5m)(2m/s)$

$= 4$ Volts

7. A current I flows through a long straight wire that is located directly above a loop of wire as shown below.

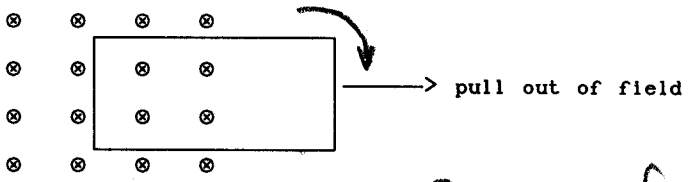


Primary B field into paper, increasing. Secondary field opposes that

If the current in the wire is made to gradually increase as time passes, a current will be induced in the loop that flows (as viewed on this diagram)

(a) in a clockwise direction.
(b) in a counterclockwise direction.

8. Consider the rectangular loop of wire below, that is slowly being pulled to the right out of the magnetic field that is directed into the page. A secondary current will be generated in the loop that is

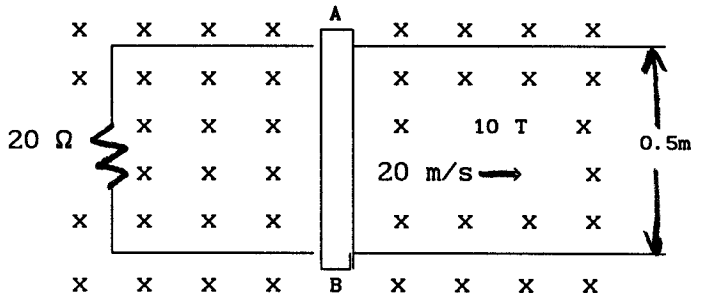


(a) Clockwise
(b) Counterclockwise

Primary field into paper, Total BA inside loop decreases

Secondary adds to primary.

9.



$\mathcal{E} = Blv = (10T)(.5m)(20\frac{m}{s})$

$= 100$ Volts

$I = \frac{\mathcal{E}}{R} = \frac{100}{20} = 5$ amps

opposes primary field

A conducting rod AB slides on metal rails 0.5 m apart with a 20 Ω resistor attached as shown above. The apparatus is in a uniform magnetic field of 10 T directed perpendicularly inward to the page. The rod is moving to the right at a speed of 20 m/s. What is the magnitude of the induced current? Is it clockwise or counterclockwise?

(a) 1 amp, CW
(b) 2 amps, CW
(c) 3 amps, CCW
(d) 4 amps, CCW
(e) 5 amps, CCW

10. Compare a circuit containing a resistor, a capacitor, and an inductor with a mechanical system with a mass on the end of spring that oscillates in the presence of frictional drag with the air around it. Select the analog which best connect these two systems.

	Capacitor	Inductor	Resistor
(a)	Mass	Friction	Spring Constant
(b)	Friction	Spring Constant	Mass
(c)	Friction	Mass	Spring Constant
(d)	Spring Constant	Mass	Friction
(e)	Mass	Spring Constant	Friction

11. A circuit consists of a resistor R, a capacitor C, and an inductor L. The inductive reactance is given by $X_L = \omega L$, the capacitive reactance is given by $X_C = 1/\omega C$. The tuned circuit will be in resonance (minimum impedence) when

(a) the resistance is zero.
(b) the inductive reactance is zero.
(c) the capacitive reactance is zero.
(d) the inductive reactance equals the capacitive reactance.

12. Which of the following examples of electromagnetic radiation would be expected to have the shortest wavelength?

(a) visible light
(b) x-rays
(c) radio waves
(d) infrared light
(e) ultraviolet light

13. Light can be thought of as consisting of

(a) Propagating oscillating electric and magnetic fields.
(b) Transverse waves possessing frequency, wavelength, and polarization.
(c) Individual particles possessing momentum and energy.
(d) All of the above.

14. If water has an index of refraction of 1.33, what is the effective speed of light through water? ($c = 3 \times 10^8$ m/s)

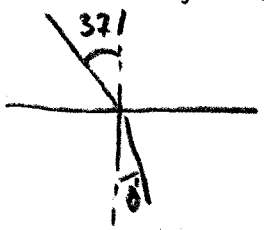
(a) 2.25×10^8 m/s
(b) 2.50×10^8 m/s
(c) 3.50×10^8 m/s
(d) 4.00×10^8 m/s

$n = \frac{c}{v}$; $v = \frac{c}{n} = \frac{3\times10^8}{4/3} = \frac{9}{4}\times10^8$

$= 2.25\times10^8$ m/s

15. A ray of light is incident on an air-to-glass boundary at an angle of 37° to the normal. If the index of refraction of the glass is 1.60, what is the angle of the refracted ray within the glass with respect to the normal?

(a) 56 degrees
(b) 46 degrees
(c) 30 degrees
(d) 22 degrees



$1 \sin 37^\circ = 1.6 \sin\theta'$

$\sin\theta' = \frac{\sin 37^\circ}{1.6} = \frac{0.602}{1.6} = 0.376$

$\theta = 22.09$

16. If the critical angle for internal reflection inside a certain transparent material is found to be 36°, what is the index of refraction of the material? (Air is outside the material.)

(a) 1.4
(b) 1.5
(c) 1.6
(d) 1.7
(e) 1.8

$1 \sin 90^\circ = n \sin 36^\circ$

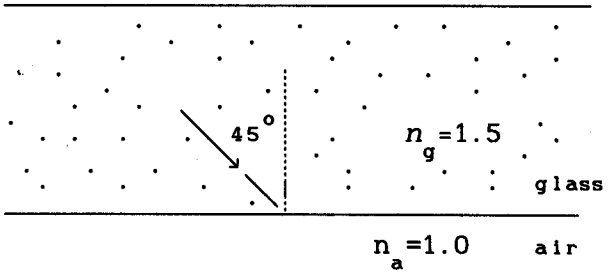
$n = \frac{1}{\sin 36^\circ} = 1.7013$

17. When white light passes through a prism and is broken up into its colors, blue light is bent more than red light. This means that the effective speed of blue light in glass is

(a) less than the effective speed of red light in glass.
(b) more than the effective speed of red light in glass.

slow speed ⇒ more bending

18. Light traveling inside a sheet of glass strikes the boundary at an angle of 45° to the air-glass surface. The indices of refraction of glass and air are 1.5 and 1.0 respectively. Which of the following statements is correct?



$1.5 \sin 45 = 1 \sin\theta$

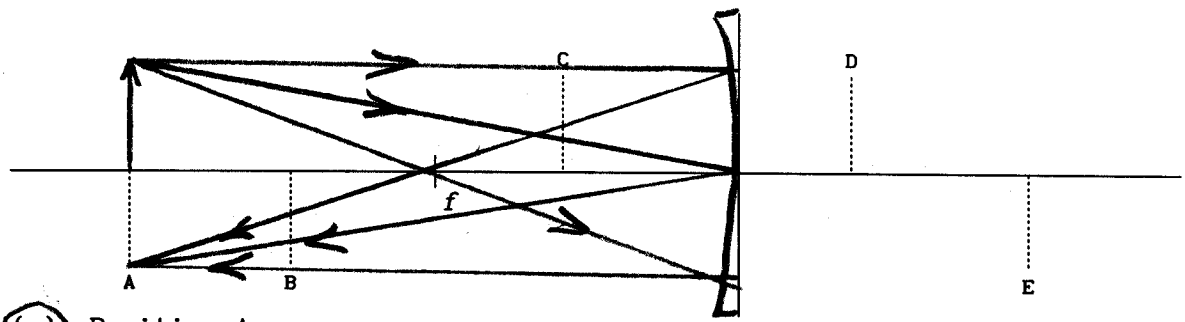
$\frac{1.5}{1.414} \rightarrow$ larger than 1, so a nonphysical angle. Total internal reflection.

(a) Some light is reflected and some light is refracted, and the angle of of refraction smaller than 45°.
(b) Some light is reflected and some light is refracted, and the angle of refraction is exactly equal to 45°.
(c) Some light is reflected and some light is refracted, and the angle of refraction is larger than 45°.
(d) All of the light is internally reflected back into the glass.

19. A spherical concave mirror has a focal length f. An object is placed at distance x from of the mirror, and a lifesize inverted image is formed a the same position x. Which of the following statements is correct?

(a) $x = 4f$
(b) $x = 2f$ (See #20)
(c) $x = f$
(d) $x = f/2$

20. The figure below represents a curved mirror. If f denotes the focal point and the arrow represents the object, which of the letters best represents the position of the image formed by the mirror?



(a) Position A
(b) Position B
(c) Position C
(d) Position D
(e) Position E

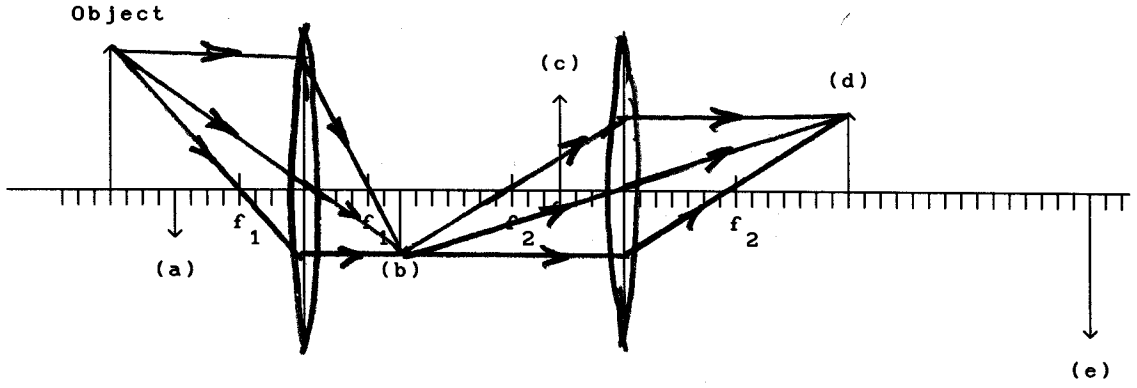
21. A magnifying glass of focal length f is used to form an image of the sun on a piece of paper. To form a sharp image, the distance from the lens to the paper should be

(a) $f/2$ (b) f (c) $2f$

Use this material to answer questions 22 and 23.

In a two lens combination (both converving), the first lens has a focal length f_1 = 4 cm and the second has a focal length f_2= 7 cm. The lenses are separated by 20 cm. An object is placed 12 cm in front of the first lens.

Use either graphical or algebraic methods to determine whether the arrows denoted by (a), (b), (c), (d) or (e) most closely coincides with each of the following images.



22. The position of the image of the object formed by the FIRST converging lens alone is

(a) at position a
(b) at position b
(c) at position c
(d) at position d
(e) at position e

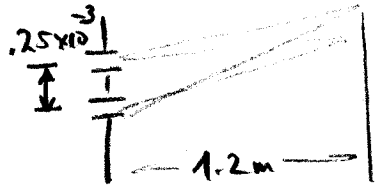
23. The position of the image of the object formed by BOTH converging lenses is

(a) at position a
(b) at position b
(c) at position c
(d) at position d
(e) at position e

---

24. A pair of narrow, parallel slits separated by 0.250 mm are illuminated by a monochromatic light source. It is observed that the bright fringes on a screen that is located 1.20 m from the slits are separated by a distance of 2.62 mm. What is the wavelength of this light beam? (1 nm = 10^{-9} m.)

(a) 454 nm
(b) 546 nm
(c) 667 nm
(d) 717 nm



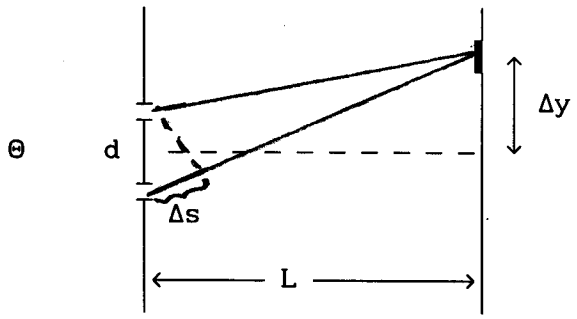
$n\lambda = d\sin\theta = d\frac{y_1}{L}$

$(n+1)\lambda = d\frac{y_2}{L}$

$\lambda = d\cdot\frac{\Delta y}{L} = \frac{(.25\times10^{-3})(2.62\times10^{-3})}{1.2\,m}$

$= 546\times10^{-9}\,m$

25. After light from a monochromatic source passes through two slits, a first order bright spot on the wall is seen, as shown on the diagram to the right. Which labelled distance corresponds to one wavelength of the light from the source?



(a) The slit separation d
(b) The distance to the wall L
(c) The distance to the spot Δy
(d) The extra path Δs