

Instructor(s): *Reitze/Kumar*PHYSICS DEPARTMENT  
Final Exam

PHY2054

December 11, 2010

Name (print, last first): \_\_\_\_\_ Signature: \_\_\_\_\_

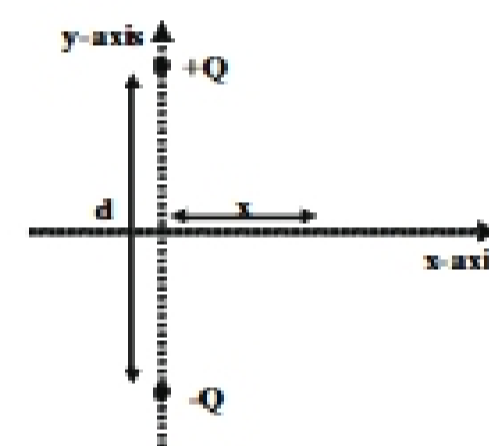
*On my honor, I have neither given nor received unauthorized aid on this examination.***YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.**

- (1) Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number). Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY.** Code your UFID number on your answer sheet.
- (2) Print your name on this sheet and sign it also.
- (3) Do all scratch work anywhere on this exam that you like. **Circle your answers on the test form.** At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.
- (4) **Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink.** Do not make any stray marks or some answers may be counted as incorrect.
- (5) **The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.**
- (6) Hand in the answer sheet separately.

**Useful Constants:**

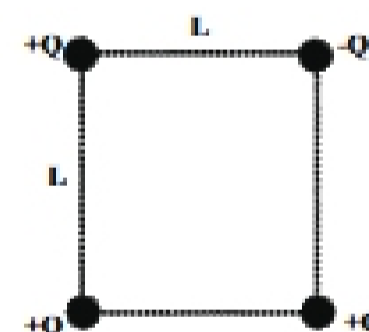
$k_e = 8.99 \times 10^9 \text{Nm}^2/\text{C}^2$	$\epsilon_0 = 8.85 \times 10^{-12} \text{C}^2/(\text{Nm}^2)$	V=volt	N=newton
$\mu_0 = 4\pi \times 10^{-7} \text{Tm/A}$	$k_0 = \mu_0/(4\pi) = 10^{-7} \text{Tm/A}$	$c = 3 \times 10^8 \text{ m/s}$	$g = 9.8 \text{ m/s}^2$
electron charge = $-1.6 \times 10^{-19} \text{C}$	electron mass = $9.11 \times 10^{-31} \text{kg}$		C=coulomb
"milli" = $10^{-3}$	"micro" = $10^{-6}$	n="nano" = $10^{-9}$	"pico" = $10^{-12}$
		J=joule	m=Meter

1. Two equal and opposite point charges  $+Q$  and  $-Q$  are located on the y-axis at  $y = d/2$  and  $y = -d/2$  as shown in the figure. What is the magnitude of the electric field on the x-axis a distance  $x = d/2$  from the origin?



- (1)  $2.83k_e Q/d^2$
- (2)  $1.41k_e Q/d^2$
- (3)  $0.71k_e Q/d^2$
- (4)  $5.6k_e Q/d^2$
- (5)  $4k_e Q/d^2$

2. Four point charges form a square with sides of length  $L$  as shown in the figure. Three of the charges have charge  $+Q$  and one has charge  $-Q$ . What is the minimum amount of work that must be done (*against the electric force*), to move the  $-Q$  charge to infinity?



- (1)  $2.71k_e Q^2/L$
- (2)  $-0.91k_e Q^2/L$
- (3)  $-1.83k_e Q^2/L$
- (4)  $-1.41k_e Q^2/L$
- (5)  $0.91k_e Q^2/L$

3. Two equal and opposite point charges  $+Q$  and  $-Q$  each with a mass of 1 gram are released from rest 1 meter apart. They attract each other and fly toward each other at speed  $V$  as shown in the figure. If  $Q = 1\mu\text{C}$ , what is their speed (in m/s) when they are 0.5 meters apart?

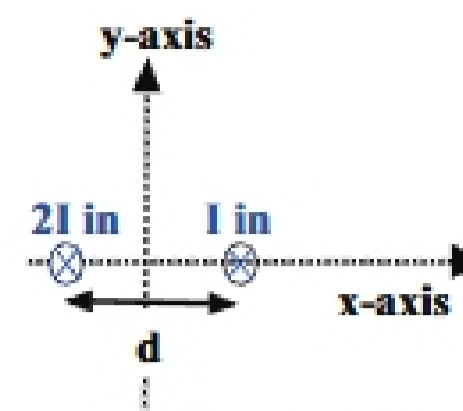


- (1) 3
- (2) 1.5
- (3) 6
- (4) 9
- (5) 2.1

4. A copper cable with resistivity  $\rho = 2.0 \times 10^{-8} \Omega\text{-m}$  is designed to carry a current of 300 Amps with a power loss of 2 Watts per meter of cable. What is the required radius of this cable (in cm)?

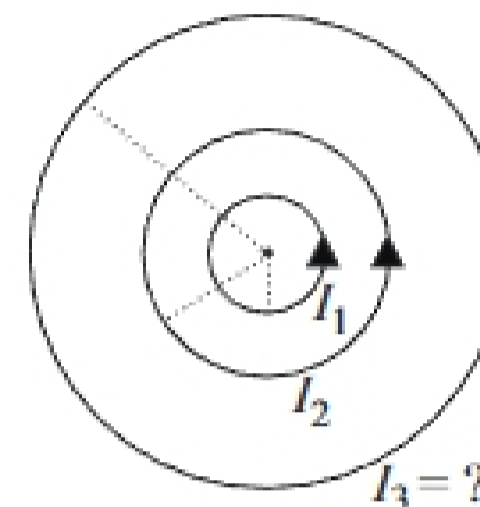
- (1) 1.69
- (2) 1.41
- (3) 0.83
- (4) 2.35
- (5) 0.66

5. Two infinitely long parallel wires lie in the  $xz$ -plane and are located at  $x = -d/2$  and  $x = d/2$  as shown. The left wire ( $x = -d/2$ ) carries a current  $2I$  (into the page), while the right wire ( $x = d/2$ ) carries a current  $I$  in the same direction (into the page). What is the  $y$ -component of the magnetic field on the  $x$ -axis at  $x = 0$ ?



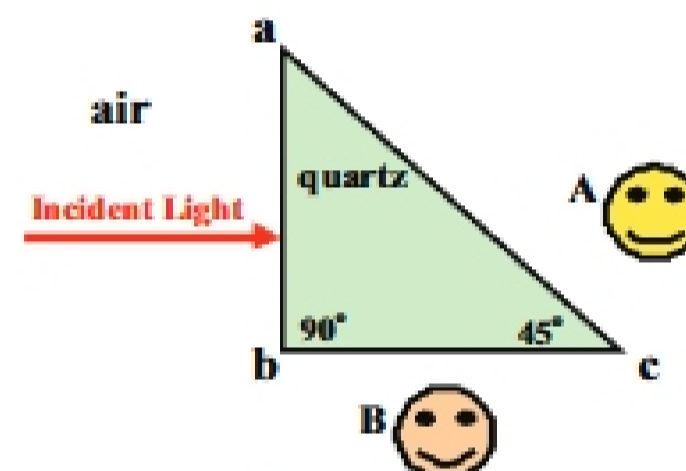
- (1)  $-\mu_0 I / (\pi d)$       (2)  $-2\mu_0 I / (\pi d)$       (3)  $2\mu_0 I / (\pi d)$       (4)  $\mu_0 I / (\pi d)$       (5)  $-\mu_0 I / (2\pi d)$

6. Three circular concentric loops of wire, each having 10 turns, are shown in the figure. The inner loop has a radius of 10 cm, the middle loop has a radius of 20 cm, and the outer loop has a radius of 35 cm. The current in the inner loop is  $I_1 = 2.0$  A and the current in the middle loop is  $I_2 = 4$  A. Both the inner and middle loop currents are traveling in a counterclockwise direction. What is the current  $I_3$  (magnitude and direction) in the outer loop if the magnetic field at the center is  $3.6 \times 10^{-4}$  T directed into the page?



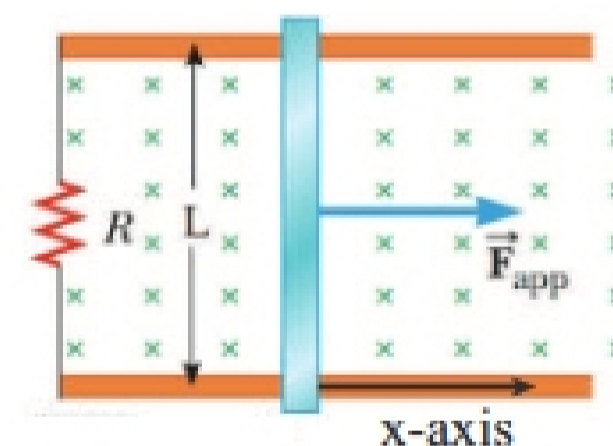
- (1) 34.0 A, clockwise  
 (2) 8.5 A, clockwise  
 (3) 14.0 A, counterclockwise  
 (4) 8.5 A, counterclockwise  
 (5) 32.0 A, clockwise

7. In general the index of refraction of quartz depends on the wavelength of the light. Suppose that a ray of light is incident normally on face  $ab$  of a quartz prism in the shape of an equilateral right triangle as shown with an index of refraction of the quartz that is inversely proportional to the wavelength,  $\lambda$ , of the light as given by the formula  $n = a/\lambda$ , with  $a = 735$  nm. If the incident light has wavelength  $\lambda = 600$  nm, what is the angle (in degrees) between the light ray entering the quartz and the light ray that exits the quartz?



- (1) 15      (2) 90      (3) 10      (4) 5      (5) 45

8. A conducting bar with mass  $M = 10$  kg can slide with no friction along two conducting rails separated by distance  $L = 0.5$  m, as shown in the figure. A uniform 5 Tesla magnetic field points into the page, as indicated by crosses. An external force  $F_{app}$  is applied to the bar such that the velocity of the bar in the  $x$ -direction as a function of time  $t$  is given by  $v = v_0 \cos(\omega t)$ , where  $v_0 = 4$  ms and  $\omega = \pi$  rad/s. What is the magnitude of the maximum induced current in the  $R = 0.5$  Ohm resistor?



- (1) 20 Amps  
 (2) 10 Amps  
 (3) 5 Amps  
 (4) 30 Amps  
 (5) 40 Amps

9. In the previous problem, at what time  $t$  (in s) is the induced current equal to zero?

- (1) 0.5      (2) 1      (3) 2      (4) 0      (5) never

10. At time  $t = 0$  s, the switch of an RL circuit consisting of a 12 V battery (EMF), a  $0.5 \Omega$  resistor, and a 0.3 H inductor is closed. How long does it take the current in the circuit to reach 50% of its maximum value?

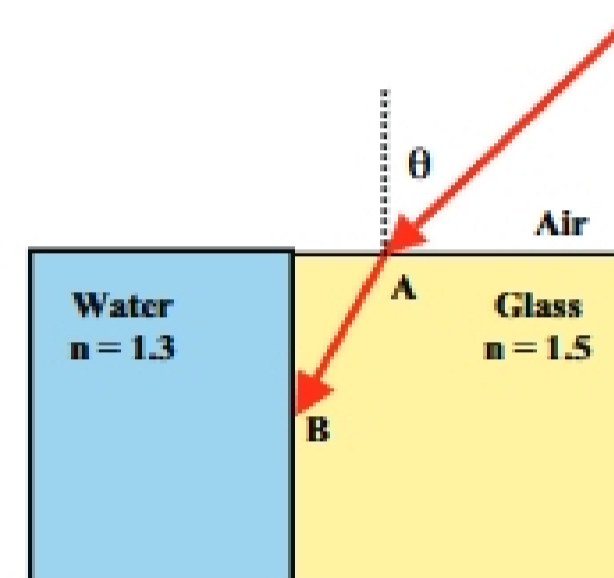
- (1) 0.42 s      (2) 1.5 s      (3) 0.11 s      (4) 12 s      (5) 4.1 s

11. Two wires each carrying a current of 2 A are placed in a uniform magnetic field. The wires make an angle of 40 degrees with respect to each other. If the net force on one wire is zero and the other wire experiences a force of 5 N per meter of wire, what is the magnitude of the external magnetic field? Neglect forces due the magnetic field generated by the wires.
- (1) 3.9 T                      (2) 2.5 T                      (3) 1.6 T                      (4) 0.7 T                      (5) 8.2 T
12. Which of the following four statements are true:  
 (A) Electric fields are produced by charged particles.  
 (B) Magnetic fields are produced by moving charged particles.  
 (C) Electric fields are produced by magnetic fields that vary with time.  
 (D) Magnetic fields are produced by electric fields that vary with time.

- (1) ABCD                      (2) ABD                      (3) ABC                      (4) only A and B                      (5) only A

13. A light ray enters a rectangular glass slab ( $n = 1.5$ ) at point A at an incident angle  $\theta$  and then undergoes total internal reflection at point B at the interface between the glass and water ( $n = 1.3$ ) as shown in figure. What is the maximum incident angle  $\theta$  (in degrees) for this to occur?

- (1) 48.5  
 (2) 31.3  
 (3) 23.6  
 (4) 41.5  
 (5) 62.8



14. A 5.0-ft woman wishes to see a full length image of herself in a plane mirror. The minimum length mirror required is:

- (1) 2.5 ft (2) 5 ft (3) 10 ft (4) 3.54 ft (5) variable: the farther away she stands the smaller the required mirror length

15. Which of the following four statements are true:

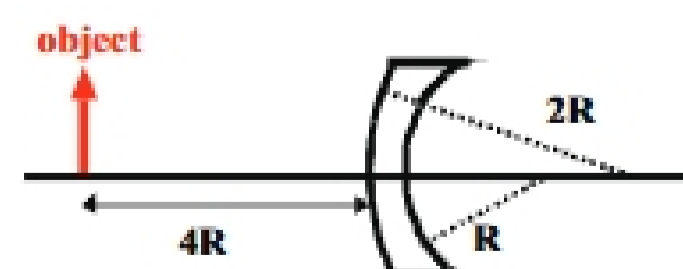
- (A) A concave spherical mirror can produce both real and virtual images.  
 (B) A convex spherical mirror can produce both real and virtual images.  
 (C) The size of a virtual image from a concave spherical mirror is always equal or larger than the size of the object.  
 (D) The size of a virtual image from a convex spherical mirror is always equal or smaller than the size of the object.

- (1) ACD                      (2) ABCD                      (3) ABC                      (4) only A and C                      (5) only A and D

16. An image formed by a convex mirror (with focal length  $f = -30$  cm) has a magnification of 0.5. Which way and by how much should the object be moved to shrink the size of the image to one-half of its original size?

- (1) 60 cm further from mirror  
 (2) 60 cm closer to mirror  
 (3) 30 cm closer to mirror  
 (4) 30 cm further from mirror  
 (5) 90 cm further from mirror

17. A thin lens is constructed with index of refraction,  $n = 1.5$ , and with radii of curvature equal to  $2R$  and  $R$  as shown in the figure. An object with height  $H$  is placed a distance of  $4R$  in from of the lens. What is the height and orientation of the image?



- (1)  $H/2$ , non-inverted      (2)  $H/2$ , inverted      (3)  $2H$ , non-inverted      (4)  $2H$ , inverted      (5)  $H/4$ , non-inverted