

## Exam 4 Solutions

**Note: First answer is the correct one.**

1. An object is moved along the central axis of a spherical mirror while the magnification is measured. When the object is at a distance of 8.0 cm from the mirror the magnification cannot be determined because no image is formed. When the object is at 16 cm from the mirror what is the magnification and is the image non-inverted or inverted (in that order)?

- (1)  $-1$ , inverted
- (2)  $0.33$ , inverted
- (3)  $1$ , non-inverted
- (4)  $0.33$ , non-inverted
- (5)  $-1$ , non-inverted

2. Two slits in an opaque barrier each have a width of 0.020 mm and are separated by 0.050 mm. When coherent, monochromatic light passes through the slits the number of interference maxima within the central diffraction maximum is

- (1) 5
- (2) 2
- (3) 3
- (4) 4
- (5) need the wavelength

3. Two stars that are close together are photographed through a telescope. The black and white film is equally sensitive to all colors. Which situation would result in the most clearly separated images of the stars?

- (1) Large lens, blue stars
- (2) Small lens, red stars
- (3) Small lens, blue stars
- (4) Large lens, red stars
- (5) Large lens, one star red and the other blue

4. An N-slit grating has slit separation  $d$  and slit width  $a$ . Plane waves with intensity  $I$  and wavelength  $\lambda$  are incident normally on it. The angular separation of the lines depends only on

- (1)  $d$  and  $\lambda$
- (2)  $a$  and N
- (3)  $a$  and  $\lambda$
- (4) N and  $\lambda$
- (5)  $I$  and N

5. Convention dictates that a convex mirror, and a concave mirror have signs for their focus that are respectively,

- (1)  $-, +$
- (2)  $+, -$
- (3)  $+, +$
- (4)  $-, -$
- (5)  $-, \pm$  (depending on location)

6. A charge  $q_1$  lies at the point  $-a$  on the  $x$  axis while a second charge  $q_2$  lies at the point  $+a$  on the  $x$  axis. A third charge  $+Q$  lies at the point  $+1.5a$  on the  $x$  axis. What must the ratio  $q_2/q_1$  be for the net electrostatic force on the  $+Q$  charge to vanish?

- (1)  $-1/25$
- (2)  $1/25$
- (3)  $25$
- (4)  $-25$
- (5)  $F$  cannot vanish here

7. A heater element with a potential difference of 200 V across it dissipates energy at a rate of 3000 W. The element is 20.0 cm long with a cross-sectional area of  $1.00 \times 10^{-3} \text{ m}^2$ . What is the resistivity of the heater element operating under these conditions (in  $\text{Ohm}\cdot\text{m}$ )?

- (1)  $6.67 \times 10^{-2}$
- (2)  $3.33 \times 10^{-4}$
- (3)  $1.20 \times 10^2$
- (4)  $2.67 \times 10^3$
- (5) 13.4

8. Three wires at the vertices of an equilateral triangle, of side length 0.100 m, each carry current of 60.0 A in the same direction. What is the magnitude of the force per unit length (in N/m) acting on each wire and is the force toward the inside or the outside of the triangle?

- (1) 0.0125, inside
- (2) 0.0144, inside
- (3) 0.0125 outside
- (4) 0.0144, outside
- (5) 0.00720, inside

9. A very long solenoid A has 400 turns/m and a diameter of 2 m. A similarly long solenoid B has 330 turns/m, a diameter of 0.400 m and sits inside solenoid A. While the central axes of the solenoids are parallel, solenoid B's central axis is not at the center of solenoid A, but rather 0.500 m from the center. Solenoid A's turns carry 2.60 A of current. To make the magnetic field within solenoid B vanish, its turns must carry current (in amperes) of

- (1) 3.15
- (2) 78.8
- (3) 2.15
- (4) 1.58
- (5) 122

10. A series RLC circuit has  $R = 1.200$  Ohms,  $L = 220.0$  mH,  $C = 12.00$   $\mu$ F. What fraction of its original maximum charge does the capacitor attain after one cycle?

- (1) 0.9725
- (2) 0.9925
- (3) 0.9825
- (4) 0.9625
- (5) 0.9993

11. Three concentric conducting shells have radii  $R_1 < R_2 < R_3$  and charges  $+2Q$ ,  $-6Q$  and  $+5Q$ , respectively. What is the charge on the outer surface of the outermost shell?

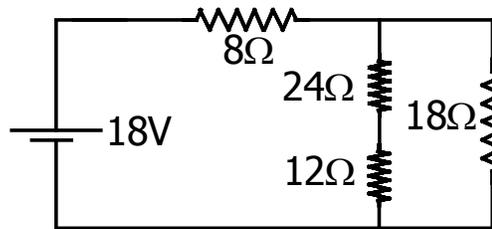
- (1)  $+Q$
- (2)  $+9Q$
- (3)  $+5Q$
- (4)  $-2Q$
- (5)  $+4Q$

12. Three polarizing sheets are stacked on top of one another. The first and third have their polarization directions 90 degrees apart. The second one has its polarization direction oriented 60 degrees relative to the first sheet. What fraction of the intensity of initially unpolarized light is transmitted by the stack?

- (1)  $3/32$
- (2)  $1/8$
- (3)  $3/8$
- (4)  $1/2$
- (5)  $3/16$

13. In the circuit shown, what is the current (in amps) flowing through the  $18\Omega$  resistor?

- (1) 0.60
- (2) 1.08
- (3) 0.90
- (4) 0.30
- (5) 0.50



14. Two parallel plate capacitors,  $C_1 = 20 \mu\text{F}$  and  $C_2 = 10 \mu\text{F}$ , respectively, are connected in series to a battery. Which statement is true?

- (1)  $Q_1 = Q_2$
- (2)  $V_1 = V_2$
- (3)  $Q_1 = 2Q_2$
- (4)  $V_1 = 2V_2$
- (5)  $Q_2 = 2Q_1$

15. An elastic conducting material is stretched into a circular loop of 15.0 cm radius. It is placed with its plane perpendicular to a uniform 0.500 T magnetic field. When released, the radius of the loop starts to shrink at an instantaneous rate of 78.0 cm/s. What emf in volts is induced in the loop at that instant?

- (1) 0.37
- (2) 0.74
- (3) 1.23
- (4) 0.11
- (5) 0.23

16. An inverted image is formed 50cm from an object by a thin lens located between the two. The image is  $1/3$  the height of the object. What is the distance in cm from the object to the lens?

- (1) 37.5
- (2) 40.0
- (3) 66.7
- (4) 25.0
- (5) 12.5

17. Plane wave light enters a glass slab having an index of refraction  $n = 1.500$ , from air ( $n = 1.00$ ) at an angle of incidence of  $30.0^\circ$ . The slab has parallel faces and is 20.0 cm thick. On exiting the slab, how far *along the slab face* (in cm) is the light deviated from where it would be if the glass had a refractive index of 1?

- (1) 4.48
- (2) 0.237
- (3) 1.26
- (4) 2.23
- (5) 3.13

18. Two waves of light with wavelength  $\lambda = 500$  nm move in parallel and are initially in phase. Each then travels through a separate glass layer and emerges. The first layer has length  $L_1 = 6.0$   $\mu\text{m}$  and index of refraction  $n_1 = 1.5$ . The second layer has length  $L_2 = 4.5$   $\mu\text{m}$  and index of refraction  $n_2 = 1.60$ . What is the magnitude of the phase difference between the waves when they emerge (in units of  $\lambda$ ).

- (1) 0.60
- (2) 0.80
- (3) 0.50
- (4) 0.00
- (5) 0.63

19. We wish to coat a plate of glass ( $n_1 = 1.5$ ) with a transparent material ( $n_2 = 1.35$ ) so that reflection of light from the front and back surfaces of the coating at wavelength 550 nm is eliminated by interference. What minimum thickness in nm of the coating is necessary?

- (1) 102
- (2) 149
- (3) 138
- (4) 275
- (5) 92

20. White light shines on a double slit interference experiment. Assume that waves at any wavelength are coherent. The fourth-order maximum occurs at  $90^\circ$  at a wavelength of 450 nm. Which of the following wavelengths (in nm) will not occur in third order?

- (1) 650
- (2) 580
- (3) 562
- (4) 535
- (5) 590