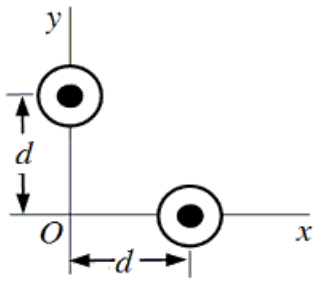
1. A long, straight wire carries a current *I*. If the magnetic field at a distance *d* from the wire has magnitude *B*, what would be the the magnitude of the magnetic field at a distance *d/3* from the wire, and if the current were halved?
   A) *9B*/2
   B) *3B*/2
   C) *B/6*
   D) 2*B/3*
   E) None of these

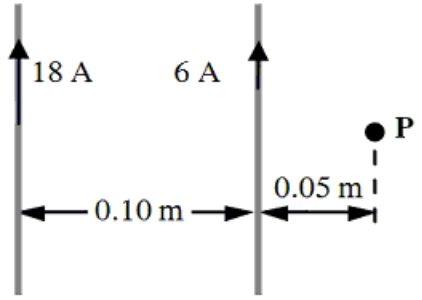
2. Two long, straight wires are perpendicular to the plane of the paper as shown in the drawing. Each wire carries a current of magnitude *I*. The currents are directed out of the paper toward you. Which one of the following expressions correctly gives the magnitude of the total magnetic field at the origin of the *x*, *y* coordinate system?



   A) $\frac{\mu_0 I}{2d}$
   B) $\frac{\mu_0 I}{\sqrt{2}d}$
   C) $\frac{\mu_0 I}{2\pi d}$
   D) $\frac{\mu_0 I}{\pi d}$
   E) $\frac{\mu_0 I}{\sqrt{2}\pi d}$

Use the following to answer question 3:

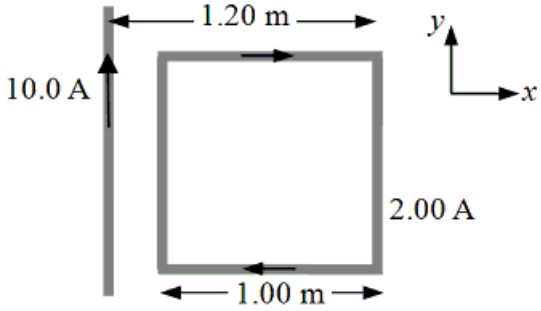
Two long, straight wires separated by 0.10 m carry currents of 18 A and 6 A in the same direction as shown.



3. Determine the magnitude of the magnetic field at the point **P**.
   A) 2.4×10^{-5} T
   B) 4.8×10^{-5} T
   C) 7.2×10^{-5} T
   D) 9.6×10^{-5} T
   E) zero tesla

Use the following to answer question 4:

A long, straight wire carries a 10.0-A current in the +*y* direction as shown in the figure.



Next to the wire is a square copper loop that carries a 2.00-A current as shown. The length of each side of the square is 1.00 m.

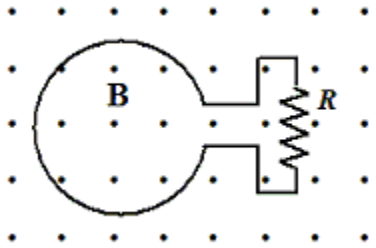
4. What is the magnitude of the net magnetic force that acts on the loop?
   A) 8.0×10^{-6} N
   B) 1.1×10^{-5} N
   C) 1.4×10^{-5} N
   D) 1.7×10^{-5} N
   E) 2.3×10^{-5} N

5. A conducting loop has an area of 0.065 m^2 and is positioned such that a uniform magnetic field is perpendicular to the plane of the loop. When the magnitude of the magnetic field *decreases* to 0.30 T in 0.087 s, the average induced emf in the loop is 1.2 V. What is the initial value of the magnetic field?
   A) 0.42 T
   B) 0.75 T
   C) 0.87 T
   D) 1.2 T
   E) 1.9 T

6. A magnetic field is directed perpendicular to the plane of a 0.15-m × 0.30-m rectangular coil consisting of 240 loops of wire. To induce an average emf of –2.5 V in the coil, the magnetic field is increased from 0.1 T to 1.8 T during a time interval Δt. Determine Δt.
   A) 0.053 s
   B) 0.13 s
   C) 12 s
   D) 6.4 s
   E) 7.3 s

Use the following to answer question 7:

The figure shows a uniform, 3.0-T magnetic field that is normal to the plane of a conducting, circular loop with a resistance of 1.5 Ω and a radius of 0.024 m. The magnetic field is directed out of the paper as shown. **Note**: The area of the non-circular portion of the wire is considered negligible compared to that of the circular loop.



7. If the magnetic field is held constant at 3.0 T and the loop is pulled out of the region that contains the field in 0.2 s, what is the magnitude of the average induced emf in the loop?
   A) 8.6×10^{-3} V
   B) 9.8×10^{-2} V
   C) 2.7×10^{-2} V
   D) 5.4×10^{-2} V
   E) 6.4×10^{-2} V

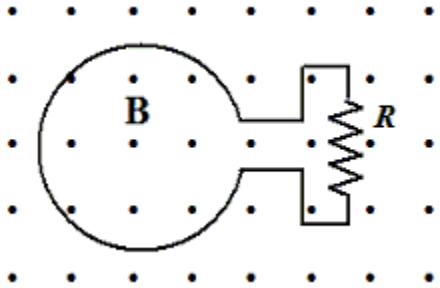
Use the following to answer question 8:

A small power plant produces a voltage of 6.0 kV and 150 A. The voltage is stepped up to 240 kV by a transformer before it is transmitted to a substation. The resistance of the transmission line between the power plant and the substation is 75 Ω.

8. What is the current in the transmission line from the plant to the substation?
   A) 3.8 A
   B) 5.2 A
   C) 6.4 A
   D) 7.0 A
   E) 7.5 A

Use the following to answer questions 9-10:

The figure shows a uniform magnetic field that is normal to the plane of the conducting loop of resistance *R*. **Note**: the area of the non-circular portion of the circuit is negligible compared to that of the loop.



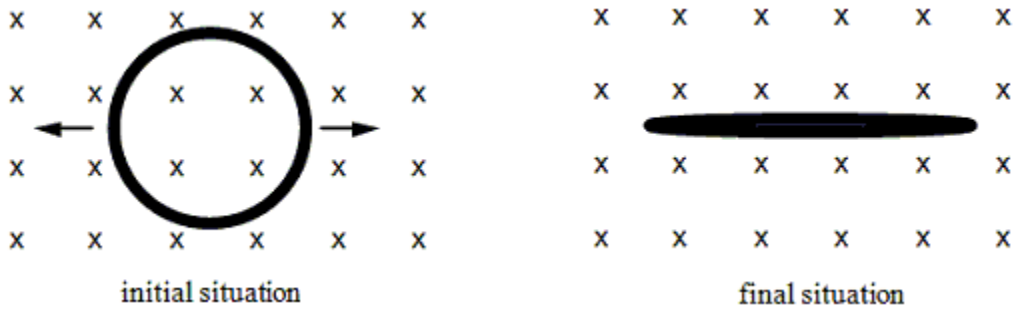
9. Which entry in the table below correctly pairs the change in the system with the direction of the induced current through *R*?

	change in the system	*direction of current through R*
A)	decrease the area of the loop	from top toward bottom
B)	rotate loop into the paper	no induced current
C)	increase the area of the loop	from bottom toward top
D)	decrease the magnitude of **B**	from bottom toward top
E)	pull loop to the right	from top toward bottom

10. Suppose that the radius of the loop is 0.500 m. At what *rate* must **B** change with time if the emf induced in the loop is 3π volts?
    A) 12.0 T/s
    B) 18.8 T/s
    C) 24.0 T/s
    D) 37.7 T/s
    E) 49.2 T/s

Use the following to answer questions 11-12:

A flexible, circular conducting loop of radius 0.15 m and resistance 4.0 Ω lies in a uniform magnetic field of 0.25 T. The loop is pulled on opposite sides by equal forces and stretched until its enclosed area is essentially zero m^2, as suggested in the drawings. It takes 0.30 s to close the loop.



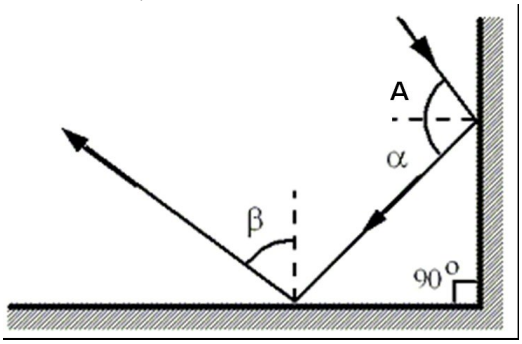
11. Determine the magnitude of the emf induced in the loop.
    A) 1.2×10^{-1} V
    B) 1.8×10^{-2} V
    C) 1.8×10^{2} V
    D) 5.9×10^{-2} V
    E) 5.9×10^{2} V

12. Which one of the following phrases best describes the direction of the *induced* magnetic field generated by the current induced in the loop while the loop is being stretched?
    A) clockwise
    B) counterclockwise
    C) into the page
    D) out of the page
    E) The induced field is zero.

13. A cellular telephone transmits electromagnetic waves at a frequency of 835 MHz. What is the wavelength of these waves?
    A) 0.0146 m
    B) 0.359 m
    C) 0.842 m
    D) 1.62 m
    E) 2.47 m

14. What would the speed of an observer be if a red (4.688×10^{14} Hz) traffic light appeared green (5.555×10^{14} Hz) to the observer?
    A) 4.445×10^{8} m/s
    B) 2.219×10^{8} m/s
    C) 8.438×10^{7} m/s
    D) 5.548×10^{7} m/s
    E) 2.890×10^{6} m/s

15. A ray of light is incident at angle A on a mirror, and is reflected twice, as shown below. If A = 19 °, what are the values of α and β?

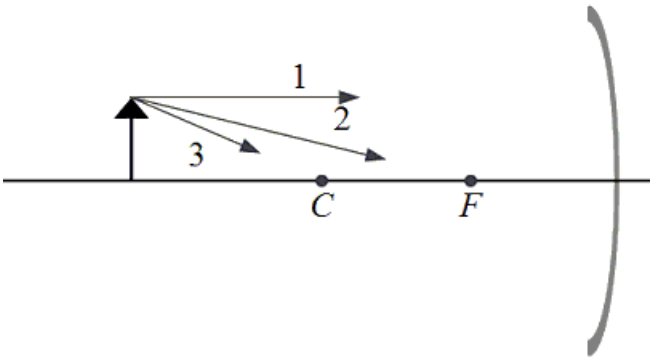


	Value of α	*Value of* β
A)	19°	19°
B)	71°	19°
C)	38°	52°
D)	52°	19°
E)	19°	71°

16. An object is placed 1 m in front of a plane mirror. An observer stands 3 m behind the object. For what distance must the observer focus his eyes in order to see the image of the object?
    A) 1 m
    B) 2 m
    C) 3 m
    D) 4 m
    E) 5 m

Use the following to answer question 17:

An object is placed in front of a concave spherical mirror as shown below. The three rays **1**, **2**, and **3**, leave the top of the object and, after reflection, converge at a point on the top of the image. Ray **1** is parallel to the principal axis, ray **2** passes through *F*, and ray **3** passes through *C*.



17. Which one of the following groups of terms best describes the image?
    A) real, upright, enlarged
    B) real, inverted, reduced
    C) virtual, upright, enlarged
    D) real, inverted, enlarged
    E) virtual, inverted, reduced

18. A concave mirror in an amusement park has a radius of curvature of 4.0 m. A child stands in front of the mirror so that she appears 3.0 times taller than her actual height. If the image is upright, how far is she standing from the mirror?
    A) 1.1 m
    B) 1.3 m
    C) 2.8 m
    D) 3.0 m
    E) 4.5 m

19. A convex mirror in an amusement park has a radius of curvature of 3.00 m. A man stands in front of the mirror so that his image is half as tall as his actual height. At what distance must the man focus his eyes in order to see his image?
    A) 2.25 m
    B) 3.00 m
    C) 4.50 m
    D) 5.00 m
    E) 6.75 m

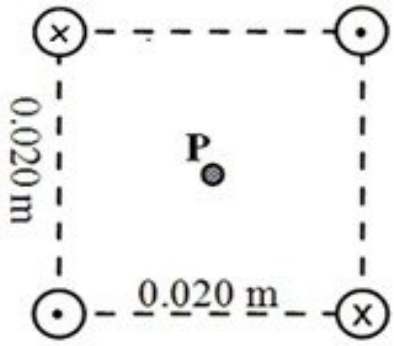
20. A spherical concave mirror has a radius of curvature of 6.0 cm. At what distance from the mirror should a 6.0-cm object be placed to obtain an image that is 48 cm tall?
    A) 1.3 cm
    B) 3.6 cm
    C) 4.2 cm
    D) 5.3 cm
    E) 6.8 cm

21. A convex mirror with a focal length of 58 cm is used to form an image that is 29 cm behind the mirror. What is the object distance?
    A) +22 cm
    B) +15 cm
    C) +69 cm
    D) +28 cm
    E) +58 cm

22. A scuba diver shines a flashlight from beneath the surface of water (n = 1.33) such that the light strikes the water-air boundary with an angle of incidence of 37°. At what angle is the beam refracted?
    A) 31°
    B) 53°
    C) 48°
    D) 65°
    E) 90°

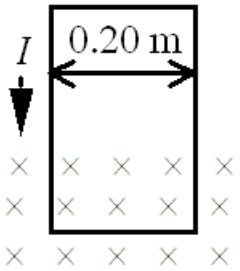
23. A ray of light propagates in water (n = 1.333) and strikes a sheet of crown glass (n = 1.523). If the angle of refraction in the glass is 35.2°, determine the angle of incidence.
    A) 30.3°
    B) 32.8°
    C) 35.2°
    D) 41.2°
    E) 45.0°

24. Four long, straight wires are parallel to each other; and their cross-section forms a square. Each side of the square is 0.020 m as shown in the figure. If each wire carries a current of 8.0 A in the direction shown in the figure, determine the magnitude of the total magnetic field at P, the center of the square.



A) 5.1×10^{-5} T
B) 1.1×10^{-4} T
C) 1.7×10^{-4} T
D) 2.3×10^{-4} T
E) zero tesla

25. A loop of wire with a weight of 0.55 N is oriented vertically and carries a current I = 2.25 A. A segment of the wire passes through a magnetic field directed into the plane of the page as shown. The net force on the wire is measured using a balance and found to be zero. What is the magnitude of the magnetic field?



A) zero tesla
B) 0.51 T
C) 0.84 T
D) 1.2 T
E) 4.5 T

Answer Key

1. A
2. E
3. B
4. D
5. E
6. E
7. C
8. A
9. D
10. A
11. D
12. C
13. B
14. D
15. B
16. E
17. B
18. B
19. A
20. B
21. E
22. B
23. D
24. D
25. D