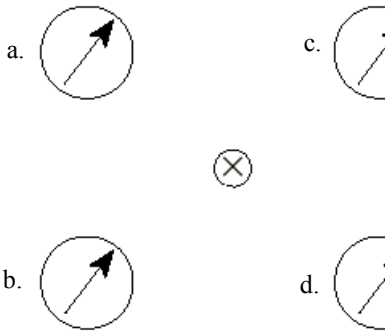
Unit 8: Electromagnetism

Multiple Choice Portion

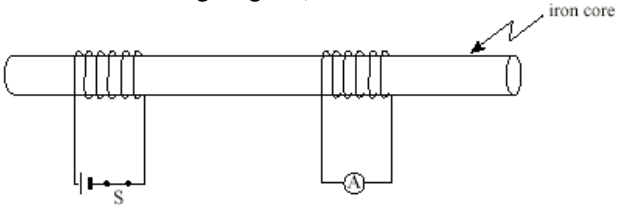
1. Four compasses are placed around a conductor carrying a current into the page, as shown below. Which compass correctly shows the direction of the magnetic field due to the current?



2. What is the radius of curvature of the path of a proton travelling at 4.7 x 10^5m/s in a plane perpendicular to a 0.52 T magnetic field?
   a. 2.0 x 10^{-8} m
   b. 5.1 x 10^{-6} m
   c. 9. 4 x 10^{-3} m
   d. 1.1 x 10^{2} m

3. A motor operating at full speed draws a current of 4.0 A when connected to a 110 V source. The motor has an armature resistance of 3.5 Ω. What is the back emf at full speed?
   a. 14 V
   b. 96 V
   c. 110 V
   d. 124 V

4. In the following diagram, ammeter A shows a current



   a. while switch S remains closed.
   b. while switch S remains opened.
   c. only while switch S is being closed
   d. while switch S is being opened or being closed.

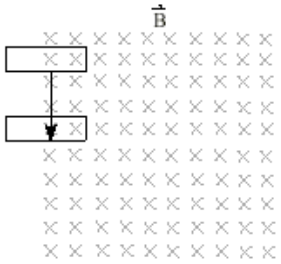
5. A transformer connected to a 120 V ac source has an output of 24 V ac. If the primary coil has 330 turns, how many turns of wire are there in the secondary coil?
   a. 24 turns
   b. 66 turns
   c. 330 turns
   d. 1 650 turns

6. Transformers are commonly used in which electrical device?
   a. toaster
   b. television set
   c. electric kettle
   d. incandescent bulb

7. A dc motor is connected to a constant voltage supply. The load on the motor decreases, allowing the motor to rotate faster. How do the back emf and current through the motor change?

	BACK EMF	CURRENT
a.	decreases	decreases
b.	decreases	increases
c.	increases	decreases
d.	increases	increases

8. In which of the following situations would an induced emf be produced in a rectangular loop of wire? The loop of wire is moved as indicated.

a.


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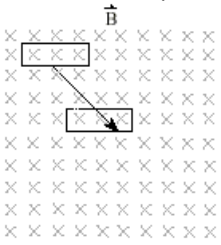
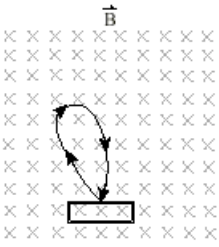


c.


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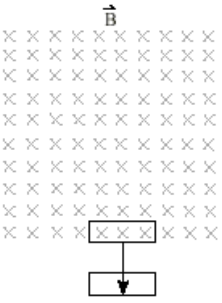
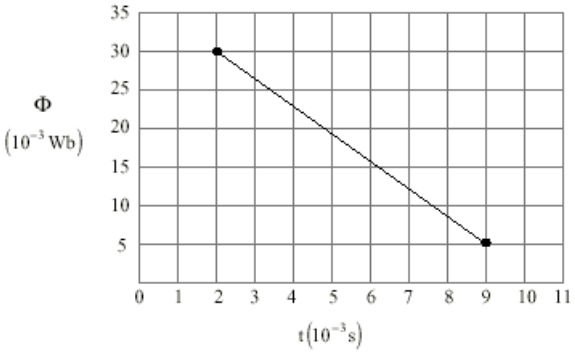
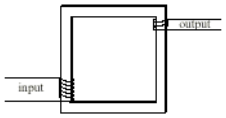


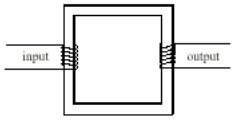
9. The graph below shows how the magnetic flux through a single loop changes with respect to time. What is the average emf induced between t = 2.0 x 10^{-3} s and t = 9.0 x 10^{-3} s?

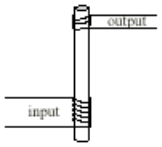


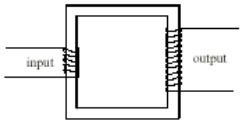
a. 1.2 x10^{-4} V
b. 1.8 V
c. 3.6 V
d. 25 V

10. Which of the following is a step-up transformer?

a. 

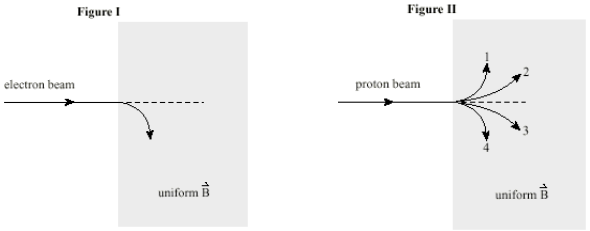
c. 

b. 

d. 

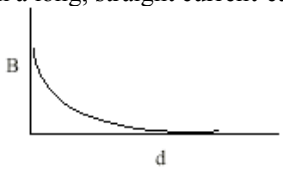
11. A solenoid of diameter 0.018 m is 0.30 m long. A current of 5.3 A is used to create a magnetic field of 0.25 T at the centre of the solenoid. How many turns of wire does this solenoid have?
    a. 6.8 x 10^2
    b. 2.1 x 10^3
    c. 1.1 x 10^4
    d. 3.8 x 10^4

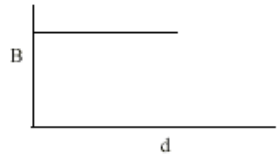
12. A beam of electrons is directed into a uniform magnetic field and deflects as shown in Figure I. If a beam of protons with the same speed were to enter this same magnetic field, which of the paths shown in Figure II would the protons take?

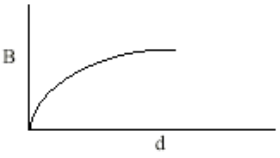


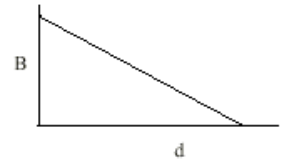
a. 1
b. 2
c. 3
d. 4

13. Which of the following graphs best shows how the magnetic field B varies with the perpendicular distance d from a long, straight current-carrying conductor?

a. 

b. 

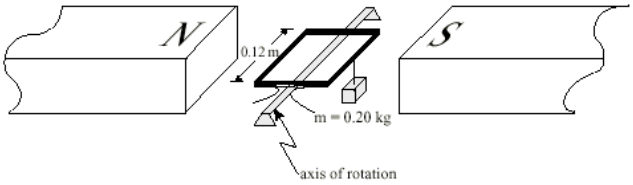
c. 

d. 

14. For what type of input current will the output current in a transformer be zero?
    a. dc
    b. ac
    c. increasing dc
    d. decreasing dc

15. A motor designed to operate on 120 V draws a current of 33 A when it first starts up. At its normal operating speed, the motor draws a current of 2.7 A. What is the back emf at normal operating speed?
    a. 9.8 V
    b. 110 V
    c. 120 V
    d. 130 V

16. A 35 loop square coil 0.12 m on a side is positioned in a 0.050 T magnetic field. A 0.20 kg mass is suspended from one side of the coil as shown in the diagram below.

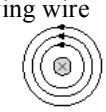


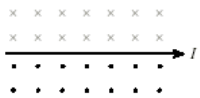
How much current must pass through the coil in order for the coil to remain horizontal?

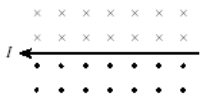
a. 2.3 A
b. 4.7 A
c. 9.3 A
d. 330 A

17. Which of the following diagrams shows the magnetic field produced by a long current-carrying wire

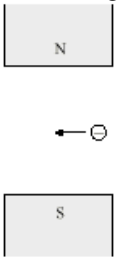
A.


B.


C.


D.


18. The diagram below shows an electron travelling to the left in a magnetic field.



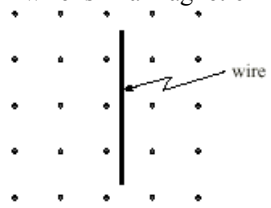
In which direction will the electron be deflected?

a. into the page
b. out of the page
c. towards the north pole
d. towards the south pole

19. A doubly-ionized atom (Q = 2e) with a mass of 6.8×10^{-27} kg enters a 3.0 T magnetic field with a speed of 5.0×10^{7} m/s. What is the radius of the circular path of the atom?

a. 0.35 m
b. 0.71 m
c. 1.4 m
d. 2.8 m

20. A wire is in a magnetic field as shown. wire



In which direction could the wire be moved to induce an emf across the length of the wire?

a. to the left
b. up the page
c. into the page
d. down the page

21. An emf is induced in a coil if the magnetic flux through the coil is

a. zero.
b. changing.
c. constant and large.
d. constant and small.

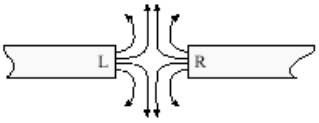
22. A coil of wire contains 55 loops. The coil is rotated such that the flux changes from 2.0×10^{-4} Wb to 8.0×10^{-4} Wb in 1.5×10^{-2} s. What is the average induced emf?

a. 1.1 V
b. 1.8 V
c. 2.2 V
d. 3.7 V

23. A door bell transformer has 900 primary windings and 60 secondary windings. The secondary current is 0.30 A. What is the primary current and what is the type of transformer?

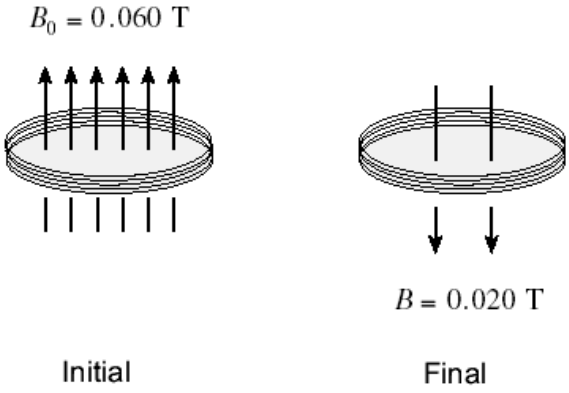
	PRIMARY CURRENT (A)	TRANSFORMER TYPE
a.	0.020	Step-Up
b.	0.020	Step-Down
c.	4.5	Step-Up
d.	4.5	Step-Down

24. Identify the poles of the magnets shown.



	POLE L	POLE R
a.	North	North
b.	North	South
c.	South	North
d.	South	South

25. A 500-turn circular coil with an area of 1.54 x 10^{-2} m^2 is perpendicular to a 0.060 T field. The magnetic field changes to 0.020 T in the opposite direction in 0.12 s.



What is the average emf induced in the coil?
   a. 5.1 x 10^{-3} V
   b. 1.0 x10^{-2} V
   c. 2.6 V
   d. 5.1 V

26. Which of the following devices commonly uses a solenoid?
   a. kettle
   b. battery
   c. television set
   d. incandescent bulb

27. A compass placed on a table points north. In which direction should a conductor, placed directly above the compass, carry current in order to reverse the direction of the compass needle?
   a. east to west
   b. west to east
   c. north to south
   d. south to north

28. In a step-up transformer, how do the primary and secondary voltages, and the primary and secondary currents, compare to one another?
   a. $V_s > V_p$ and $I_s > I_p$
   b. $V_s > V_p$ and $I_s < I_p$
   c. $V_s < V_p$ and $I_s > I_p$
   d. $V_s < V_p$ and $I_s < I_p$

29. When a 9.0 V power supply is connected to a motor whose internal resistance is 0.40 Ω, a current of 1.5 A flows through its windings. Find the back emf of the motor.
   a. 0.60 V
   b. 8.4 V
   c. 9.0 V
   d. 9.6 V

30. As an aircraft flies horizontally over the North Pole, a 0.80 V potential difference is induced across the wings. If the aircraft now slows to one half of the original speed, what will the new potential difference be?
   a. 0.40 V
   b. 0.57 V
   c. 0.80 V
   d. 1.6 V

31. A coil of wire of area 1.5 x 10^{-3} m^2 consists of 40 loops. A magnetic field is perpendicular to the face of the coil. In a period of 0.20 s the strength of the magnetic field decreases from 0.060 T to 0.050 T in the same direction. What is the average emf induced in the coil during this time?
   a. 7.5 x 10^{-5} V
   b. 1.5 x 10^{-3} V
   c. 3.0 x 10^{-3} V
   d. 3.3 x 10^{-2} V

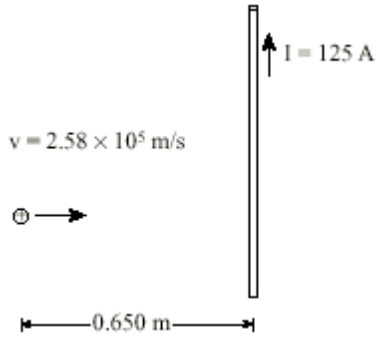
32. The current in an electric motor running at full speed is 2.5 A when connected to an 80 V dc source. If the armature resistance of the motor is 4.0 Ω, what is the back emf at this speed?
   a. 0 V
   b. 10 V
   c. 70 V
   d. 90 V

33. An ideal transformer has 150 turns in the primary coil and 1 800 turns in the secondary coil. If the primary coil is connected to 120 V ac and draws 7.5 A of current, what is the current in the secondary coil?
   a. 0.63 A
   b. 7.5 A
   c. 16 A
   d. 90 A

34. An electron moves in a circular orbit of radius r in a magnetic field. The electron moves in a path perpendicular to the magnetic field. If the kinetic energy of the electron is doubled, what is the new radius of its path?
   a. ½r
   b. $\sqrt{2}$ r
   c. 2r
   d. 4r

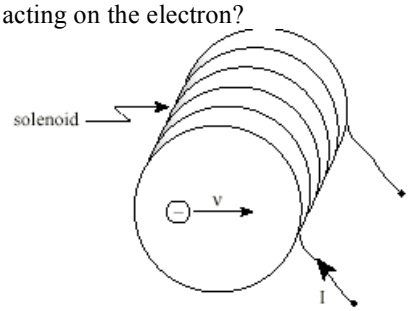
Written

1. A proton is travelling at 2.58 x 10^5 m/s towards a conductor carrying a current of 125 A. What is the magnitude of the magnetic force acting on the proton 0.650 m from the conductor?



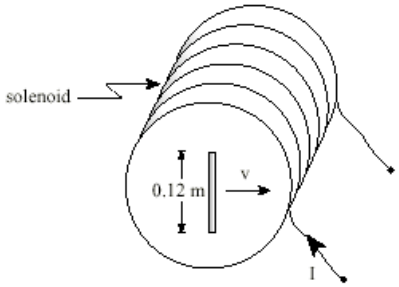
2. When an electric drill turns at normal operating speeds, there is little heat produced in the motor windings. When drilling harder material, the drill motor turns much slower than normal and overheats. Using principles of physics, give an explanation for the increased heat in the windings.

3. A 0.400 m long solenoid has 6 720 turns of wire. A current of 14.5 A flows in the solenoid. An electron inside the solenoid travels perpendicular to the axis of the solenoid with a speed of 6.50 x 10^5 m/s . What is the magnitude of the magnetic force acting on the electron?



4. A 16.0 V power supply is used to run a dc motor. When the motor is jammed so that it cannot turn, it draws a current of 12.0 A.
   a. What is the back or counter emf when the motor runs freely, drawing a current of 2.50 A?
   b. Using principles of physics, explain why the motor draws a much higher current when jammed than when running freely.

5. A solenoid of length 0.85 m has a radius of 0.10 m . A current of 25 A flows through its 7 600 turns. Within this solenoid, a 0.12 m wire moves as shown and develops an emf of 0.055 V across its ends.



   With what speed does the wire move perpendicular to the solenoid's magnetic field?

6. A proton enters a magnetic field of magnitude 2.4 x 10^{-2} T at a speed of 5.0 x 10^5 m/s perpendicular to the field.
   a. What magnetic force acts on the proton?
   b. What is the radius of the proton's circular path?

7. Electrons accelerated from rest through a potential difference of 300 V enter a 4.1 x 10^{-2} T magnetic field at right angles. What is the radius of curvature of the path taken by the electrons?

8. An ideal transformer is connected to a 12 V ac power supply. The light bulb connected to the secondary of the transformer is lit (Figure A). The transformer is then connected to a 12 V dc battery (Figure B).

Figure A

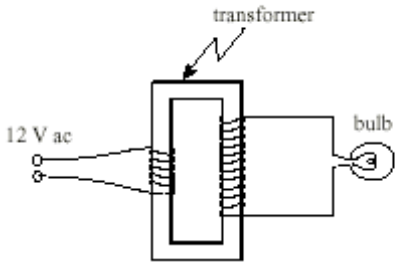
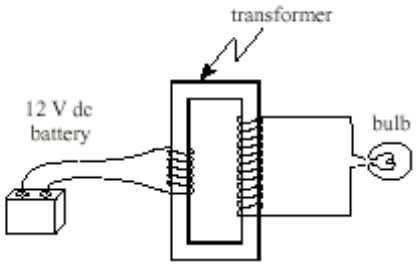


Figure B



a. The bulb will (check one response)
   - o not be lit.
   - o be dimmer.
   - o have the same brightness.
   - o be brighter.

b. Using principles of physics, explain your answer to a).

Answers

Multiple Choice

1.	A	6.	B	11.	C	16.	B	21.	B	26.	C	31.	C
2.	C	7.	C	12.	B	17.	D	22.	C	27.	A	32.	C
3.	B	8.	D	13.	A	18.	A	23.	B	28.	B	33.	A
4.	D	9.	C	14.	A	19.	A	24	A	29.	B	34.	B
5.	B	10.	D	15.	B	20.	A	25.	D	30.	A		

Written

1. $F = Bqv = (\mu_o I \div 2\pi d) \times q\ v = 1.6 \times 10^{-18}$ N

2. When the motor turns at normal operating speeds, the rotating coils act as a generator and produce a back emf. This back emf reduces the effective voltage across the coil so only a small current flows, producing a small amount of heat ($I^2 R$) . When the motor slows, the generator effect, and thus the back emf, is reduced. This means more of the line voltage is applied to the small resistance of the armature resulting in more current and in turn the motor produces more heat.

3. $F = Bqv = (\mu_o N \div l I) \times q\ v = 3.18 \times 10^{-14}$ N

4. a) $R = V \div I = 1.3\ \Omega$ $\quad V_b = V_{app} - IR = 16\text{ V} - (1.3\Omega \times 2.5\text{ A}) = 12.7$ V
   b) When running freely, the motor acts as a generator producing an emf that opposes the applied voltage (1 mark). When the motor is jammed (1 mark), there is no back emf (1 mark) and thus no opposition to the current (1 mark), which is therefore larger.

5. $\varepsilon = Bl_w v = \mu_o (N \div l_s) I\ l_w v$ $\quad v = 1.6$ m/s

6. a) $F = qv\ B = 1.9 \times 10^{-15}$ N
   b) $Fc = Fb$ $\quad mv^2 \div r = qvB$ $\quad r = 0.22$ m

7. Step one $PE = KE$ $\quad qV = \frac{1}{2} mv^2$ $\quad v = 1.0 \times 10^7$ m/s
   Step two: $F_B = F_c$ $\quad Bqv = mv^2 \div r$ $\quad r = 1.4 \times 10^{-3}$ m

8. a) not be lit
   b) Faraday's law states that an induced current is produced by a changing flux. Since a battery provides a dc current there is no flux change in the transformer. Therefore, there is no induced current.

