Physics 12 Name:

The Ultimate Electromagnetic Forces Assignment (9%)

Key Formulae:

$\vec{F} = \vec{B}Il$ $\vec{F} = Qv\vec{B}$ $B = \mu_0 nI = \mu_0 \frac{N}{l} I$

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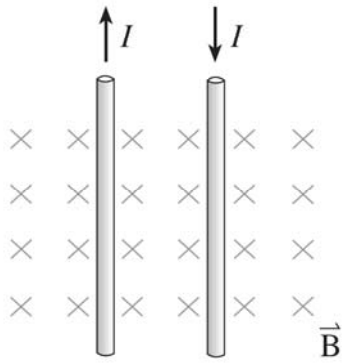
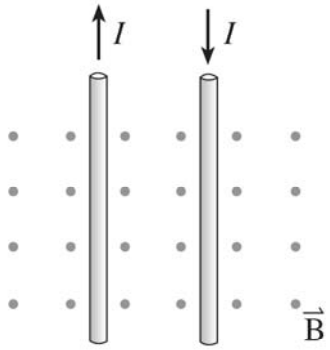
1.

In which diagram would an **external** magnetic field, $\vec{B}$, cause two current-carrying wires to move towards one another?

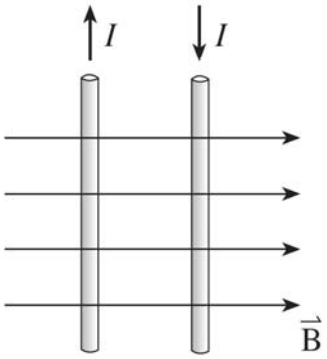
A.



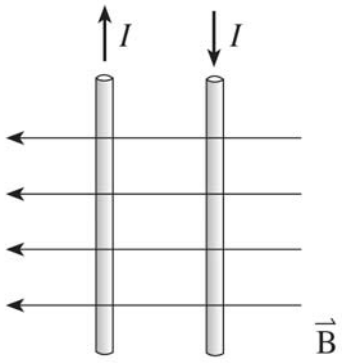
B.



C.

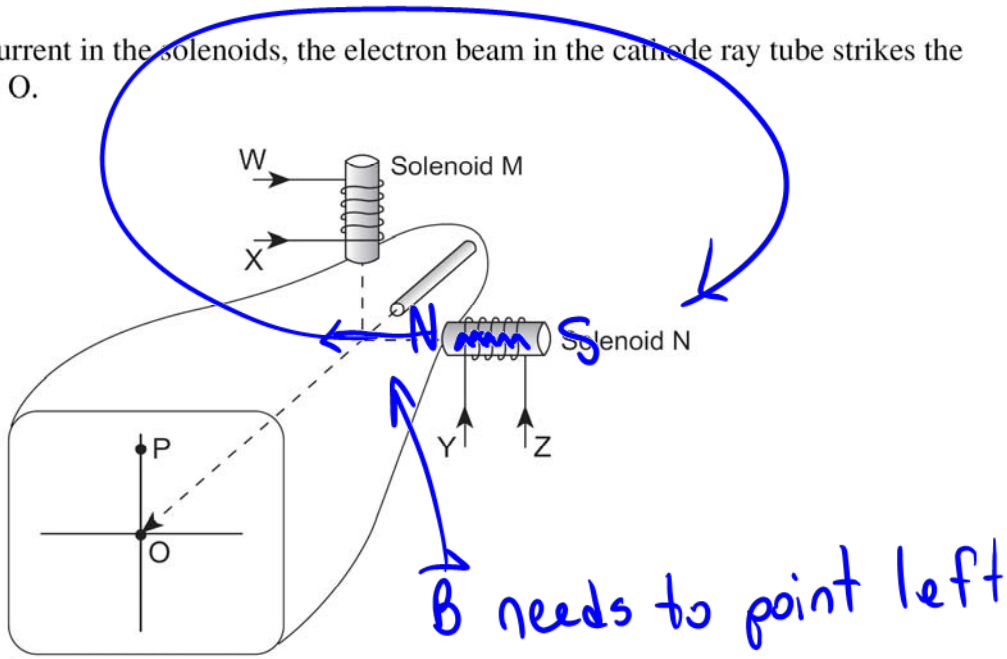


D.



2.

When there is no current in the solenoids, the electron beam in the cathode ray tube strikes the screen at the origin O.



In order to move the beam to position P, which solenoid is used and what is the direction of the current applied?

	SOLENOID	CURRENT DIRECTION
A.	M ✗	W
B.	M ✗	X
C.	N ✓	Y ✓
D.	N ✓	Z

3. An electron travelling at 7.7×10^6 m/s enters at right angles into a uniform magnetic field. Inside the field the path of the electron has a radius of 3.5×10^{-2} m.

a) What is the magnitude of the magnetic field? **(4 marks)**

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$B = \frac{mv}{qr} = \frac{(9.11 \times 10^{-31})(7.7 \times 10^6)}{(1.6 \times 10^{-19})(3.5 \times 10^{-2})}$$

$$\vec{B} = 1.25 \times 10^{-3} \text{ T}$$

b) If the magnetic field is produced at the centre of a solenoid by a current of 0.62 A, what is the number of turns per unit length of the solenoid? **(3 marks)**

$$B = \mu_0 n I$$

$$n = \frac{B}{\mu_0 I} = \frac{(1.25 \times 10^{-3})}{(4\pi \times 10^{-7})(.62)}$$

$$n = 1.6 \times 10^3 \text{ turns/m}$$

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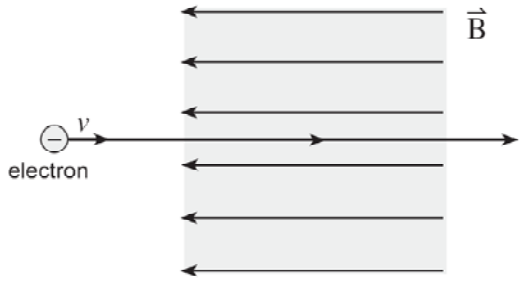
4. Which of the following devices commonly uses a solenoid?

A. Kettle B. Battery C. Television set D. Incandescent bulb

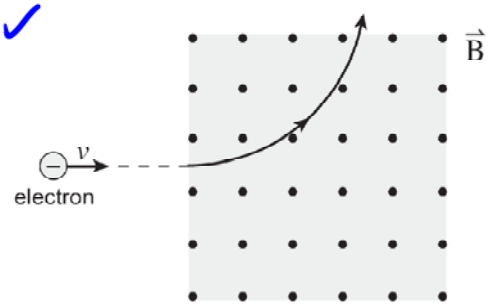
5.

An electron, travelling with a constant velocity, enters a region of uniform magnetic field. Which of the following is **not** a possible pathway?

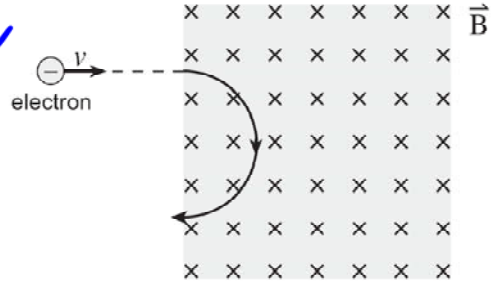
A.



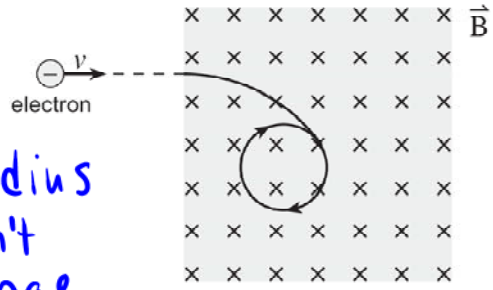
B.



C.



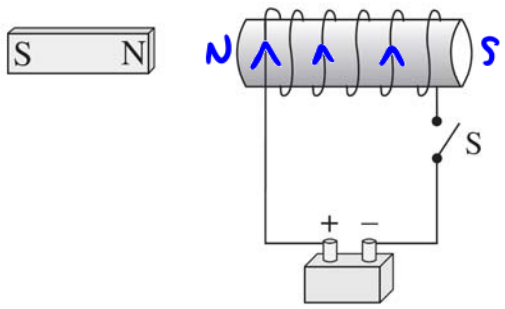
D.



radius wouldn't change

6.

A bar magnet is at rest, next to a fixed coil. When switch S is closed, the bar magnet will move



A. to the left.
B. to the right.
C. up the page.
D. down the page.

N will repel

7. Protons travelling at 2.2×10^5 m/s enter at right angles to a magnetic field. The field is produced by a 0.16 m long solenoid. A current of 5.3 A flows through the 820 turns of wire in the solenoid.

a) What is the magnetic field of the solenoid? **(3 marks)**

$$B = \mu_0 \frac{N}{\ell} I = (4\pi \times 10^{-7})\left(\frac{820}{.16}\right)(5.3)$$

$$B = 3.4 \times 10^{-2}\ T$$

b) What is the radius of curvature of the proton beam in the magnetic field of the solenoid?

(4 marks)

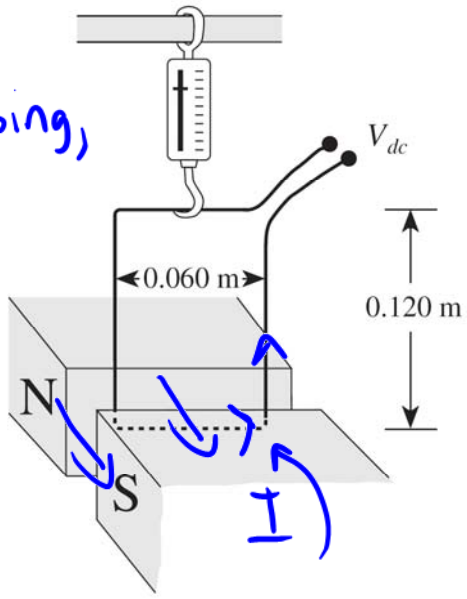
$$F_c = F_B \quad \frac{mv^2}{r} = qvB \quad \rightarrow r = \frac{mv}{qB}$$

$$r = \frac{(1.67 \times 10^{-27})(2.2 \times 10^5)}{(1.6 \times 10^{-19})(3.4 \times 10^{-2})} = 6.75 \times 10^{-2}\ m$$

8.

A rectangular loop is suspended by a spring scale between magnetic poles. The loop is 0.60 m wide by 0.120 m high.

Since spring scale is increasing, F_B must be down the page.

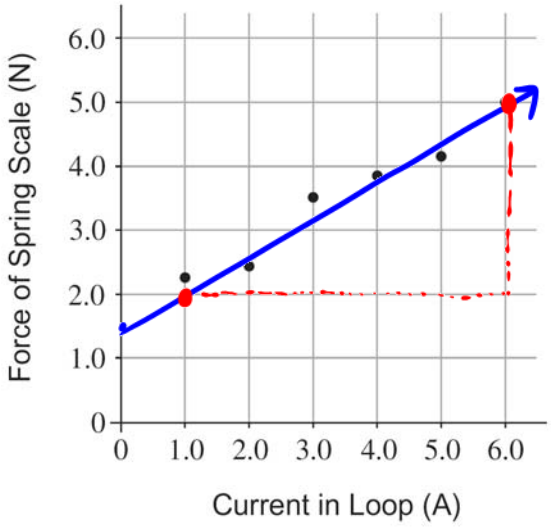


current ⊙ ⊙ ⊙ →

⊙ ⊙ ⊙

B field

As the current in the loop is varied, the readings of the spring scale and current are plotted on a graph.



$m = \frac{3}{5}$

a) What is the weight, in newtons, of the loop? **(1 mark)**

when $I = 0$, $F \approx 1.5$ N

b) What is the slope of the best fit line? **(2 marks)**

$m = 3/5 = 0.60 \ N/A$

c) What is the magnitude of the magnetic field? **(2 marks)**

$F = BIl$ ← from graph

$B = \frac{F}{Il} = \frac{0.5}{(1)(0.06)} \approx 8.3 \ T$

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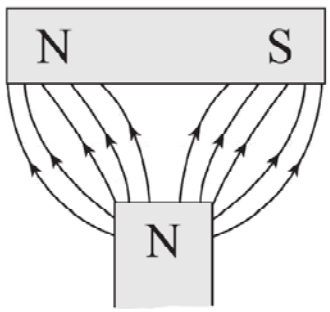
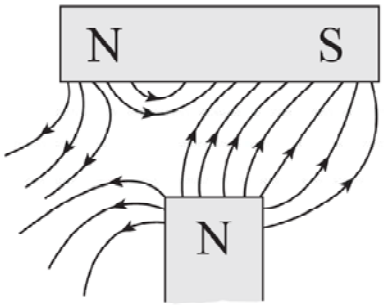
9.

Which of the following diagrams best represents the magnetic field in the region between the two permanent magnets?

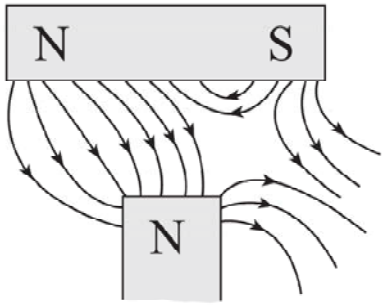
A.



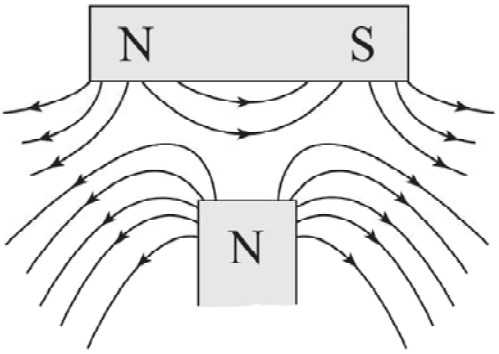
B.



C.



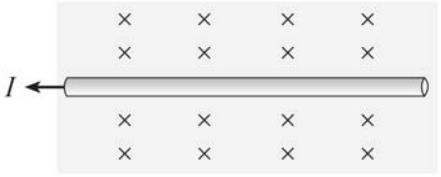
D.



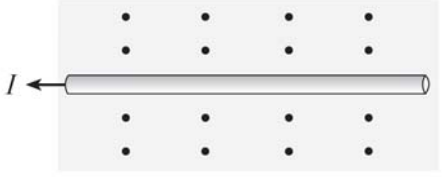
10.

In which diagram would the current-carrying conductor experience a magnetic force out of the page?

A.

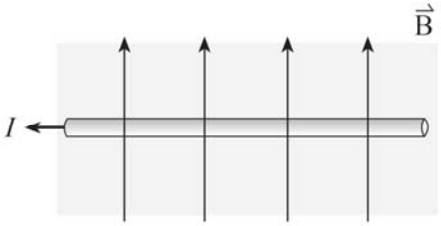


B.

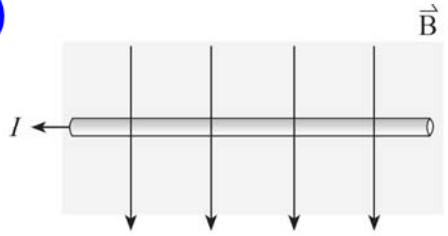


RHR.

C.

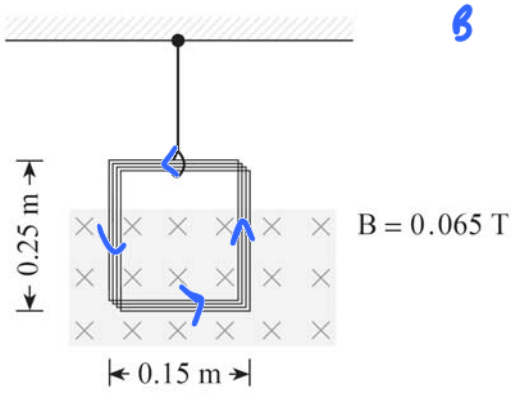


(D.)



11.

A coil of 25 turns of wire is suspended by a thread. When a current flows through the coil, the tension in the thread is reduced by 4.0×10^{-2} N. ← F_B is up the page



$F = BIl$

$I = \frac{F}{Bl} = \frac{4 \times 10^{-2}}{(.065)(.15)}$

What are the magnitude and direction of the current?

	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT
A.	0.16 A ✓	clockwise ✗
(B.)	0.16 A ✓	counter-clockwise ✓
C.	4.1 A ✗	clockwise ✗
D.	4.1 A ✗	counter-clockwise ✓

$I_{total} = 4.1$, now divide by 25 = 0.16 A/wire

12. A proton moves with a speed of 3.6×10^5 m/s at right angles to a uniform 5.0×10^{-5} T magnetic field.

a) What is the radius of curvature for the motion of the proton? **(5 marks)**

$$F_c = F_B$$

$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB} = \frac{(1.67 \times 10^{-27})(3.6 \times 10^5)}{(1.6 \times 10^{-19})(5 \times 10^{-5})} = 75 \text{ m}$$

b) Describe the path of the proton in the magnetic field and use principles of physics to explain the proton's motion. **(4 marks)**

The charge is moving perpendicular to magnetic field. By R.H.R., the charge will experience a force. Its path will be circular.

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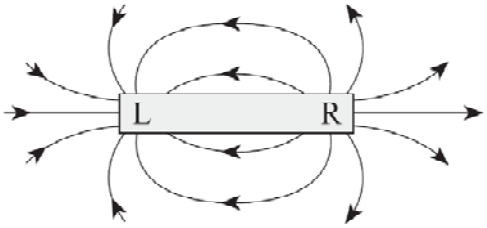
13.

Identify the magnetic poles labelled L and R in the diagram shown.

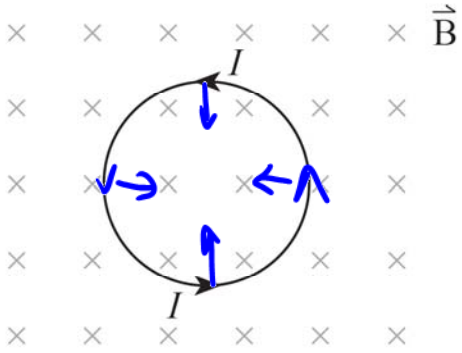


	POLE L	POLE R
A.	North	North
B.	North	South
C.	South	North
D.	South	South

14.

The diagram shows current *I* flowing in a circular coil located in a magnetic field.

Use R.H.R.



The magnetic force acting on the coil will tend to cause it to

A. expand.
B. contract.
C. move up the page.
D. move down the page.

15.

An aircraft whose wingspan is 15 m carries a static charge of 0.60 C. It travels at 240 m/s perpendicular to a 1.5×10^{-4} T magnetic field. What magnetic force does the aircraft experience?

A. 0.022 N
B. 0.060 N
C. 0.54 N
D. 9.6×10^{5} N

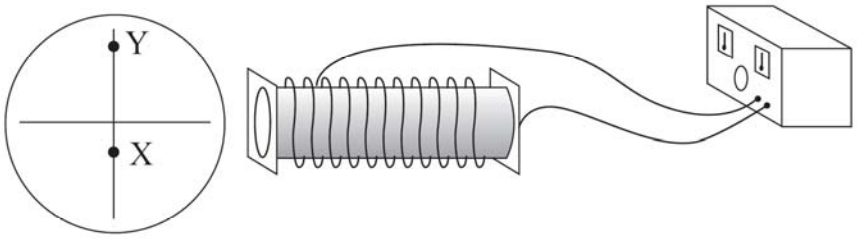
$F = qvB$

$= (0.60)(240)(1.5 \times 10^{-4})$

$F = 0.0216$ N

16.

An undeflected electron beam strikes the centre of a cathode ray tube. A solenoid placed beside a cathode ray tube causes the electron beam to strike the screen at position X.



What changes to the magnitude and direction of the current in the solenoid would cause the electron beam to strike the screen at Y?

	CHANGE TO CURRENT MAGNITUDE	CHANGE TO CURRENT DIRECTION
A.	Increases ✓	Remains the same ✗
B.	Increases ✓	Reverses ✓
C.	Decreases ✗	Remains the same ✗
D.	Decreases ✗	Reverses ✓

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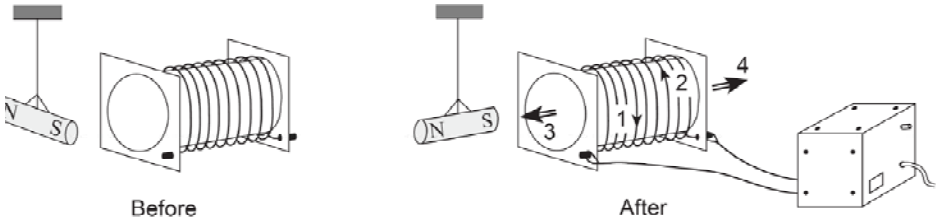
17.

The diagram shows a magnet suspended near a solenoid. After the solenoid has been connected to a power supply, the magnet rotates to a new position with its south pole pointing towards the solenoid.



there must be a N pole at 3.

Which arrows show the direction of the current in the solenoid and the direction of the magnetic field caused by this current?

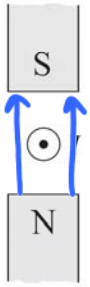
Use RHR to find current direction.

	DIRECTION OF CURRENT	DIRECTION OF MAGNETIC FIELD
A.	1 ✗	3 ✓
B.	1 ✗	4 ✗
C.	2 ✓	3 ✓
D.	2 ✓	4 ✗

18.

The diagram shows a conductor between a pair of magnets. The current in the conductor flows out of the page.

Use RHR.



In what direction will the magnetic force act on the conductor?

A. up the page
B. down the page
C. towards the left
D. towards the right

19.

$F_c = F_B$

$\frac{mv^2}{r} = qvB$

$r = \frac{mv}{qB}$

A charged particle travels in a circular path in a magnetic field. What changes to the magnetic field and to the velocity of the particle would both cause the radius of its path to decrease?

	CHANGE TO THE MAGNETIC FIELD	CHANGE TO THE VELOCITY
A.	increase ✓	increase ✗
B.	increase ✓	decrease ✓
C.	decrease ✗	increase ✗
D.	decrease ✗	decrease ✓

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20. The direction of a magnetic field is determined to be the direction in which

A. A positive charge would tend to move

B. A negative charge would tend to move

C. The north end of a compass needle would point

D. The south end of a compass needle would point

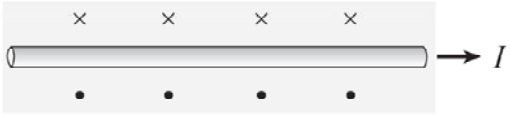
21.

Which diagram shows the magnetic field created near a conductor carrying current towards the right?

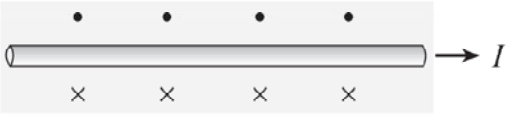
A.

B.

C.



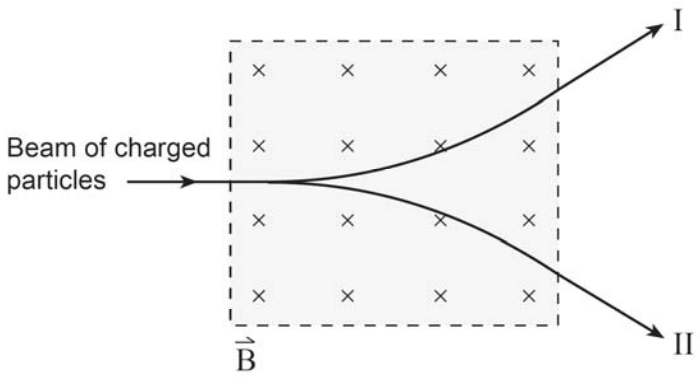
D.



22.

A beam of positively and negatively charged particles enters a magnetic field as shown. Which paths illustrate the positive and negative charges leaving the magnetic field region?

Use R.H.R.



	PATH OF POSITIVE CHARGES	PATH OF NEGATIVE CHARGES
A.	I ✓	I ✗
B.	I ✓	II ✓
C.	II ✗	I ✗
D.	II ✗	II ✓

23.

A solenoid has a length of 0.30 m, a diameter of 0.040 m and 500 windings. The magnetic field at its centre is 0.045 T. What is the current in the windings?

A. 2.9 A
B. 3.0 A
C. 21 A
D. 170 A

$$B = \mu_0 \frac{N}{\ell} I$$

$$I = \frac{B\ell}{\mu_0 N} = \frac{(.045)(.3)}{(4\pi \times 10^{-7})(500)} = 21 \text{ A}$$

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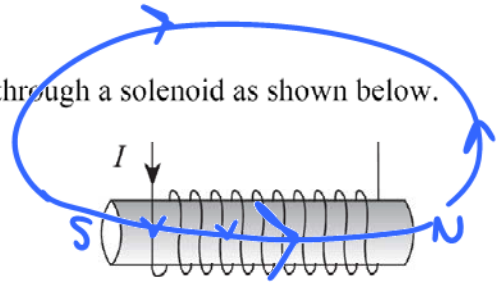
24.

An electric current flows through a solenoid as shown below.



Use RHR

What is the direction of the magnetic field inside the solenoid?

A. $\vec{B}$ →

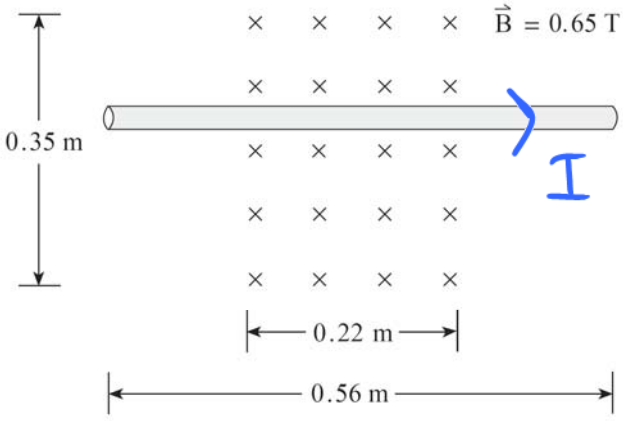
B. ← $\vec{B}$

C. ↑ $\vec{B}$

D. ↓ $\vec{B}$

25.

A long conductor is placed in a 0.65 T magnetic field as shown below.



Use RHR

$F = BIl$

$I = \frac{F}{Bl}$

$I = \frac{1.6}{(.65)(.22)}$

What are the magnitude and direction of the current that produces a 1.6 N force on the wire directed up the page?

	MAGNITUDE OF CURRENT	DIRECTION OF CURRENT
A.	4.4 A ✗	Right ✓
B.	4.4 A ✗	Left ✗
C.	11 A ✓	Right ✓
D.	11 A ✓	Left ✗

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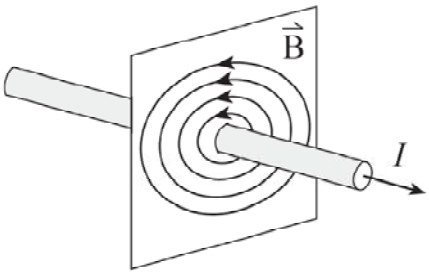
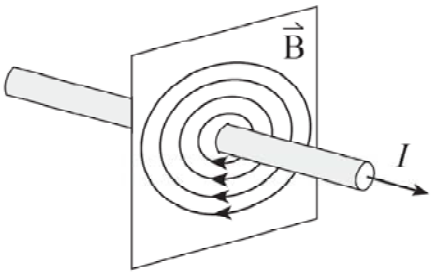
26.

Which of the following diagrams best shows the magnetic field due to a long straight wire carrying a conventional current I as shown?

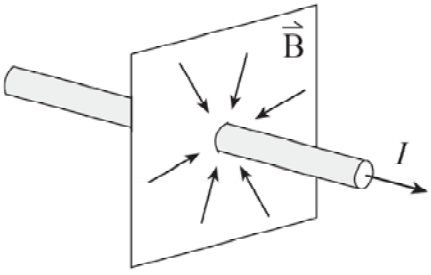
A.



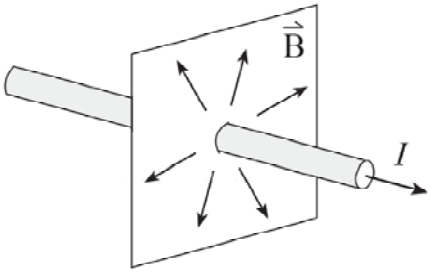
B.



C.



D.



27.

A proton is travelling at 2.3×10^{6} m/s in a circular path in a 0.75 T magnetic field. What is the magnitude of the force on the proton?

A. 1.6×10^{-24} N
B. 2.9×10^{-21} N
C. 2.8×10^{-13} N
D. 1.7 N

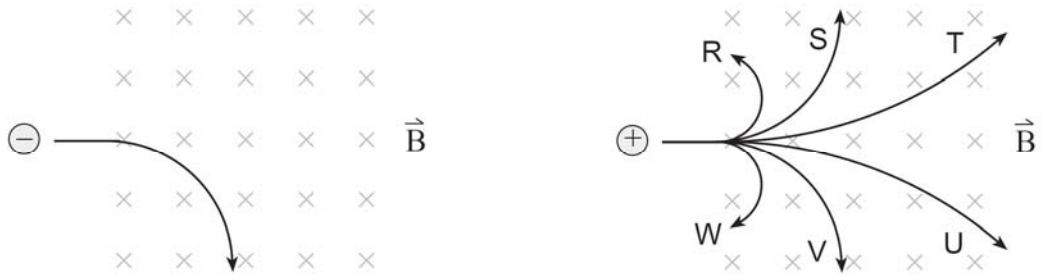
$F = qvB$

$F = (1.6\times10^{-19})(2.3\times10^{6})(.75)$

$F = 2.76\times10^{-13}$ N

28.

An electron travelling at a high speed enters a magnetic field as shown. A proton travelling at the same speed then enters the magnetic field.



a) Which of the six choices best illustrates the path the proton will follow? **(1 mark)**

T

b) Using principles of physics, explain why the proton takes the path selected in a). **(3 marks)**

By RHR, F_B will be in opposite direction on proton than electron, so up the page.

$F_c = F_B$

$\frac{mv^2}{r} = qvB$

$r = \frac{mv}{qB}$, m is larger, v, q, B are constant.

$\therefore$ r is larger.

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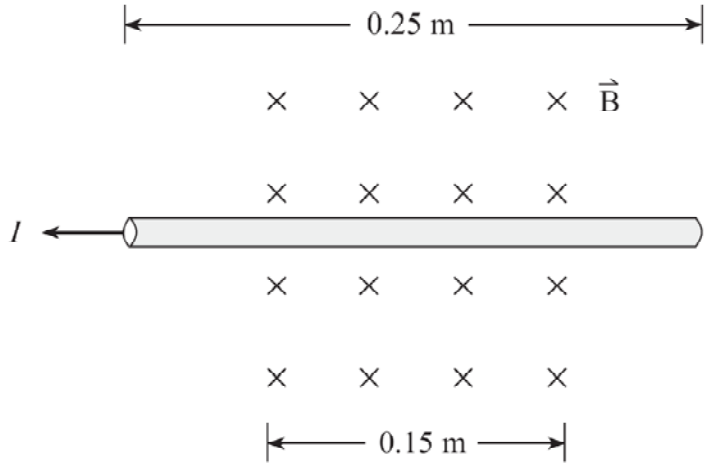
29.

A wire carrying 12 A of current is placed in a magnetic field of strength 0.63 T.



$F = BIl$

$= (.63)(12)(.15)$

What are the magnitude and direction of the magnetic force acting on the wire?

	FORCE	DIRECTION
A.	1.1 N ✓	down the page ✓
B.	1.1 N ✓	up the page ✗
C.	1.9 N ✗	down the page ✓
D.	1.9 N ✗	up the page ✗

30. A particle having a charge of 3.2×10^{-19} C follows a circular path of 0.45 m radius while travelling at a speed of 1.2×10^{4} m/s in a 0.78 T magnetic field. What is the mass of the particle?

A. 7.8×10^{-28} kg

B. 9.4×10^{-24} kg

C. 1.1×10^{-19} kg

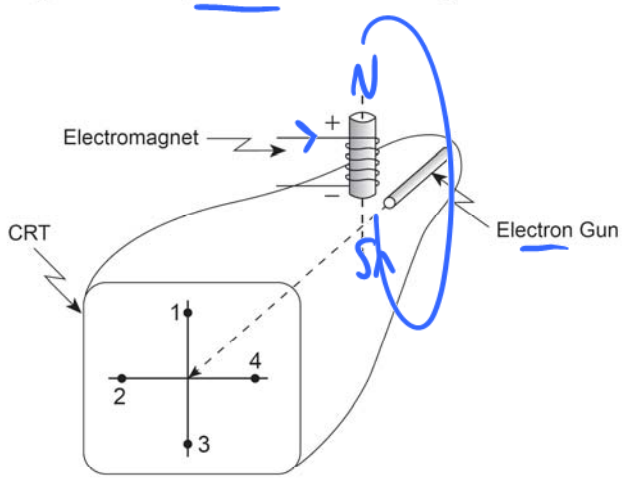
D. 3.0×10^{-15} kg

$$\frac{mv^2}{r} = qvB$$

$$m = \frac{qBr}{v} = \frac{(3.2 \times 10^{-19})(.78)(.45)}{1.2 \times 10^{4}}$$

31.

With the electromagnet turned off, electrons in a cathode ray tube strike the centre of the screen as shown.



B field is up

Use R HR

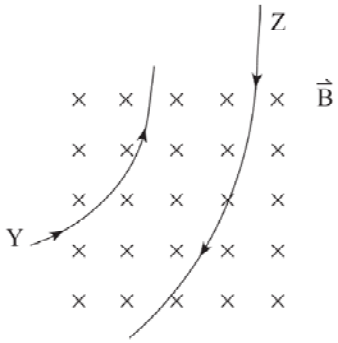
When the electromagnet is turned on, where will the electron beam now strike the screen?

A. 1
B. 2
C. 3
D. 4

9808

32.

Two particles Y and Z with equal mass and speed enter a uniform magnetic field and follow the paths as shown. How do their magnitude and polarity of charge compare?



$r = \frac{mv}{qB}$

As $q \downarrow$, $r \uparrow$

$\therefore Z < Y$

or $Y > Z$

	MAGNITUDE OF CHARGE	POLARITY
A.	Y < Z ✗	same charge ✗
B.	Y < Z ✗	opposite charge ✓
C.	Y > Z ✓	same charge ✗
D.	Y > Z ✓	opposite charge ✓

$r = \frac{mv}{qB}$

0686

33. When a proton with a speed of *v* enters a uniform magnetic field which is perpendicular to the proton's velocity, it travels in a circle of radius *r*. What would its speed have to be for the radius to be *r/4*?

A. v/16 B. v/4 C. v/2 D. v

34. An electron is accelerated from rest through a potential difference of 900 V. It then enters a uniform 2.4 x 10^{-3} T magnetic field at right angles to the field.

a) What is the speed of the electron? **(3 marks)**

$KE = PE$

$\frac{1}{2}mv^2 = qV$

$v = \sqrt{\frac{2qV}{m}} = \sqrt{\frac{2(1.6\times10^{-19})(900)}{9.11\times10^{-31}}} = 1.78\times10^{7}\ m/s$

b) What is the radius of its path in the magnetic field? **(4 marks)**

$F_c = F_B$

$\frac{mv^2}{r} = qvB$

$r = \frac{mv}{qB}$

$r = \frac{(9.11\times10^{-31})(1.78\times10^{7})}{(1.6\times10^{-19})(2.4\times10^{-3})}$

$r = 0.042\ m$

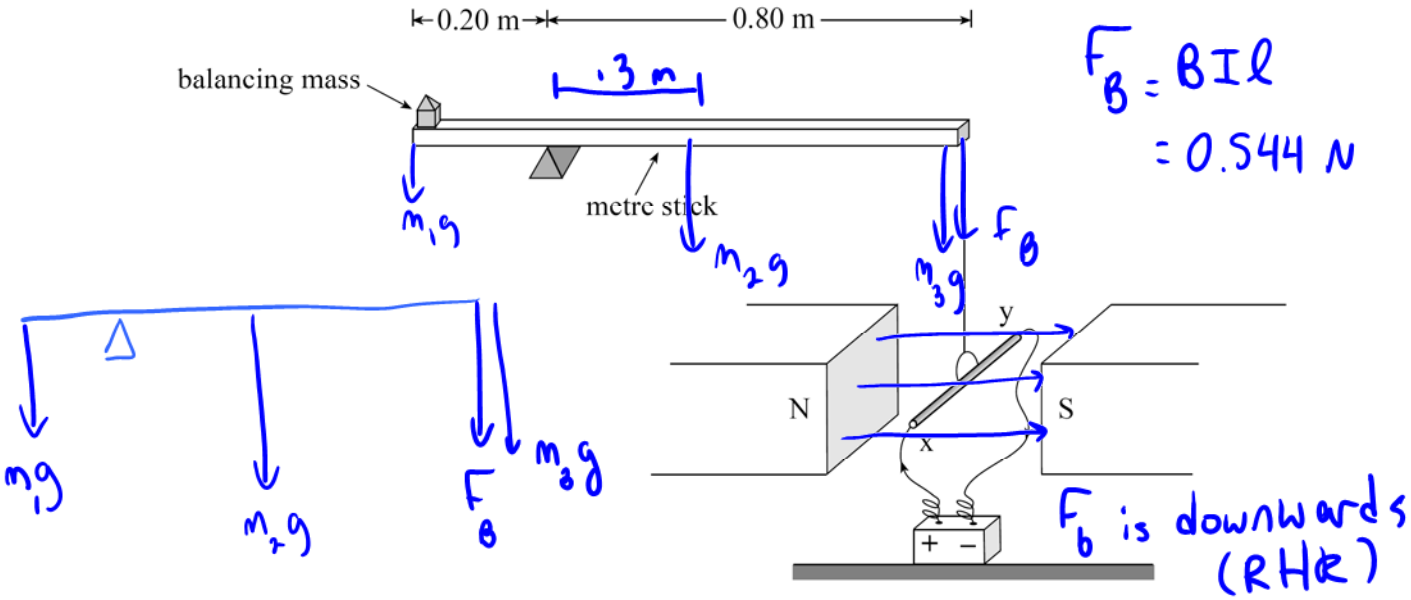
Scholarship Questions!

9501

33.

A uniform 0.125 kg metre stick is pivoted 0.20 m from its left end. A 0.250 kg conducting rod xy of length 0.16 m is suspended from the right end of the metre stick. An 8.5 A current flows through this rod. What balancing mass is needed to produce static equilibrium if the magnetic field is 0.40 T ?

(12 marks)



$F_B = BIl$

$= 0.544\ N$

m_1g m_2g F_B m_3g

F_b is downwards (RHR)

$$\Sigma \tau_{cw} = \Sigma \tau_{ccw}$$

$$m_2g(.3) + F_B(.8) + m_3g(.8) = m_1g(.2)$$

$$\frac{(.125)(9.8)(.3) + (0.544)(.8) + (.25)(9.8)(.8)}{(9.8)(.2)} = m_1$$

$$m_1 = 1.41\ kg$$

9601

34.

Ions with a charge of 1.6×10^{-19} C are accelerated from rest through a potential difference of 140 V before entering a 0.23 T magnetic field at right angles to the field. In the field, the ions travel along a circular path of radius 0.015 m. What is the mass of these ions? **(12 marks)**

$F_c = F_B$

$\frac{mv^2}{r} = qvB$

$\frac{mv}{r} = qB$

$m = \frac{qBr}{v}$

need v!

$KE_f = PE_i$

$\frac{1}{2}mv^2 = qV$

$v = \sqrt{\frac{2qV}{m}}$

square both equations to make math easier!

$m^2 = \frac{q^2B^2r^2}{v^2}$, where $v^2 = \frac{2qV}{m}$

$m^2 = \frac{q^2B^2r^2}{\frac{2qV}{m}} \Rightarrow m^2 = \frac{q^2B^2r^2 \cdot m}{2qV}$

$m = \frac{qB^2r^2}{2V} = \frac{(1.6\times10^{-19})(.23)^2(.015)^2}{2(140)} = 6.8\times10^{-27}$ kg

Answers:

1. B
2. C
3. A) $B=1.3 \times 10^{-3}$ T B) 1.6×10^{3} turns/m
4. C
5. ~~A~~ D
6. A
7. A) $B=3.4 \times 10^{-2}$ T B) $r=6.8 \times 10^{-2}$ m
8. A) 1.5 N B) 0.58 N/A C) B= 9.7 T
9. B
10. D
11. B
12. A) r= 75 m B) see solution key
13. C
14. B
15. A
16. B
17. C
18. C
19. B
20. C
21. D
22. B
23. C
24. A
25. C
26. A
27. C
28. A) Path T b) see solution key
29. ~~C~~ A
30. ~~D~~ B
31. D
32. D
33. B
34. A) $v=1.78 \times 10^{7}$ m/s B) r= 0.042 m
35. 1.41 kg
36. 6.8×10^{-27} kg