2018-2019 Term 2

PHYS1001 Essential Physics

Assignment 8

Due date: 9th April, 2019 by 6:00 pm

(Please leave your homework in the box with the label "PHYS 1001" outside room 213 in Science Centre North Block)

Please answer **all** six questions

1. Peter uses a light bulb with a power rating of 220V 55W (meaning that the power dissipated is 55W when the potential difference across the light bulb is 220 V) to illuminate his room. However, he finds that the light bulb is not bright enough. Subsequently, he connects another light bulb in series to the original light bulb.

   (a) Calculate the resistance of the light bulb.
   (b) Calculate the total power when the two light bulbs are connected in series. Hence explain why Peter's attempt to brighten up the room is unsuccessful.
   (c) After consulting a smart physics student, Peter connects the two light bulbs in parallel. Calculate the total power when the two light bulbs are connected in parallel.

Answer:

(a) $P = \frac{V^2}{R}$

$$55 = \frac{(220)^2}{R}$$
$$R = 880\Omega$$

(b) The potential difference across each light bulb is $\frac{220}{2} = 110$ V

For each light bulb, the power P is:

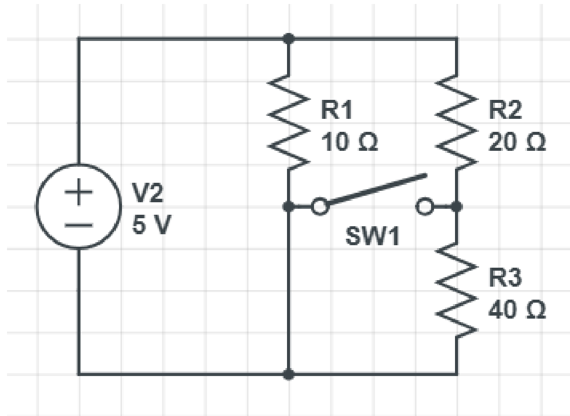
$$P = \frac{V^2}{R} = \frac{(110)^2}{880} = 13.75 \text{ W}$$

The power for two light bulbs is (13.75)(2)=27.5 W

The total power is smaller than the original power (55W). The brightness is going to decrease.

(c) $P = IV$, where I and V remains the same as a single light bulb connected to the power supply. The total power is (55)(2)=110 W.

2. Three resistors $R_1 = 10\ \Omega$, $R_2 = 10\ \Omega$ and $R_3 = 40\ \Omega$ are connected to a 2V battery as shown in the figure below. Initially, switch 1 (SW 1) is open.



(a) Calculate the current passing through each branch when SW1 is opened.
(b) Determine the potential difference across each resistor.
(c) Calculate the power dissipated in each resistor.
(d) Switch 1 is now closed. Determine the potential difference across each resistor.

Answer:

(a) Equivalent resistance in the lower branch= 20Ω+40 Ω=60 Ω
Current in the lower branch:

$$I = \frac{V}{R} = \frac{5}{60} = 0.083 \text{ A}$$

Current in the upper branch:

$$I = \frac{V}{R} = \frac{5}{10} = 0.5 \text{ A}$$

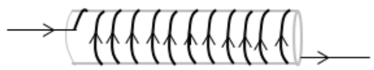
(b) Potential difference across resistance $R_1 = IR = (0.5)(10) = 5$ V
Potential difference across resistance $R_2 = IR = (0.083)(20) = 1.67$ V
Potential difference across resistance $R_3 = IR = (0.083)(40) = 3.32$V

(c) Power dissipated by $R_1 = I^2R = (0.5)^2(10) = 2.5$ W
Power dissipated by $R_2 = I^2R = (0.083)^2(20) = 0.139$ W
Power dissipated by $R_3 = I^2R = (0.083)^2(40) = 0.28$ W

(d) Potential difference across resistance R_1 and $R_2 = 5$ V
Potential difference across resistance $R_3 = 0$ V

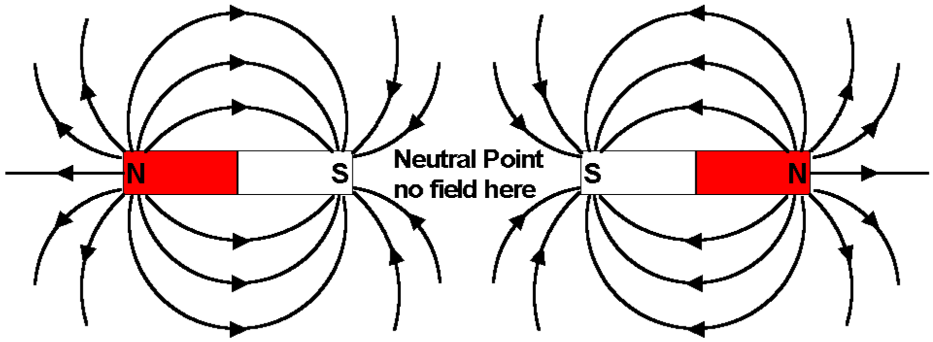
3. (a) Two magnets are placed side by side as shown in the figure below. Draw the magnetic field pattern around the two magnets.

(b) Draw the magnetic field line pattern of the following solenoid. The direction of current flow is shown below.

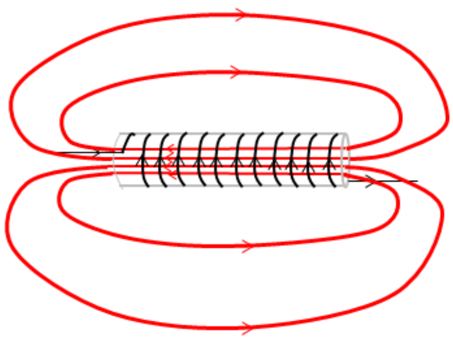


Answer:

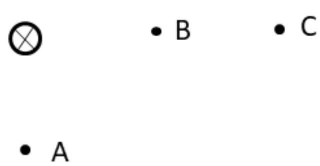
(a)



(b)

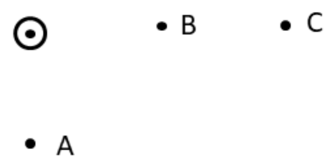


4. The current in a long wire points into the page as shown in the figure below. Points and points B are located at a distance 1 m from the wire while point C is located at a distance of 2 m from the wire.



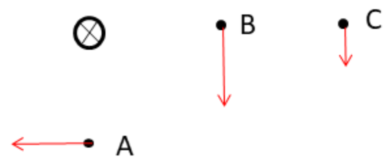
(a) Draw the direction of the magnetic field at point A, point B and point C. Which point has the weakest magnetic field strength? Explain your answer.

(b) How would your answer in (a) change if the current is going out of the page instead of going out of the page?

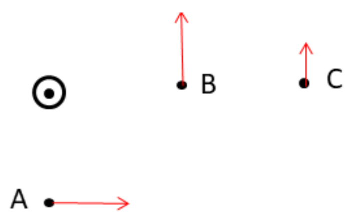


Answer:

(a) The magnetic field at point C is the weakest as it is the furthest away from the wire (Remember, the magnitude of the B-field of a long current carrying wire is given by $B = \frac{\mu_0 I}{2\pi r}$)



(b) The magnetic field at point C is still the weakest as it is the furthest away from the wire.



5. (a) What is the maximum current a long straight wire can carry so that the magnetic field is 0.5×10^{-4} T at a distance of 12 cm from the wire?
(b) You are asked to design a solenoid which is 30 cm long and 1.25 cm in diameter so that it produces a magnetic field of 4.65 mT at the centre. If the maximum current is 1.19 A, what is the minimum number of turns the solenoid must have?

Answer:

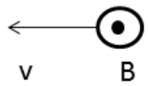
(a)
$$B = \frac{\mu_0 I}{2\pi r}$$
$$0.5 \times 10^{-4} = \frac{4\pi \times 10^{-7} I}{2\pi(0.12)}$$
$$I = 30\text{A}$$

(b) Note that the length of the solenoid is much larger than the diameter of the cross section of the solenoid, so we can use the following equation to calculate the magnetic field at the centre:
$$B = \mu_0 n I$$
$$4.65 \times 10^{-3} = (4\pi \times 10^{-7}) n (1.19)$$
$$n = 3109.5 \text{ turns/m}$$
Number of turns in a 0.3 m solenoid=$3109.5 \times 0.3 = 932.9$ turns
The minimum number of turns is 933 for the solenoid.

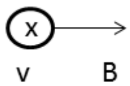
6. A charged particle with a speed of 2.8×10^4 m/s is passing through an area with a uniform field with a magnitude 2 T.

(a) The direction of motion of the charged particle and the magnetic field are indicated by the arrows in the diagram below. If the charged particle is a proton, calculate the force and draw the direction of the magnetic force in each of the following cases:

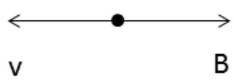
(i)



(ii)



(iii)



(b) Repeat (a) if the charged particle is an electron traveling at the same speed.

Answer:

(a) and (b)

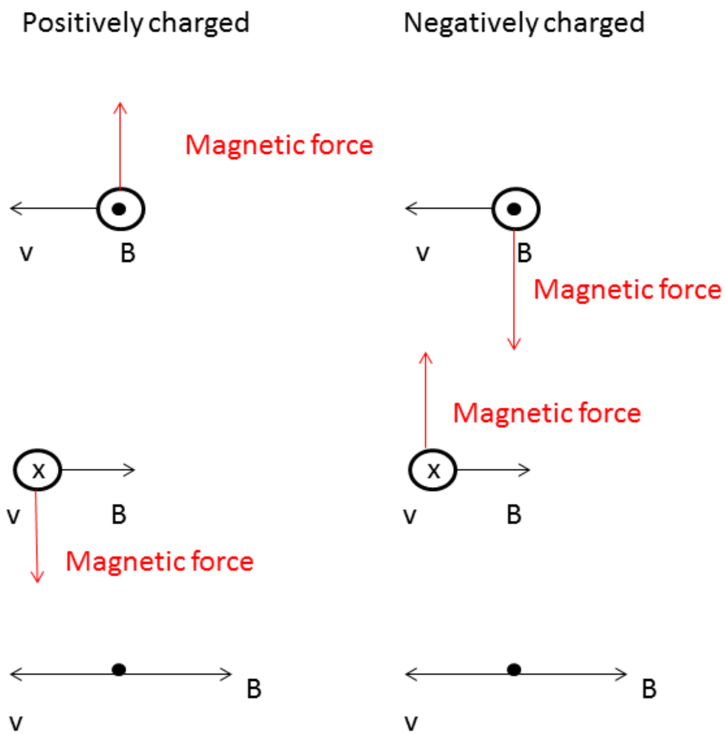
In each case, the magnitude is given by:

(i) $qvB = (1.6 \times 10^{-19})(2.8 \times 10^{4})(2)\sin 90° = 8.96 \times 10^{-15}\text{N}$

(ii) $qvB = (1.6 \times 10^{-19})(2.8 \times 10^{4})(2)\sin 90° = 8.96 \times 10^{-15}\text{N}$

(iii) $qvB = (1.6 \times 10^{-19})(2.8 \times 10^{4})(2)\sin 180°=0$

The direction is given as follows:


Positively charged
Negatively charged
Magnetic force
v
B
v
B
Magnetic force
Magnetic force
x
v
B
Magnetic force
x
v
B
B
v
B
v