ALL SAINTS' COLLEGE

Ewing Avenue, Bull Creek, Western Australia

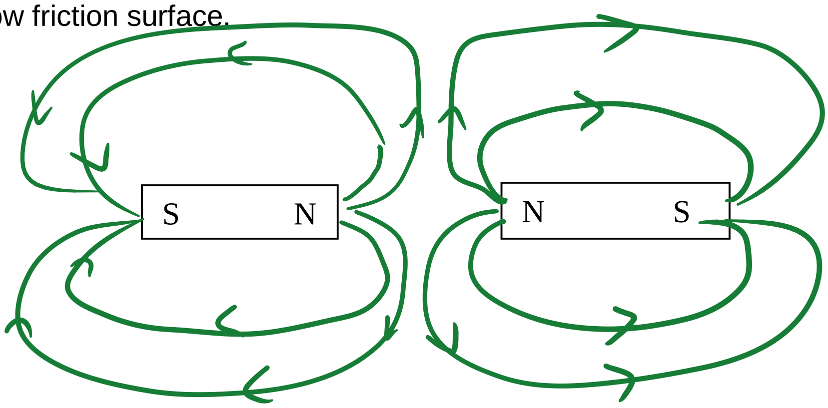
Year 12 Physics 3A3B   Electric Power Test 1   Practice

Student Name: Solutions

Time allowed: 50 minutes
Total marks available: 50
Show calculation answers to 3 significant figures

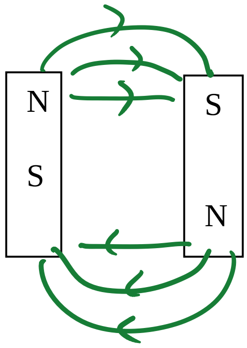
Q1 Sketch the magnetic field lines that would be established in the bar magnet configurations below and state whether the magnets are likely to attract, repel or remain stationery if set on a low friction surface.

a) (2)



repulsion

b) (2)

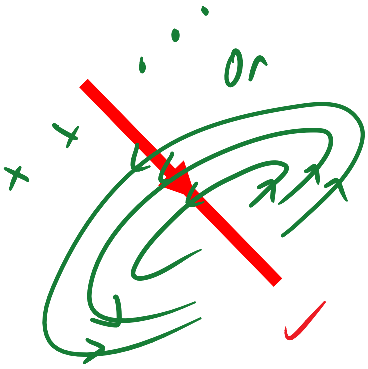


attraction

Q2 The following diagrams indicate current flow in wires. Draw the magnetic field lines associated with them. For each diagram, indicate where the dipoles (North and South) are formed or state "no dipole".

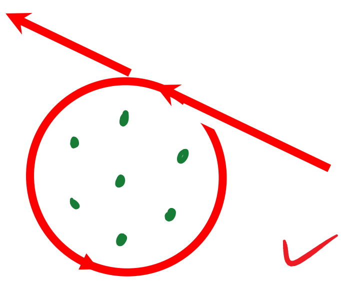
(3)

a)



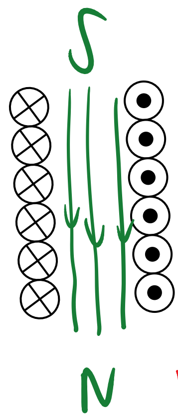
no dipole

b)



N above page
S below page

c)



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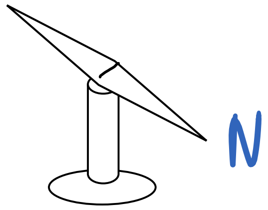
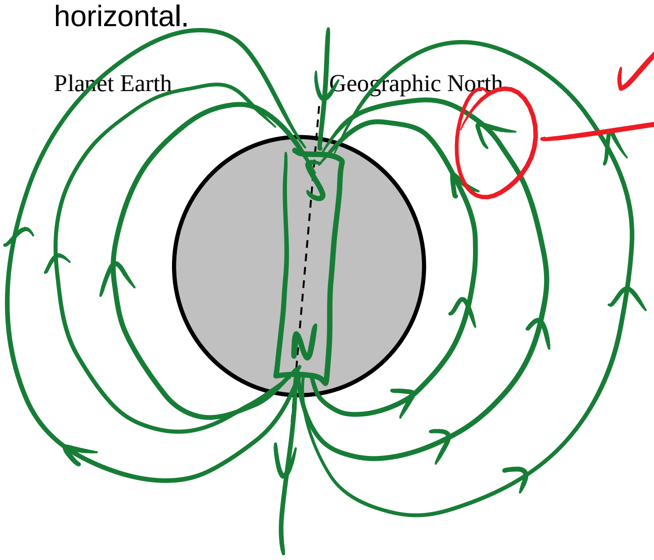
Q3 A compass that is free to align in 3 dimensions aligns with the Earth's field as in the diagram below; the left pole of the magnet rests higher than the pole on the right.



a) If this compass is in the northern geographical hemisphere indicate, on the diagram at left, which is the North Pole of the compass. (1)

b) Explain, with the aid of field lines added to the diagram below, why the compass does not lay horizontal. (2)



relative to Earth's surface the compass aligns with the field lines of Earth (down)

Q4 The Holden Volt is an electric vehicle whose DC electric motor is powered by a 370 V Lithium Ion battery. During a 7 second period of acceleration from rest the battery delivers a current of 45.0 A to the motor. The mass of a Holden Volt and driver is 1800 kg. The energy conversion efficiency of the vehicle is 80%.

a. Calculate the velocity of the vehicle after 7 seconds of acceleration. (4)

$P_{out} = VI = 370 \times 45 = 16{,}650\ W$

$P_{transfer} = P_{out} \times 80\% = 16{,}650 \times 80\% = 13{,}320\ W$

$\Delta KE = P_{trans} \times t = 13{,}320 \times 7 = 93{,}240\ J$

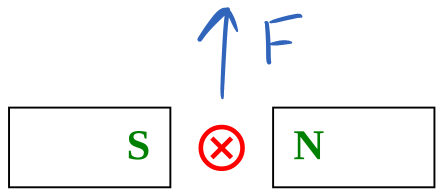
$\Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 \quad (u = 0,\ m = 1800\ kg)$

$93{,}240 = \frac{1}{2} \cdot 1800 \cdot v^2$

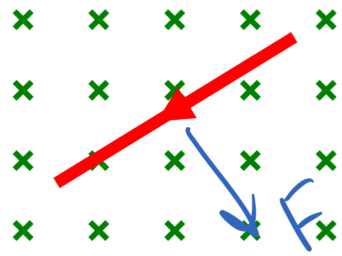
$v^2 = 103.6 \qquad v = 10.2\ m/s$

Q5 a) Indicate the direction of force acting on the current carrying wires in the following diagrams (4)

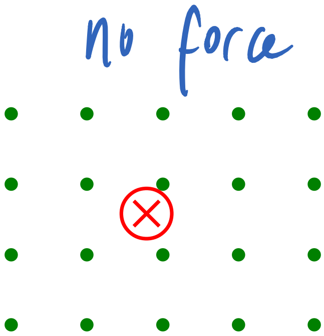
i)



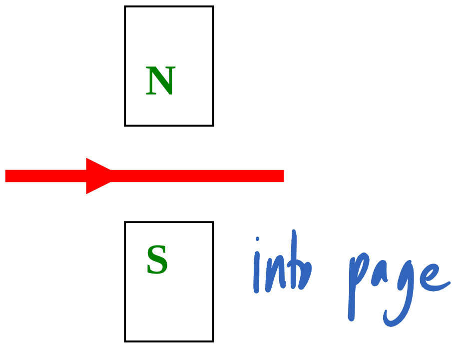
ii)



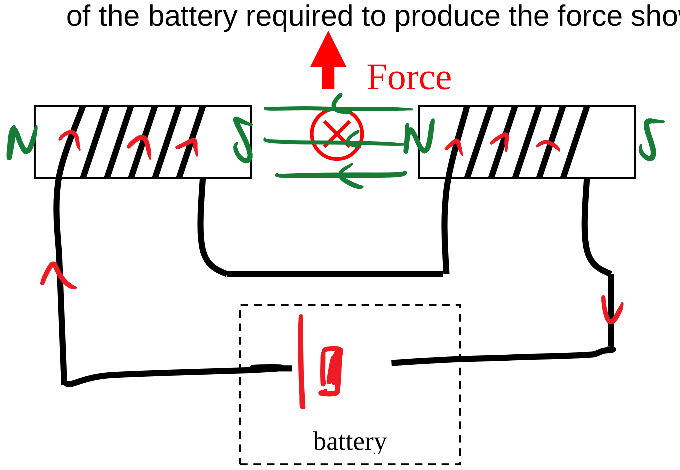
iii)



iv)

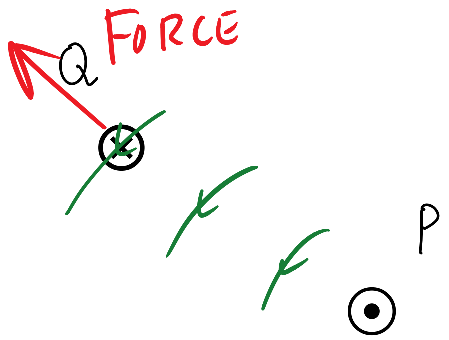


b) Indicate the external magnetic field, direction of current in the solenoid circuit and the polarity of the battery required to produce the force shown. (2)



✓ ✓

Q6 Two conductors P and Q are placed next to each other and each carry a current of 1.75 A. Q is placed North East of P. The magnetic flux density at position Q established by the current in P is 325 mT. Calculate the magnetic force and direction experienced by Q which has a length of 640 mm



(3)

$F = B.I.l$

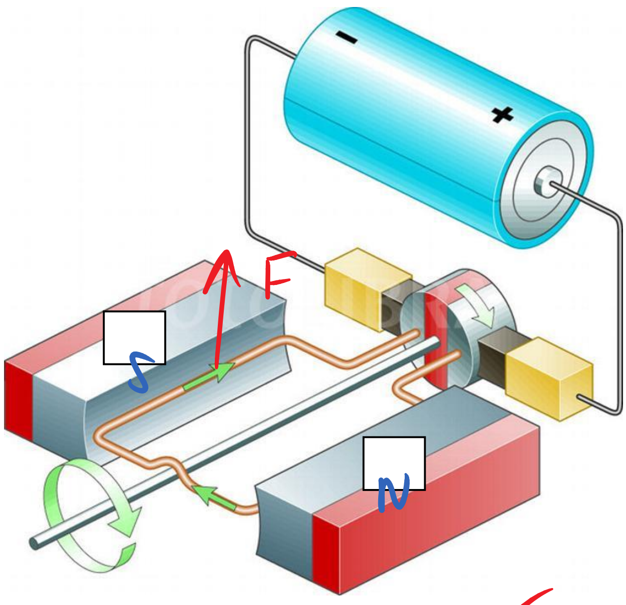
$F = 0.325 \times 1.75 \times 0.64$ ✓

$F = 0.364\ N$ ✓ north west ✓

Q7 The diagram shows a small DC motor connected via a commutator and brushes to a 12.0 V DC battery.

The direction of conventional current is shown.

The direction of rotation is also shown.



a) Indicate the magnetic poles in the boxes on the diagram required to achieve the direction of rotation shown.

✓ (1)

b) Explain how the commutator and brush arrangement works and why it is necessary on a DC motor.

(3)

- The coil rotates. When torque approaches zero the commutator disconnects the external emf.
- When the coil rotates beyond this point the commutator reconnects the coil
- This ensures a switch the direction of current in the frame of reference of the coil, Ensures constant direction of torque
- Direction of force in wire lengths next to each magnetic pole is always the same

The coil has a length (*l*) of 8.00 cm and width (w) 5.00 cm with a single turn of wire. The uniform magnetic flux density between the poles is 270 mT. The coil is drawing a current of 515 mA from the battery.

c) Calculate the force acting on the length of the coil that runs alongside the North pole in this motor

(2)

$\text{length} = 0.08 \quad I = 0.515\text{ A} \quad B = 0.270\text{ T} \quad n = 1$

$F = B.I.l.n$

$F = 0.27 \times 0.515 \times 0.08 \times 1$

$F = 0.0111\text{ N down}$

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d) Calculate the torque acting on this length of the coil at the position shown.

(2)

$F = 0.0111$ N down $\qquad r = 0.025$ m $\quad \theta = 90^{\circ}$

Torque = r.F.sin θ

Torque $= 0.025 \times 0.0111 \times \sin 90^{\circ}$

Torque $= 2.78 \times 10^{-4}$ N m clockwise

(1)

f) When the coil rotates 40° from the position shown, determine what percentage of the maximum torque the motor will have then.

(2)

A rotation of 40º means torque angle $\theta = 90^{\circ} - 40^{\circ} = 50^{\circ}$

Torque = r.F.sin 50

Torque = 76.6 % of maximum

g) When the coil rotates 40° from the initial position shown, determine what will happen to the magnitude and direction of the force on each length.

(1)

No change

h) This simple design means that the motor is not smooth in its operation. Describe 3 possible design changes that make an industrial DC electric motor smoother and more efficient.

(3)

Any 3 valid points that address smoothness:

Multiple coils /commutator groups
Multiple poles
Better bearings to reduce friction
Less break time on commutator

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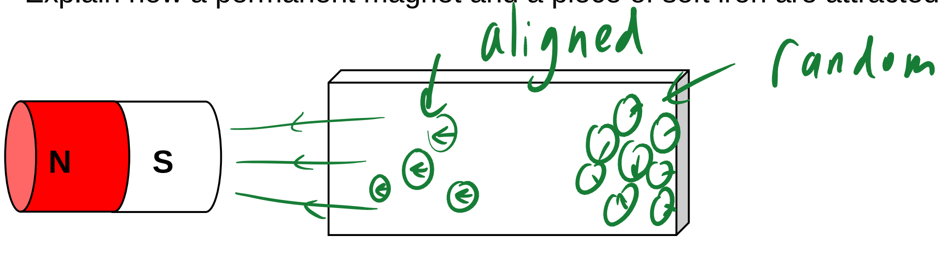
Q8 Referring to magnetic domain theory:

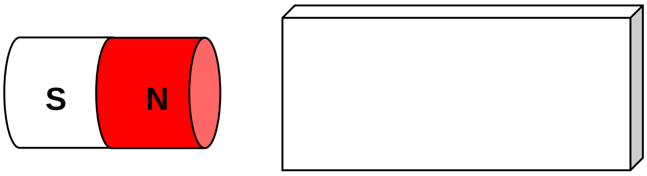
a. Explain how a permanent magnet and a piece of soft iron are attracted to each other. (3)



Soft Iron

Domains in soft iron randomly arranged when isolated.
Domain alignment in soft iron as a dominant field approaches. As domains have rotated the opposite poles face each other causing magnetic attraction:

b. Explain whether the copper strip will be attracted to the magnet. (1)

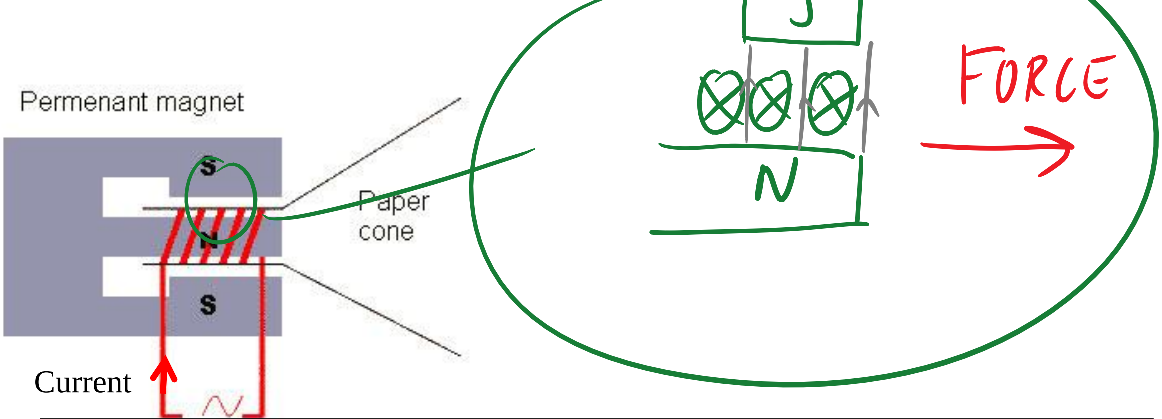


Copper

Copper is not a ferromagnetic material. It has no domains so is cannot be induced to be a temporary magnet.

Q9 The cutaway view of the magnet and coil arrangement of a loudspeaker is shown in the diagram. The coil and paper cone are attached and free to move within the cylindrical space between the magnetic poles. The magnet is fixed in position.

At this instant current is flowing in the direction shown. Determine the direction of force on the paper cone and explain briefly how you arrived at your answer. (2)



Explanation by right hand palm rule (or other valid hand rule)
As per diagram above.
Or think of coil arrangement as a solenoid – N pole forms at LHS and is repelled from N pole of magnet.

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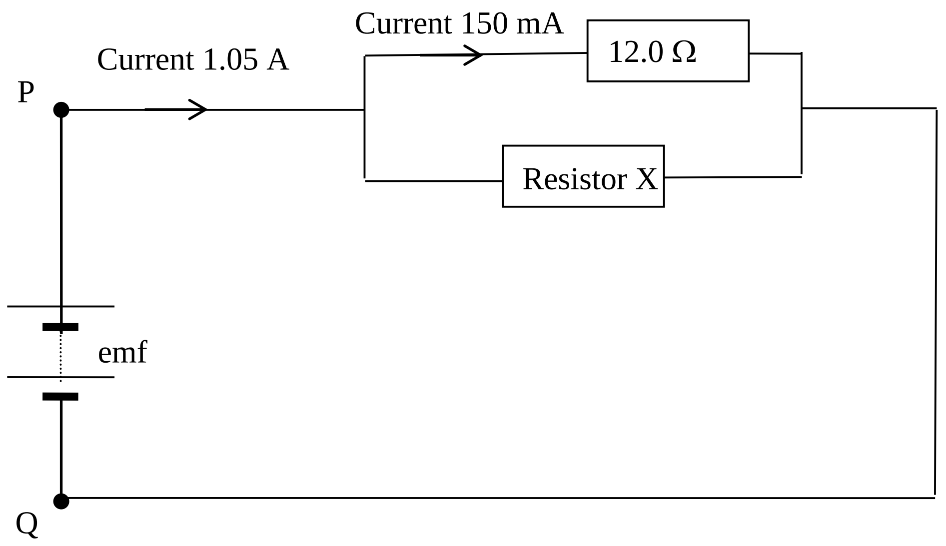
Q10 A simple circuit is shown in the diagram below. The 12.0 Ω resistor is rated to take a maximum current of 150 mA.



a) Calculate the value of Resistor X to ensure that a current of 150 mA flows in the 12.0 Ω resistor when a current of 1.05 A flows from the source of emf.

(4)

V_d across 12.0 Ω = I R = 0.150 × 12 = 1.80 V ✓

V_d common across Resistor X ✓

Current in = 1.05 – 0.150 = 0.900 A ✓

R = V / I = 1.80 / 0.90 = 2.00 Ω ✓

b) Calculate the energy delivered by the source of emf in a time of 3 minutes.

(2)

V_d across 12.0 Ω = emf across one parallel group = 1.80 V

Current into group = 1.05 A

Energy = V.I.t = 1.80 × 1.05 × 3 × 60 ✓

Energy = 340 J ✓

End of Test