

Exercise walk-through

4.5

Magnetic forces and induction (statements 105–110)

Pearson Edexcel · International A-Level · Physics

Scattering links observation to a model

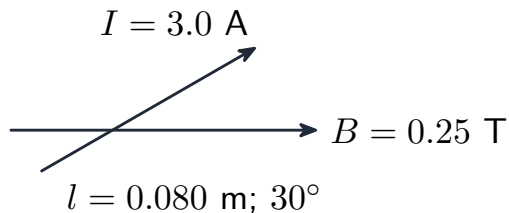
Observation / symbol	Supported conclusion
Most pass nearly straight	Most atomic volume is empty
Rare large deflections	Tiny, dense, positive nucleus
A_ZX	Proton number Z ; nucleon number A ; neutrons $A - Z$

The quark–lepton model organises particles

Family	Constituents / example
Baryon	Three quarks; proton uud
Meson	Quark + antiquark; pion
Lepton / antilepton	Electron / positron
Photon	Electromagnetic quantum

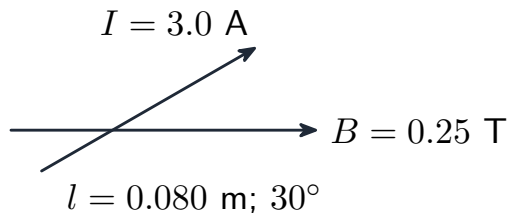
Exercise 2.1

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2.1 Use the angle between wire current and field.

$$F = BIl \sin \theta = 0.25 \text{ T} \times 3.0 \text{ A} \times 0.080 \text{ m} \times \sin 30^\circ = 0.030 \text{ N}$$

Magnitude. Parallel gives $\sin 0 = 0$, hence zero force.

Exercise 2.2

2.2 A proton travels rightwards at $2.0 \times 10^6 \text{ m s}^{-1}$ in a 0.10 T field into the page. Find force magnitude and direction. Explain the change for an electron with the same velocity, and whether magnetic force alone changes speed. [5]

× × × ×



$p: v = 2.0 \times 10^6 \text{ m/s}; B = 0.10 \text{ T}$

× × × ×

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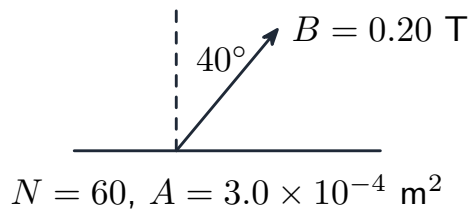
2.2 Perpendicular particle force.

$$F = qvB = 1.60 \times 10^{-19} \text{ C} \times 2.0 \times 10^6 \text{ m s}^{-1} \times 0.10 \text{ T} = 3.20 \times 10^{-14} \text{ N}$$

Magnitude. Proton force is upwards. Electron force is downwards with equal magnitude. Force is perpendicular to instantaneous velocity, doing no work and leaving speed unchanged.

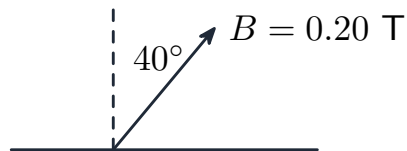
Exercise 2.3

2.3 A 60-turn coil has area $3.0 \times 10^{-4} \text{ m}^2$. A 0.20 T field makes 40° with its normal. Find flux linkage. Explain why using the angle to the plane would give the wrong result in the cosine formula. [3]



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$N = 60, A = 3.0 \times 10^{-4} \text{ m}^2$

2.3 Multiply flux per turn by turn count.

$$N\phi = NBA \cos \alpha = 60 \times 0.20 \text{ T} \times 3.0 \times 10^{-4} \text{ m}^2 \times \cos 40^\circ = 2.76 \times 10^{-3} \text{ Wb}$$

Linkage. Cosine takes the angle to the normal; the angle to the plane is its complement and would require sine.

Exercise 3.1

3.1 Magnets rest on a balance; a wire is supported independently between them. The balance reading increases by 1.2 g when a 4.0 A current flows through 0.060 m of wire perpendicular to the field. Find magnetic flux density and the force direction on the wire. Explain the error in setting force equal to 1.2. [5]

wire supported separately



balance change +1.2 g

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3.1 Convert reading change to weight change.

$$F = \Delta mg = 1.2 \times 10^{-3} \text{ kg} \times 9.81 \text{ m s}^{-2} = 1.18 \times 10^{-2} \text{ N}$$

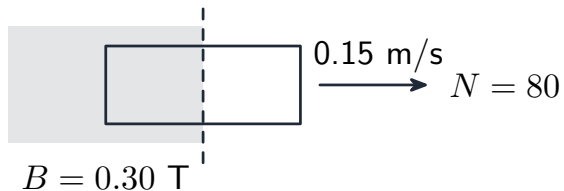
Use equal and opposite wire/magnet forces with $F = BIl$.

$$B = \frac{F}{Il} = \frac{1.1772 \times 10^{-2} \text{ N}}{4.0 \text{ A} \times 0.060 \text{ m}} = 0.0491 \text{ T}$$

Field. Increased balance reading means force on magnets downwards, so force on wire upwards. The balance change is a mass in grams; 1.2 alone is neither converted mass nor force in newtons.

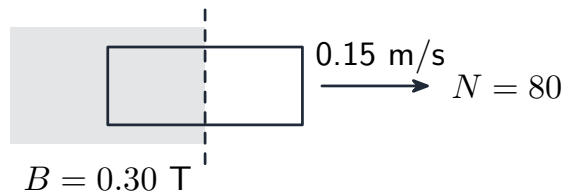
Exercise 3.2

3.2 A rectangular 80-turn coil is pulled at 0.15 m s^{-1} out of a uniform 0.30 T field normal to its plane. Its edge parallel to the straight field boundary is 0.040 m long. Find induced e.m.f. while the boundary crosses the coil and explain its direction using Lenz's law. State what happens once the coil is wholly outside. [5]



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3.2 Area leaves at rate Lv , so linkage changes at $NBLv$.

$$|\mathcal{E}| = NBLv = 80 \times 0.30 \text{ T} \times 0.040 \text{ m} \times 0.15 \text{ m s}^{-1} = 0.144 \text{ V}$$

Magnitude. Linked external flux decreases; induced current, if the circuit is closed, produces field in the original field direction to oppose that decrease. Outside, linkage no longer changes, so induced e.m.f. is zero.

Exercise 3.3

3.3 Explain wireless charging from the current in the supply coil to the induced e.m.f. in the receiving coil. Explain why d.c. after switching settles gives no sustained induction, and why equal turn counts do not guarantee equal voltages. During one interval the flux through each of 120 receiving turns falls from 5.0×10^{-5} to 1.0×10^{-5} Wb in 0.0080 s; calculate average induced e.m.f. magnitude. [7]



supply coil



receiver

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3.3 Alternating current produces changing magnetic field in the transmitting coil. Changing flux links the receiving coil and induces e.m.f. by Faraday's law. Steady d.c. gives constant linkage after the switching transient, so no sustained e.m.f.. Some flux misses the receiver because of separation/alignment or lack of a shared core; equal turns do not imply equal linkage rates. Use change in linkage per time, not flux alone.

$$|\mathcal{E}| = \frac{N|\phi_2 - \phi_1|}{\Delta t} = \frac{120 \times |1.0 - 5.0| \times 10^{-5} \text{ Wb}}{0.0080 \text{ s}} = 0.60 \text{ V}$$