INKPHYSICS FLASHCARDS

Magnetic fields

Year 13 · 19 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/flashcards.

DEFINITION

Define: Magnetic flux density.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

CHECK YOURSELF

A wire carries 3.0 A at right angles across a field of 0.20 T, with 5.0 cm of the wire in the field. Find the force, and the change in reading of a balance supporting the magnet, in grams.

Hint: $F = BIl$ in base units, then grams via g.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

SPOT THE ERROR

Say what is wrong with this claim:

Fields always push along their field lines.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

EQUATION — NOT ON THE DATA SHEET

Radius of a charge's circular path in a field:

r = ?

FORCE ON A MOVING CHARGE

CHECK YOURSELF

An electron moves at 2.0×10^{7} m s^{-1} at right angles to a field of 0.50 mT. Find the force on it and the radius of its circular path.

Hint: BQv for the force; then let it be the centripetal force.

FORCE ON A MOVING CHARGE

SPOT THE ERROR

Say what is wrong with this claim:

Magnetic fields can speed particles up.

FORCE ON A MOVING CHARGE

DEFINITION

Define: Magnetic flux.

MAGNETIC FLUX AND FLUX LINKAGE

DEFINITION

Define: Flux linkage.

MAGNETIC FLUX AND FLUX LINKAGE

CHECK YOURSELF

$F = BIl = 0.20 \times 3.0 \times 0.050 = 0.030$ N.

The magnet feels the equal and opposite partner force, so the reading changes by F/g = 0.030 / 9.81 = 3.1×10^{-3} kg, about 3.1 g.

Whether the reading rises or falls depends on the current's direction; reversing it flips the change, which is itself a check the effect is real.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

DEFINITION

The force per unit current per unit length on a wire carrying current at right angles to the field: $B = F/IL$, in tesla.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

EQUATION — NOT ON THE DATA SHEET

$r = (mv)/(BQ)$

FORCE ON A MOVING CHARGE

SPOT THE ERROR

The magnetic force is the odd one out: it acts at right angles both to the field lines and to the current, which is why Fleming needed three perpendicular fingers to describe it.

MAGNETIC FLUX DENSITY AND THE FORCE ON A WIRE

SPOT THE ERROR

The magnetic force is always perpendicular to the velocity, so it steers without ever doing work: the particle's path curves into a circle while its speed never changes. Accelerators use electric fields to speed particles up and magnetic fields only to guide them.

FORCE ON A MOVING CHARGE

CHECK YOURSELF

$F = BQv = 5.0 \times 10^{-4} \times 1.60 \times 10^{-19} \times 2.0 \times 10^{7} = 1.6 \times 10^{-15}$ N.

$r = mv/BQ = (9.11 \times 10^{-31} \times 2.0 \times 10^{7}) / (5.0 \times 10^{-4} \times 1.60 \times 10^{-19}) = 0.23$ m.

The speed stays 2.0×10^{7} m s^{-1} the whole way round: the field steered the electron without giving it a single joule.

FORCE ON A MOVING CHARGE

DEFINITION

The flux through a coil multiplied by its number of turns: NΦ.

MAGNETIC FLUX AND FLUX LINKAGE

DEFINITION

The product of flux density and the area it passes through at right angles: Φ = BA, in webers.

MAGNETIC FLUX AND FLUX LINKAGE

CHECK YOURSELF

A 500-turn coil of area 2.0×10^{-3} m² sits in a 0.15 T field with its normal at 60° to the field. Find the flux linkage, and state what it becomes face-on.

Hint: BANcosθ, with θ to the normal; then set θ to zero.

MAGNETIC FLUX AND FLUX LINKAGE

SPOT THE ERROR

Say what is wrong with this claim:

θ is the angle between the field and the coil.

MAGNETIC FLUX AND FLUX LINKAGE

DEFINITION

Define: Faraday's law.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

DEFINITION

Define: Lenz's law.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

CHECK YOURSELF

A 200-turn coil of area 1.5×10^{-3} m² rotates at 50 revolutions per second in a 0.20 T field. Find the peak emf, and state the emf at the instant the coil is face-on to the field.

Hint: Convert revolutions to radians first; then the peak is everything in front of the sine.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

SPOT THE ERROR

Say what is wrong with this claim:

The emf is biggest when the most flux passes through the coil.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

DEFINITION

Define: Root-mean-square value.

ALTERNATING CURRENTS

CHECK YOURSELF

An oscilloscope shows a sine wave of amplitude 3.0 divisions with one cycle spanning 4.0 divisions. The y-gain is 5.0 V per division and the timebase 2.0 ms per division. Find the peak voltage, the rms voltage, and the frequency.

Hint: Squares to volts and seconds first; the physics is two multiplications and a reciprocal.

ALTERNATING CURRENTS

SPOT THE ERROR

The angle in $\Phi = BA\cos\theta$ is measured between the field and the NORMAL to the coil's plane, not the plane itself. Field straight through the coil means $\theta = 0$ and maximum flux; get the angle from the wrong reference and every answer inverts.

MAGNETIC FLUX AND FLUX LINKAGE

CHECK YOURSELF

$N\Phi = BAN\cos\theta = 0.15 \times 2.0 \times 10^{-3} \times 500 \times \cos 60° = 0.075$ Wb turns.

Face-on, $\cos\theta = 1$, so the linkage doubles to 0.15 Wb turns.

Edge-on it would fall to zero: the two limits that catch any misread angle.

MAGNETIC FLUX AND FLUX LINKAGE

DEFINITION

The induced current flows in the direction that opposes the change of flux producing it.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

DEFINITION

The induced emf is equal to the rate of change of flux linkage.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

SPOT THE ERROR

Flux itself induces nothing: the emf is the rate of CHANGE of flux linkage. A generator coil gives its peak emf as it sweeps through the position of zero flux, where the flux is changing fastest — and zero emf at maximum flux.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

CHECK YOURSELF

$\omega = 2\pi \times 50 = 314$ rad s^{-1}.

Peak $\varepsilon = BAN\omega = 0.20 \times 1.5 \times 10^{-3} \times 200 \times 314 = 19$ V.

Face-on the linkage is maximal but momentarily unchanging, so the emf is zero: the quarter-turn offset in action.

ELECTROMAGNETIC INDUCTION: FARADAY AND LENZ

CHECK YOURSELF

Peak: $V_0 = 3.0 \times 5.0 = 15$ V.

$V_{rms} = V_0/\sqrt{2}$: 15 / 1.414 = 10.6 V.

Period $T = 4.0 \times 2.0$ ms = 8.0 ms, so $f = 1/T$ = 125 Hz.

ALTERNATING CURRENTS

DEFINITION

The value of the steady direct current that would dissipate the same average power in a resistor: $I_{rms} = I_0/\sqrt{2}$.

ALTERNATING CURRENTS

SPOT THE ERROR

Say what is wrong with this claim:

Mains is 230 volts at its peak.

ALTERNATING CURRENTS

CHECK YOURSELF

A station sends 10 MW down cables of total resistance 5.0 Ω. Find the power lost when transmitting at 25 kV, and at 400 kV, as a percentage of the power sent each time.

Hint: Current first from P = IV; then the loss is that current squared times R.

TRANSFORMERS

SPOT THE ERROR

Say what is wrong with this claim:

A transformer can step up power.

TRANSFORMERS

CHECK YOURSELF

At 25 kV: $I = P/V = 10^7/(2.5 \times 10^4) = 400$ A, so loss $= I^2R = 400^2 \times 5.0 = 8.0 \times 10^5$ W: 0.80 MW, 8.0% gone.

At 400 kV: $I = 25$ A, so loss $= 25^2 \times 5.0 = 3.1 \times 10^3$ W: 3.1 kW, 0.031%.

Sixteen times the voltage, 256 times less loss: the square at work, and the reason pylons carry hundreds of kilovolts.

TRANSFORMERS

SPOT THE ERROR

230 V is the rms value — the dc equivalent for power. The mains peak is $\sqrt{2}$ times higher, about 325 V, which is what insulation must actually withstand.

ALTERNATING CURRENTS

SPOT THE ERROR

A transformer trades voltage against current; it cannot create power. Step the voltage up and the current steps down in proportion — and a real transformer delivers slightly less power than it takes.

TRANSFORMERS