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Answers

Practice-for-exam questions

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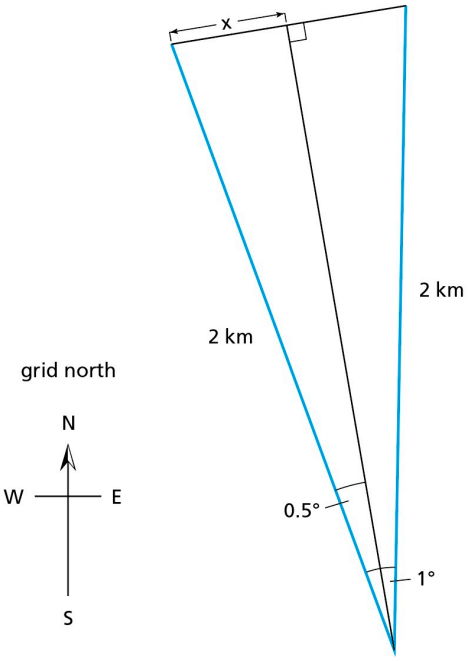
Where is the North Pole?

1 The walkers will walk at an angle 1° west of the grid line.

The diagram shows that after walking 2 km they will arrive at a point almost due west of their destination (very slightly south) and a distance 2*x* away.



$\sin 0.5° = x/2 \text{ km}$

$x = 2 \text{ km} \times \sin 0.5°$

$= 2 \text{ km} \times 0.00872 = 0.0175 \text{ km}$

They will arrive 0.035 km from their planned destination.

2 The author states the magnetic field strength of the Earth has a range of $25 – 65 \times 10^{-6}$ T.

The maximum force will be when the electron is moving at right angles to the strongest field.

$F = Bqv$

$F = 65 \times 10^{-6} \text{ T} \times 1.60 \times 10^{-31} \text{ C} \times 800 \times 10^{3} \text{ m s}^{-1}$

$= 8.3 \times 10^{-18} \text{ N}$

Will electric cars break the National Grid?

1 The main factors will be outside temperature, load and speed.

Outside temperature

Driver and passengers may want some heating on a cold day, or air conditioning on a warm day — both of these demands would require additional energy from the batteries, reducing the available energy for driving the motor. The system may also be less efficient at extreme temperatures (it has been observed that the range predicted by some hybrid cars is much lower on cold mornings).

Load

With more passengers or more luggage, the work done by the electric motor to move the vehicle will be greater, so energy will be transferred at a greater rate.

Speed

At higher speeds the resistive forces are greater, so the motor has to do more work.

Other factors that will drain the batteries include lights and sound systems. However these will be relatively small effects compared with the three mentioned above.

2 **a** The energy needed is $Q = m\,c\,\Delta\theta$

A kettle holds about 1 litre of water.

Mass of water, m = 1 kg

Suppose that water from tap at 10°C is heated to 100°C so

temperature rise $\Delta\,\theta$ = 90°C

Q = 1 kg × 4200 J kg^{-1}°C^{-1} × 90°C = 3.8 × 10^5 J

1 kWh = 1 x 10^3 J s^{-1} × 3600 s = 3.6 × 10^6 J

0.1 kWh = 3.6 × 10^5 J so the value calculated is close to the author's approximation

b Dinorwig can deliver 1.7 GW for 5 hours, so

energy stored = 1.7 × 10^6 kW × 5 h = 8.5 × 10^6 kWh

Boiling one kettle of water requires 0.1 kWh, so 8.5 × 10^7 kettles can be boiled.

Skillset: Magnetic force on a current-carrying wire

1 **a** On page 5 the maximum value for the Earth's magnetic field at the surface is given as 65 μT. In the *Skillset* the field due to the Magnadur magnets is measured as about 40 mT, which is about 700 times greater than Earth's field. The uncertainty of the experiment is shown to be 2.6%, so the effect of the Earth's magnetic field is negligible.

b The magnitude of the magnetic force on a current-carrying wire depends on the angle between the wire and the magnetic field and the wire. If the wire is parallel to the field, then the force is zero. You should use a magnetic compass to find the direction of the Earth's magnetic field and align the wire with that direction.

2 The electric current needed to produce a measurable effect is quite large and may cause heating in the wire. The circuit should only be switched on for a short time while a measurement is made.

How loud is that?

1 $S = 10 \log_{10} (I/I_0)$

$\log_{10} (I/I_0) = S/10 = 11$

$(I/I_0) = 10^{11}$

$I = 10^{11}\ I_0 = 10^{11} \times 10^{-12}$ W m^{-2} = 0.1 W m^{-2}

2 The frequencies and wavelengths of radiation in the spectrum cover many orders of magnitude, from gamma radiation (frequencies of the order 10^{14} Hz) to radio waves (frequencies of the order 10 Hz). It would be impossible to display all these values on a linear scale