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Activity

Practice-for-exam questions

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Use the questions below either in class or for individual work after students have read the articles in the magazine. Some of the questions require additional data — students should either make reasonable estimates of quantities or look up values using a data book or website. Suggested outline answers to questions are provided in a separate document.

Atomic force microscopy

1 Calculate the resonant frequency of an AFM in tapping mode using the equation from Box 1:

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where k is the spring constant of the cantilever and m is the effective mass of the tip and cantilever.

Assume $k = 2.5\ \text{N}\ m^{-1}$ and $m = 0.5$ ng

de Broglie waves

1 Calculate the de Broglie wavelength of an electron when accelerated through a potential difference of 200 V.

The Planck constant, $h = 6.626 \times 10^{-34}$ Js

The mass of an electron, $m = 9.1 \times 10^{-31}$ kg

The charge on an electron, $e = 1.6 \times 10^{-19}$ C

2 In an electron diffraction tube, electrons are fired at a piece of graphite.

The graphite consists of many crystals, all orientated in random directions. Graphite has two main layers of atoms, separated by distances of 0.123 nm and 0.213 nm. Like nickel, for the electrons, these act like the slits in an optical diffraction grating.

The diffraction pattern seen on a fluorescent screen is a series of rings.

You can watch a demonstration of the experiment at www.youtube.com/watch?v=sroqTLZNjok

a Explain why the diffraction pattern is a series of rings rather than a linear pattern.

b Explain why the experiment must be carried out in a vacuum tube.

c Assuming that the electrons are accelerated to a potential difference of 200 V, calculate the angles of the first two bright rings. The graphite is 12 cm from the fluorescent screen.

d Calculate the radii of the first two bright rings.

Phasors

1 When electricity is generated in a power station it is generated as three phase, which means that there are three coils, each generating a sinusoidal a.c. current, placed at 120° to each other. The coils can be connected as shown in Figure 1, known as a Y or star configuration.

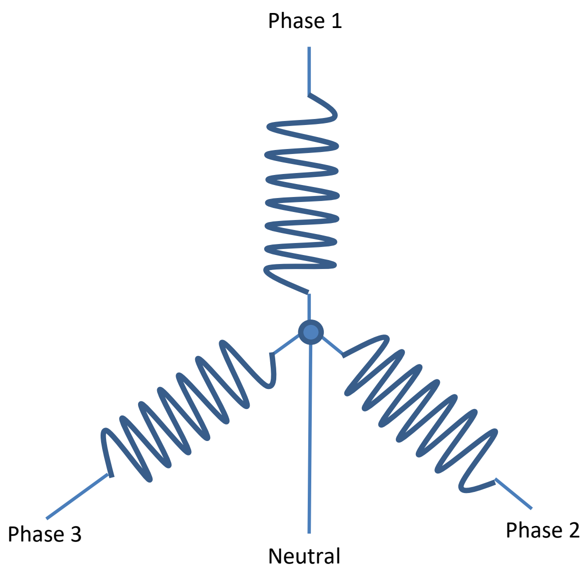

Figure 1

The electricity is transmitted along power lines using three wires and loads are connected between each phase and the neutral wire.

The neutral wire, can be very thin as the return current is always zero provided the loads are balanced.

Explain, using the idea of phasors, how the total return current is always zero.

Physics online: magnetism

and

At a glance: magnetic materials

1 A small wind turbine has a generator that has a flux maximum flux density of 1.7 T.

A coil of 3800 turns and cross-sectional area 10 cm^2 rotates in the generator 50 times per second so that the flux through the coil changes from zero to maximum 50 times per second.

a Calculate the maximum emf generated in the coil.

b Explain why the peak emf increases if the generator turns faster than 50 times per second.

c Explain why wind turbine generators use neodymium magnets in the generator (see Box 2 on p. 16).

Calculating information from graphs

1 Figure 7 in the article (p. 21) is a force extension graph for a rubber band. Estimate the area under the graph and therefore the work done, in J, in extending the rubber band.

2 A similar graph to the graph in Figure 7 is obtained when plotting a graph of stress

($\frac{\text{Force}}{\text{cross−sectional area}}$) against strain ($\frac{\text{extension}}{\text{original length}}$) when loading a piece of rubber or a wire and you

may well have carried out this standard investigation. When the load is removed, the line returns to zero (provided the elastic limit has not been exceeded) with a similar shape but below the loading curve, enclosing an area below the graph.

a Explain why the area below a stress–strain graph represents the work done per unit volume of the material.

b Explain what the area enclosed by the two curves represents.

Neutron stars

and

Exam talkback: escape velocity

1 **a** Calculate the escape velocity of a rocket from the Earth.

$G = 6.672 \times 10^{-11}$ N m^2 kg^{-2}

Mass of Earth, $M = 5.974 \times 10^{24}$ kg

Mean radius of the Earth, $r = 6.378 \times 10^6$ m

b Explain why, in practice, for a rocket from the surface of the Earth, the escape velocity would need to be much greater than the value calculated.

2 Suppose that the Earth is somehow compressed to the density of a neutron star.

Using data from the previous question and data and equations from pages 22–25:

a Show that the radius of the compressed Earth is about 180 m.

The angular momentum (L) of a sphere of uniform density, mass (M), radius (r) and rotational time period (T) is given by:

$L = 0.4 \times M\omega r^2$ and $\omega = \frac{2\pi}{T}$

Assume that the density of the Earth is uniform.

b Calculate the angular momentum of the Earth before it is compressed.

c Calculate the time it would take for the compressed Earth to rotate.