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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.

The power behind the bike

1 **a** Use Figure 3 to estimate the power required to keep a bicycle travelling at 30 km h^{-1} along a level track.

b Show that power (W) = force (N) × velocity (ms^{-1}).

c Calculate the velocity in ms^{-1} that corresponds to 30 km h^{-1}.

d Show that the total resistive force on the bicycle at 30 km h^{-1} is about 22 N.

e Use the figures given in the article to calculate Chris Froome's FTP.

f Assuming that the total resistive forces on the bicycle remain the same and the mass of Chris Froome's bicycle is about 5 kg, calculate the maximum angle of hill that he can climb continuously while maintaining a velocity uphill of 30 km h^{-1}.

Perpetual motion

1 You may have seen a Crookes radiometer working and perhaps it has been suggested to you that this is also a 'perpetual motion' machine.

If you are not familiar with a Crookes radiometer, watch the short YouTube video www.tinyurl.com/crookesradio that shows this 'perpetual motion' machine that spins in the light.

One side of each of the vanes is black and one side is shiny or sometimes white. Inside the glass container is a near but not complete vacuum.

Two possible explanations for the spinning are offered in the video.

Either by further research or from first principles, using the hints given in the video and some ideas about gases given in the article, explain why the Crookes radiometer spins and where the energy comes from to make it spin.

At a glance: on the surface

1 Paint is designed so it has a low surface tension. Explain why.

2 a A thin, flat, square metal plate of side 1 cm is carefully placed on the surface of a glass of water. Surface tension acting at the edges of the square are enough to ensure it does not sink (rather like the pond skater in Box 6). How much additional force due to surface tension would be needed to lift the metal square away from the surface of the water?

Use the value for the surface tension of the water given in Box 5. Assume the force acts vertically downwards as the plate is lifted.

b Would the answer be different if the square were replaced by a wire bent into a square shape of the same size?

Domestic heat pumps

1 a Using data given in the article, estimate the annual contribution of CO_2 into the atmosphere from the current number of domestic gas boilers in the UK.

b Outline the key factors, mentioned in the article, to be considered when changing a gas boiler for an air-source heat pump.

c Explain why a ground-source heat pump needs the buried piping to be well spread out.

Skillset: measuring the speed of sound

1 a The oscilloscope screen shown in Figure 2 shows the waveform of a sound at a frequency not listed in the results table. Use the time scale, which is in μs, to calculate the frequency of the sound wave shown.

b Calculate the most likely and the range of wavelengths of the sound wave shown, using the results given for the speed of sound in the experiment.

Physics online: royal crystals

1 The cross on the top of the Sovereign's Sceptre has a diamond on one side and an emerald on the other. The refractive index of emerald is 1.57. Calculate the critical angle for emerald.

2 Amethyst has a purple colour, caused by iron (Fe^{4+}), which absorbs 'all the wavelengths except those that give the violet colour'. Explain which wavelengths of visible light would need to be absorbed to give a violet colour.

3 There is a story that Archimedes, a Greek mathematician and scientist, was asked by King Hiero to check if a wreath that had been made for him was pure gold or if the goldsmith had cheated and replaced some of the gold with an equal mass of silver.

After some thought, Archimedes measured the amount of water displaced by the wreath and compared it with the amount of water displaced by the same mass of pure gold. He discovered that the goldsmith had cheated the king. A more modern method would be to use the densities of the two metals:

- density of gold: 19 300 kg m^{-3}
- density of silver: 10 490 kg m^{-3}
- density of the wreath: 17 560 kg m^{-3}

Calculate the fraction of the wreath that was gold.