TAP 202- 4: Forces acting on a power line

Study (from a safe distance!) an overhead power cable and estimate the force acting on the pylon.

With careful use of a pair of rulers at right angles, and a transparent protractor to find roughly the angle the cable makes with the horizontal where it joins the pylon, make a scale drawing of the cable as accurately as you can.

Consider the equilibrium of *one half of it only*, from the centre to the pylon. Mark on your diagram the three forces holding it in equilibrium (in deciding where the weight acts, you may ignore the curvature of the cable).

Now extend the lines of action of the three forces to demonstrate how they must meet at one point. In finding the direction of the tension at the pylon, can you see how you didn't in fact need to measure the angle?

Draw a triangle of forces for the equilibrium of the half of the cable. You will need a lot of 'sideways space' on the paper – sketch it roughly first to see why.

If the cable has a mass per unit length of 1.7 kg m^{-1}, estimate the force that the cable is exerting on the pylon. (Take $g = 9.8$ N kg^{-1}.)

Practical advice

The aim of this activity is to give students additional experience with force vector triangles and to encourage them to exercise a bit of ingenuity in obtaining and analysing their
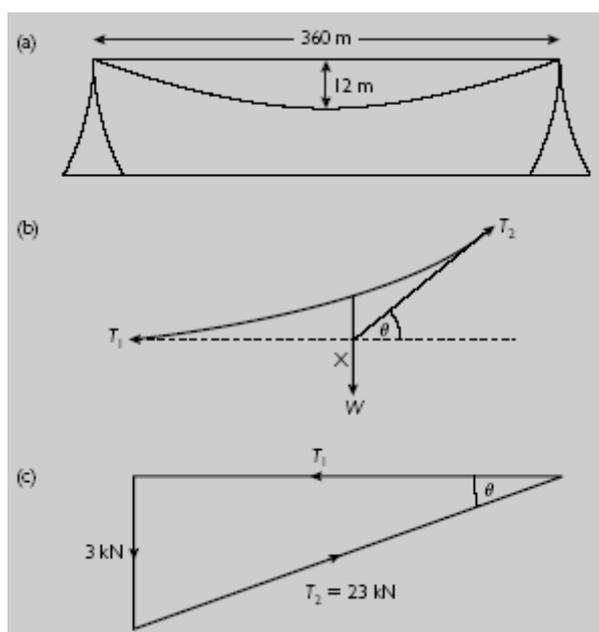
measurements. You could use a photograph instead of having students go out looking at power cables.

Typical values are shown in diagram (a).

(The exact values for 400 kV cables are 265.8 m span and 12.27 m sag.)

Answers and worked solutions

The three forces in equilibrium are shown in diagram (b), meeting at point X. The angle θ is exaggerated – it is really between 7° and 8°.

The total weight of the half-cable is 1.7 kg m^{-1}× 180 m × 9.8 N kg^{-1} = 2998.8 N = 3 kN. The triangle of forces is shown in diagram (c).

The force T_2 (approximately 23 kN) in the direction shown is the force of the pylon on the cable: the force of the cable on the pylon is in the opposite direction.

Brief technical details of the cable might be of interest. The cable described is one of a group of four which are linked by a sequence of cross-braces which together make up one conductor. There are six such conductors making a total of 24 cables, together with a lighter earth cable joining the tops of the pylons.

Each cable consists of 54 aluminium and 7 steel stands, each of diameter 3.17 mm.

External references

This activity is taken from Salters Horners Advanced Physics, AS, Section Higher, Faster, Stronger, HFS Activity 15