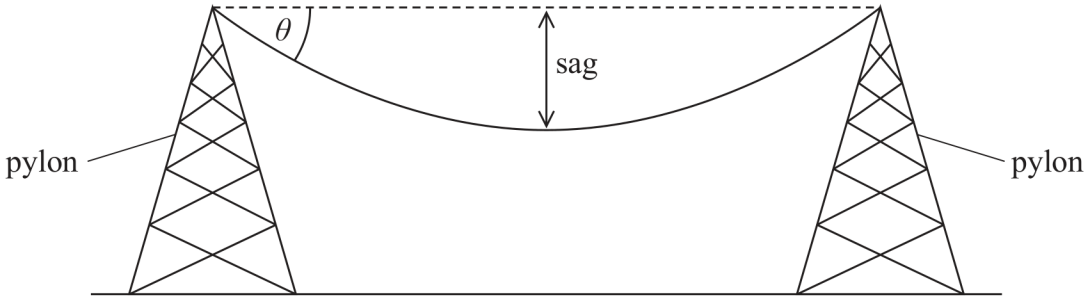
19 The transmission of electricity over long distances requires a conducting cable that is suitable to hang from supporting towers called pylons.

The vertical distance from the line of support to the lowest point on the wire is called the sag. Due to the high voltages involved, the cable must maintain a minimum distance from the ground.



(a) The temperature and the tension in the cable affect the sag.

(i) Suggest one further factor that may increase the sag of a cable.

(1)

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(ii) A cable of mass M is at an angle θ to the horizontal.

Explain why the tension in the cable decreases as the sag increases.

(3)

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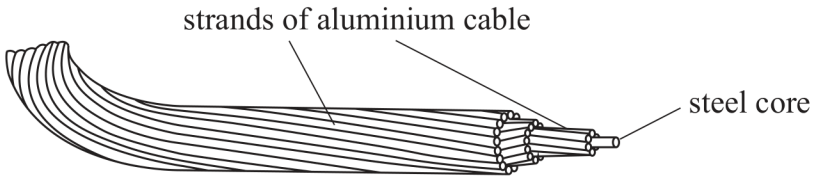
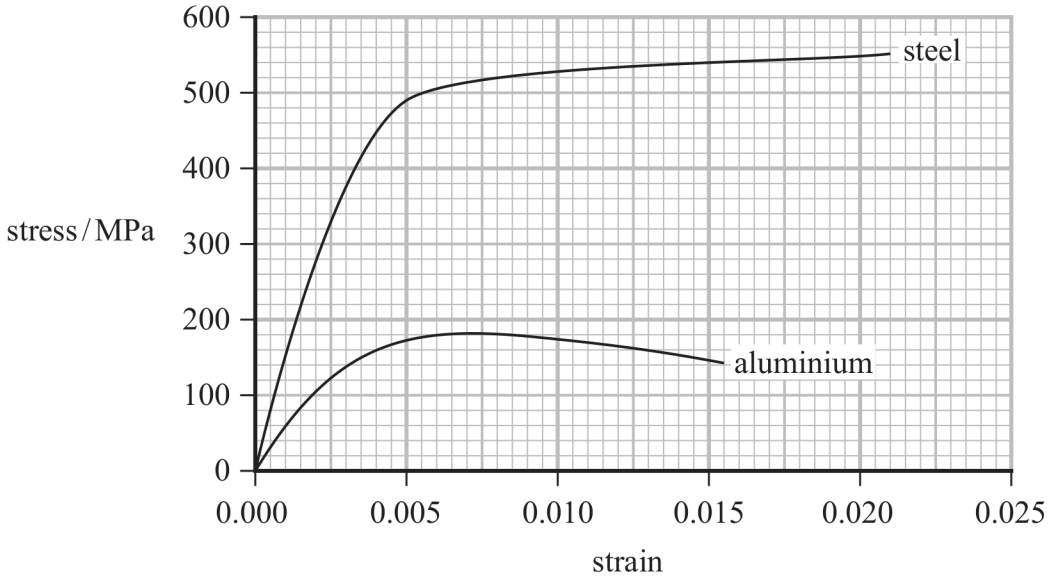
(b) A type of conducting cable used in overhead power lines is ACSR. This cable has a steel core surrounded by strands of aluminium cable of the same diameter.



Stress-strain graphs for samples of steel and aluminium typically used in each strand of the cable are shown.



(i) Show that the Young modulus of steel is about 2×10^{11} Pa.

(2)

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(ii) The pylons are positioned every 270 m.

Show that the stress in a strand of steel is about 70 MPa.

(2)

cross-sectional area of one strand = $2.3 \times 10^{-6}\,m^2$
tension per m for steel = $0.62\,N\,m^{-1}$

(iii) ACSR cables consist of a steel core surrounded by strands of aluminium cable.

The extension produced, due to the tension, for each strand of aluminium is 0.95 m.

Comment on why ACSR cables consist of both a steel core and strands of aluminium cable. You should include a calculation as part of your answer.

(3)

(Total for Question 19 = 11 marks)

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