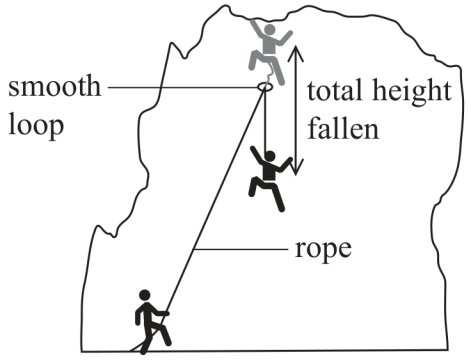
17 The diagram shows a climber on a rock face. A rope is kept firmly anchored by a person on the ground and passes through a smooth loop to the climber. The climber slips and falls a short distance as shown.

Diagram not to scale



(a) The 'fall factor' is used by climbers to estimate the severity of a climbing fall and is given by

$$\text{'fall factor'} = \frac{\text{height fallen before the rope begins to stretch}}{\text{total unstretched length of rope}}$$

A climber slips and falls with a 'fall factor' of 0.80 before coming to rest.
The energy from the fall is absorbed by the climbing rope.
The maximum strain in the rope is 9.0%.

(i) Show that the maximum force acting on the climber due to the rope is about 10 kN.
Assume the extension of the rope is proportional to its tension.

total unstretched length of rope = 15.0 m
mass of climber = 71 kg

(5)

(ii) A new climber suggests using a longer length of rope between the loop and the climber, as this would absorb more energy after a fall.

Comment on this suggestion.

(2)

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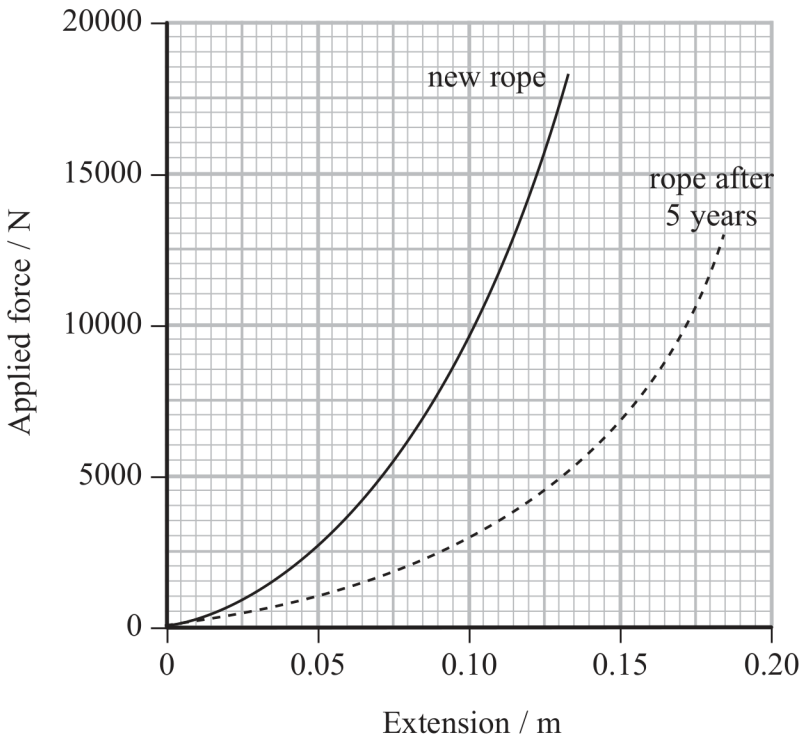
(b) Climbing rope manufacturers recommend that ropes are replaced every 5 years.
The force-extension graphs, up to the breaking point, for a one metre length of a rope when new and after 5 years are shown.



Comment on the manufacturers' recommendation. Your answer should include calculations.

(6)

(Total for Question 17 = 13 marks)

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