

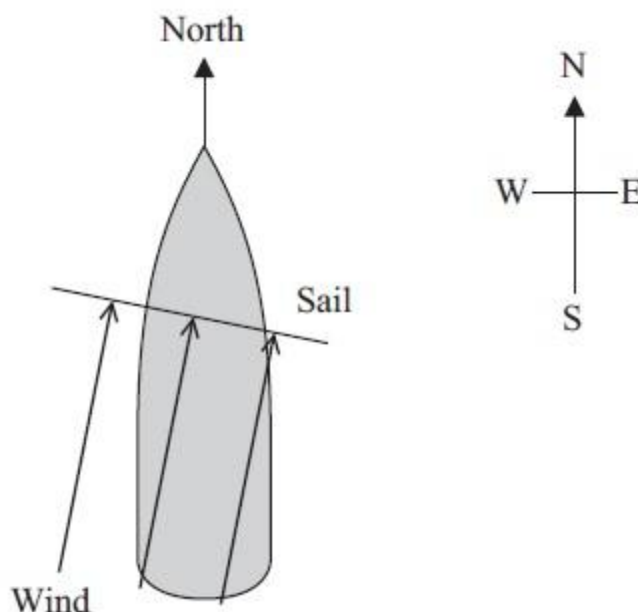
Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

Q1.

A stationary boat is pointing north as shown in the diagram. A wind starts blowing at 10 m s^{-1} in a direction 20° east of north against the sail. The boat starts to move northwards.



(a) (i) The wind exerts a force per unit area of 84 N m^{-2} on the sail, which is at right angles to the wind direction. Show that the component of force in a northerly direction is about 1400 N.

area of sail = 18 m^2

(3)

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(ii) When the wind starts to blow the water exerts a force on the boat to the west.

Explain why.

(2)

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(iii) Draw a vector diagram showing the forces exerted on the boat by the wind and the water and the resultant force calculated in part (a)(i).

(2)

(iv) Assuming the boat is starting from rest in still water, calculate the initial acceleration of the boat.

mass of boat = 400 kg

(2)

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Initial acceleration = ...

(b) Later the wind, still at a speed of 10 m s^{-1} , is blowing towards the north and the boat is travelling northwards at a steady speed of 5 m s^{-1} . The force on the sail is now 380 N towards the north.

(i) Suggest why the force on the sail is less than in part (a).

(1)

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(ii) Calculate the rate at which the wind does work against the forces that resist the boat's motion.

(2)

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Rate at which the wind does work = ...

(iii) There is now a force exerted southwards on the boat. A suggested reason for this force is because of turbulence developing at the rear of the boat. Add flow lines to the diagram to show the path of water around the boat and label the regions of laminar and turbulent flow.

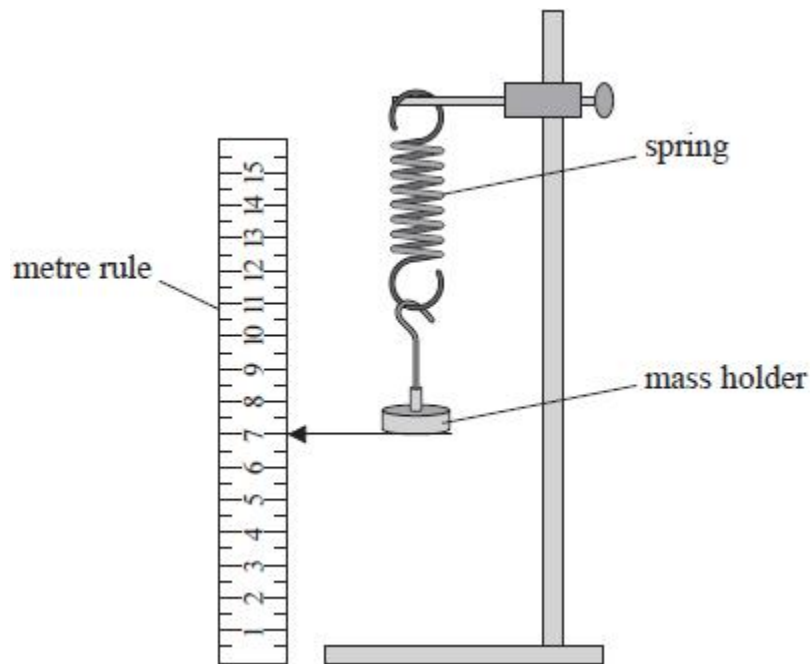
(2)



(Total for question = 14 marks)

Q2.

A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached.

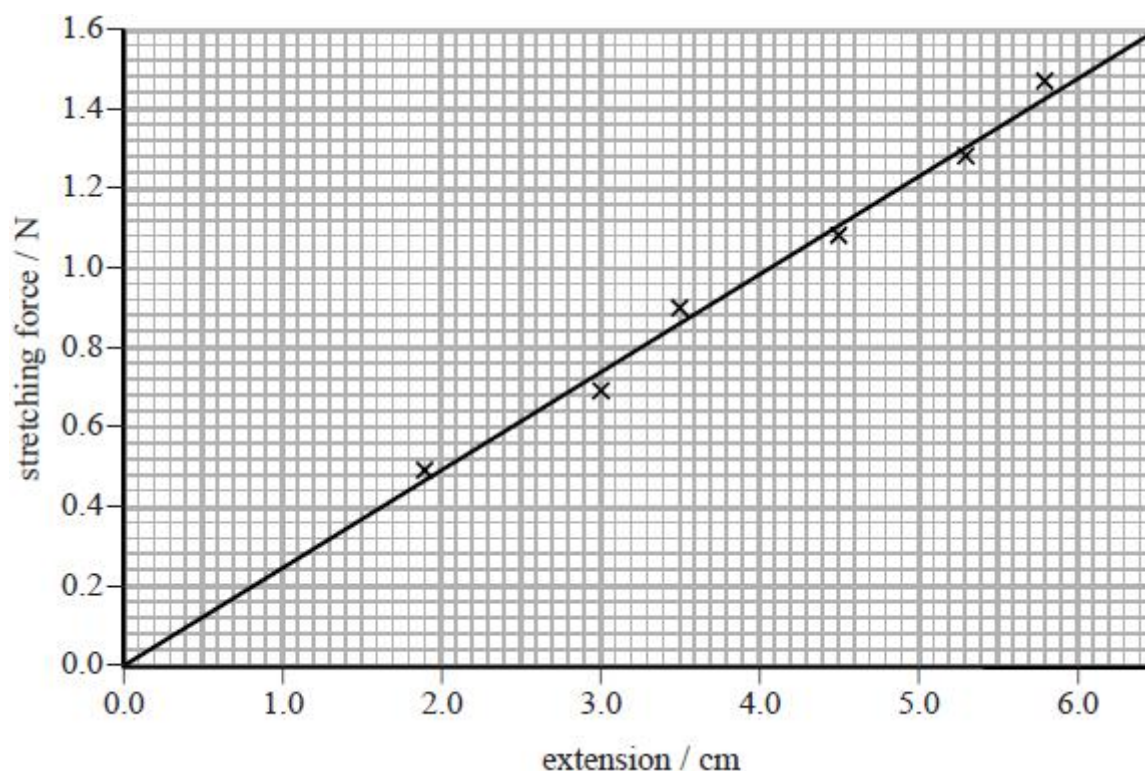


The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were recorded. The extension of the spring each time was calculated.

The student produced the following table.

Mass added / g	Extension / cm	Stretching force / N
50	1.9	0.49
70	3	0.69
90	3.5	0.9
110	4.5	1.08
130	5.3	1.28
150	5.8	1.47

The student used her data to plot a graph as shown.



Determine a value for the force constant k of the spring.

(2)

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$k =$

(Total for question = 2 marks)

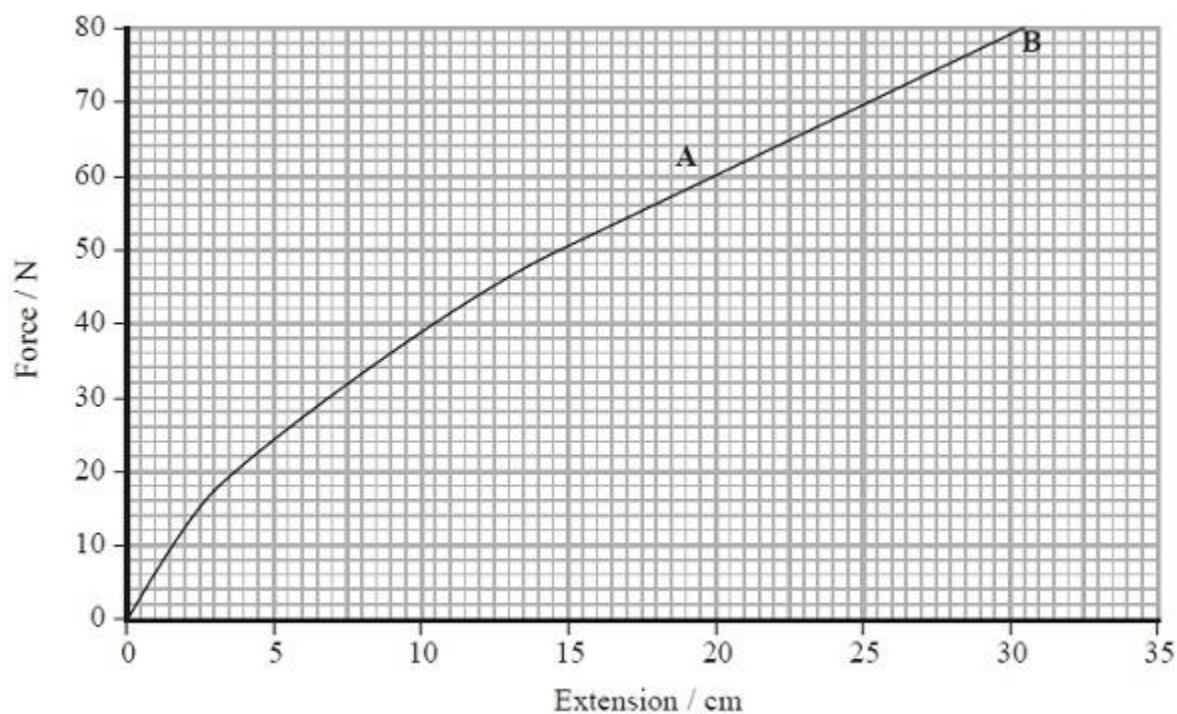
Q3.

The photographs show an exercise device and someone using it. The device contains two rubber cords which are extended when the device is used.



A student investigates the properties of the device by hanging weights on it and measuring the extension.

The student obtains the following graph for her results.



(a) The student notices that her graph is a straight line between A and B and concludes that the device obeys Hooke's law.

Comment on this conclusion.

(2)

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(b) (i) Describe how the student could use the graph to obtain an estimate of the total work done.

(2)

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(ii) The student sets up a spreadsheet to investigate the work done in stretching the device each time a weight is added.

	A	B	C	D
1	Total stretching force / N	Extension / cm	Change in extension / m	Work done (force × change in extension) / J
2	0	0.0	0.000	0.00
3	10	1.6	0.016	0.16
4	20	3.5	0.019	0.38
5	30	7.0	0.035	1.05
6	40	10.5	0.035	1.40
7	50	14.5	0.040	2.00
8	60	20.0	0.055	3.30
9	70	25.2	0.052	3.64
10	80	30.5	0.053	4.24
11			Total work done	16.17

Explain why this spreadsheet results in an over-estimate for the total work done.

(2)

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(c) The student eats a packet of crisps and then uses the exercise device. The energy content in a packet of crisps is 540 kJ. During exercise this energy is converted and 25% of it is transferred to mechanical work.

The student extends the device fully 15 times in 1 minute. An accurate value for the work done in fully extending the device is 14.7 J.

Calculate the time it would take the student, working at this rate, to transfer 25% of the energy from the crisps to

mechanical work.

(3)

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Time = ...

(d) Explain whether more or less work would be done applying the same maximum total stretching force to a similar exercise device with rubber cords of twice the cross-sectional area.

(2)

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(Total for Question = 11 marks)