3.14 Forces, Newton's Laws and Momentum: 30-minute Pack

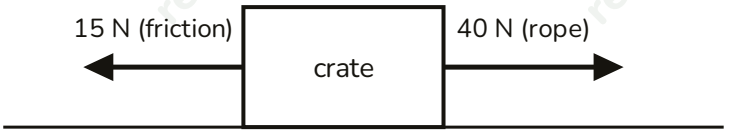
Total Marks

AQA 8464 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Figure 1 shows a crate on a rough floor. A rope pulls the crate to the right with a force of 40 N. Friction acts on the crate, opposing its motion, with a force of 15 N to the left.



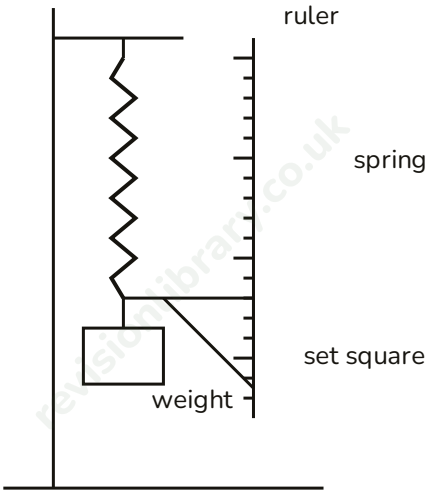
(a) Calculate the resultant (net) force acting on the crate, including its direction. **(2)**

(b) The crate starts at rest. Describe and explain what happens to the crate's motion once the rope starts pulling with this resultant force acting on it. **(2)**

(Total for Question 1 is 4 marks)

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2 Oliver, a student, carries out the required practical to investigate the extension of a spring. He clamps a spring vertically, measures its natural (unstretched) length of 12.0 cm, then hangs different weights from the bottom, measuring the new total length with a ruler and a set square each time. Figure 4 shows the equipment. His results are given in the table: Force (N): 0, 1.0, 2.0, 3.0, 4.0, 5.0; Length (cm): 12.0, 14.0, 16.0, 18.0, 20.0, 23.5.



(a) State the independent variable and the dependent variable in this investigation. **(2)**

(b) State one variable that should be controlled during this investigation, and explain why. **(2)**

(c) State why a set square is used against the ruler when measuring the length of the spring, rather than reading the ruler directly. **(1)**

(d) Calculate the extension of the spring for each force, using the natural (unstretched) length of 12.0 cm, and complete the extension column of the table. **(2)**

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(e) Using the extension values for forces from 0 to 4.0 N, show that the spring obeys Hooke's law over this range. **(2)**

(f) Describe what happens at 5.0 N, and name the point on a force-extension graph beyond which Hooke's law no longer applies. **(2)**

(g) Convert the extension at 4.0 N into metres, then use Hooke's law, $F = k\ x$, to calculate the spring constant, k, while the spring is obeying Hooke's law. **(3)**

(h) Suggest one improvement to the method that would give a more accurate value for the spring constant, and explain why it would improve the result. **(2)**

(Total for Question 2 is 16 marks)

3 A spring is stretched within its limit of proportionality. A different spring is stretched beyond its limit of proportionality.

(a) State what is meant by 'elastic deformation'. **(1)**

(b) State whether the spring stretched beyond its limit of proportionality will return to its original length when the force is removed, and explain your answer. **(2)**

(Total for Question 3 is 3 marks)

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Mark scheme · 3.14 Forces, Newton's Laws and Momentum: 30-minute Pack

Question 1

(a) 40 - 15 (subtracts the smaller force from the larger) oe **M1**

(a) 25 N to the right cao (direction required) **A1**

(a) Answer: 25 N to the right

(b) the crate accelerates (starts moving and speeds up) in the direction of the resultant force, i.e. to the right, oe **B1**

(b) because there is a non-zero (unbalanced) resultant force acting on it, oe **B1**

(b) Answer: The crate accelerates to the right, because a non-zero resultant force is acting on it.

Question 2

(a) independent variable: the force (weight) applied to the spring **B1**

(a) dependent variable: the extension (or length) of the spring **B1**

(a) Answer: Independent: force applied. Dependent: extension of the spring.

(b) the spring used (the same spring must be used throughout, not swapped partway through) **B1**

(b) reason: different springs have different spring constants (stiffness), so changing spring would make the extension values not comparable, oe **B1**

(b) Answer: The spring used, because different springs have different spring constants, which would make results incomparable.

(c) to line up the ruler at a right angle to the spring, so the exact position of the bottom of the spring can be read accurately, avoiding a parallax error, oe **B1**

(c) Answer: To line up the reading at 90 degrees to the spring and avoid a parallax error.

(d) correct method (length - 12.0) applied correctly to at least one row **M1**

(d) all six extensions correct: 0, 2.0, 4.0, 6.0, 8.0, 11.5 cm **A1**

(d) Answer: 0, 2.0, 4.0, 6.0, 8.0, 11.5 cm

(e) calculates extension / force for at least two forces in this range and shows it is constant (2.0 cm per N each time) **M1**

(e) conclusion: extension is directly proportional to force over this range, so Hooke's law is obeyed, oe **A1**

(e) Answer: Extension / force = 2.0 cm/N for 1.0, 2.0, 3.0 and 4.0 N, so extension is directly proportional to force: Hooke's law is obeyed.

(f) the extension increases disproportionately: 11.5 cm is more than the 10.0 cm expected if proportionality had continued, oe **B1**

(f) this point is called the limit of proportionality **B1**

(f) Answer: The extension (11.5 cm) is more than the expected 10.0 cm; this point is called the limit of proportionality.

(g) converts: 8.0 cm = 0.080 m **M1**

(g) rearranges and substitutes: k = 4.0 / 0.080 **M1**

(g) 50 N/m cao **A1**

(g) Answer: 50 N/m

(h) e.g. repeat each length measurement and calculate a mean, or use smaller force increments close to the expected limit of proportionality, or use a fixed marker/fiducial and view the ruler at eye level **B1**

(h) linked reason: reduces random error or pinpoints the limit of proportionality more precisely, giving a more reliable value of k, oe **B1**

(h) Answer: E.g. repeat each length measurement and take a mean, reducing random error and giving a more reliable spring constant.

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Question 3

(a) the object returns to its original shape and length when the deforming force is removed, oe **B1**

(a) Answer: The object returns to its original shape and length when the force is removed.

(b) cannot determine from the information given whether it returns to its original length **B1**

(b) exceeding the limit of proportionality only means force and extension are no longer directly proportional; permanent deformation requires the elastic limit to be exceeded, oe **B1**

(b) Answer: Cannot determine: exceeding the limit of proportionality does not establish permanent deformation. It returns to its original length if the elastic limit has not been exceeded.

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