Springs Old Exam Questions

Q1. A spring has a stiffness of 125 N m⁻¹. Calculate the extension of the spring when a weight of 8.0 N is suspended on it. Give your answer in metres.

extension of spring ......................... m
(Total 2 marks)

Q2. A load of 3.0 N is attached to a spring of negligible mass and spring constant 15 N m⁻¹.

What is the energy stored in the spring?

A 0.3 J  B 0.6 J  C 0.9 J  D 1.2 J
(Total 1 mark)

Q3. A load of 4.0 N is suspended from a parallel two-spring system as shown in the diagram.

The spring constant of each spring is 20 N m⁻¹. The elastic energy, in J, stored in the system is

A 0.1  B 0.2  C 0.4  D 0.8
(Total 1 mark)
Q4. The diagram below shows a lorry of mass $1.2 \times 10^3$ kg parked on a platform used to weigh vehicles. The lorry compresses the spring that supports the platform by 0.030 m.

![Diagram of a lorry on a platform, with a spring compressed]

Calculate the energy stored in the spring.

Gravitational field strength $g = 9.8 \text{ N kg}^{-1}$

Energy stored = ...........................................

(Total 3 marks)

Q5. The diagram shows a metal rod suspended in a magnetic field by two vertical conducting springs. The cell and rod have negligible resistance. When the switch $S$ is closed the effect of the magnetic field is to displace the rod vertically a distance $y$.

![Diagram of a metal rod suspended by springs, with a magnetic field]

When both the spring constant and electrical resistance of each spring is doubled, closing the switch would now cause the rod to be displaced a distance $A$

A $\frac{y}{2}$

B $\frac{y}{4}$

C $y$

D $4y$

(Total 1 mark)
Q6. The diagram below shows a laboratory experiment to test the loading of a uniform horizontal beam of weight $W$. The length of the beam is 1.50 m. The load, $M$, has a weight of 100 N and its centre of mass is 0.40 m from the pivot. The beam is held in a horizontal position by the tension, $T$, in the stretched spring.

(a) Add clearly labelled arrows to the diagram above so that it shows all of the forces acting on the beam.

(b) The tension, $T = 36$ N. Calculate the moment of $T$ about the pivot.

Moment .........................

(c) Calculate the weight, $W$, of the beam.

Weight $W$ .......................  

(Total 7 marks)

Q7. A type of exercise device is used to provide resistive forces when a person applies compressive forces to its handles. The stiff spring inside the device compresses as shown in the figure below.
(a) The force exerted by the spring over a range of compressions was measured. The results are plotted on the grid below.

(i) State Hooke's law.

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(ii) State which two features of the graph confirm that the spring obeys Hooke's law over the range of values tested.

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(iii) Use the graph to calculate the spring constant, stating an appropriate unit.

answer = .....................................

(3)

(b) (i) The formula for the energy stored by the spring is

\[ E = \frac{1}{2} k \Delta \ell \]
Explain how this formula can be derived from a graph of force against extension.

(ii) The person causes a compression of 0.28 m in a time of 1.5 s. Use the graph in part (a) to calculate the average power developed.

\[
\text{answer} = \text{..................................W}
\]

Q8. Heavy duty coil springs are used in vehicle suspensions. The pick-up truck shown in the diagram below has a weight of 14 000 N and length of 4.5 m. When carrying no load, the centre of mass is 2.0 m from the rear end. The part of the vehicle shown shaded in grey is supported by four identical springs, one near each wheel.
(a)  

(i)  Define the moment of a force about a point.

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.................................................................................................................

(2)

(ii)  State and explain which pair of springs, front or rear, will be compressed the most.

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(2)

(iii)  By taking moments about axle B, calculate the force exerted on the truck by each rear spring.

answer = ...................................... N

(4)

(b)  
The spring constant for each of these springs is 100 000 N m\(^{-1}\).

Calculate the distance that each of these rear springs is compressed by this vehicle as shown in the diagram above.

answer = ..................................... m

(2)
(c) The springs must not be compressed by more than an additional 0.065 m. Calculate the maximum load that could be placed at point $X$, which is directly above the centre of the rear axle $A$, as shown in the diagram above.

answer = ...................................... N

(2)
(Total 12 marks)
ANSWERS

M1. correct substitution into \( F = k \Delta L \) (condone power 10 error)

\[ 0.064 \text{ (m)} \] [2]


M4. use of \( mg \) with \( g = 9.8 \) [use of \( g \) 10 – 1]

\[ \text{energy} = \frac{1}{2} Fl = \frac{1}{2} (1200 \times 9.8) \times 0.03 \]

\[ = 180 \text{ J [176]} \text{ [omission of } g \text{ will score only 1]} \] [3]

M5. B [1]

M6. (a) two correct weight arrows with labels (100N, W)

arrows must act on beam (horiz. scope: M, 50 m respectively)

normal reaction arrow at pivot point (with label) [BI]

(b) Use of 36 \( \times \) a distance

\[ \text{moment} = 43.2 \text{ Nm} \quad (36 \times 1.3 = 46.8) \] [C1]

\[ = 180 \text{ J [176]} \text{ [omission of } g \text{ will score only 1]} \] [3]

M7. (a) (i) \( F \propto \Delta L \) up to limit of proportionality (1)

accept ‘elastic limit’

\[ F = k \Delta L \text{ with terms defined gets first mark} \] 2

(ii) straight line (1) through origin (1) 2

(iii) working shown and \( F \geq 200 \text{ N (1)} \) \((500/0.385) = 1290 \pm 20 \) (1)

\[ \text{N m}^{-1} \text{ or N/m kg s}^{-2} \text{ (1)} \] 3
(b) (i) \(\Delta W = F\Delta s\) so area (beneath line from origin to \(\Delta L\)) represents (work done or) energy (to compress/extend) (1)

work done (on or by the spring) linked to energy stored (1)

\[
\frac{1}{2} b \times h \quad \text{(area of triangle)} = \frac{1}{2} (\therefore E = \frac{1}{2} F\Delta L) (1)
\]

(ii) \(F = 360 \text{ (N)}\) used (1)

\[
P = \frac{\frac{1}{2} \times (360) \times 0.26}{1.5} = \frac{50.4}{1.5} (1) = 34 (33.6) \text{ (W)} (1)
\]

ecf from wrong force

M8. (a) (i) force \(\times\) perpendicular distance (1)

between line of action of force and the point (1)

(ii) rear (1)

at rear + idea that centre of mass is closer to the rear wheel (than to the front wheel) (1)

(iii) \(14000 \times 1.4 = F \times 2.5 (1)\)

\(F = 7840 \text{ (N)} (1)\)

divides their final answer by 2 (1)

\(= 3900 \text{ (N)} (1) (3922)\)

\[
F \quad \text{(a)(ii)}
\]

(b) \((F = k\Delta l)\) \(k\) or \((\Delta l =) 100000 \quad (1)\)

\(= 0.039 \text{ (m)} (1)\) ecf

(c) \(F = (100000 \times 0.065 =) 6500 \text{ (N)} (1)\)

\(F = (2 \times 6500) = 13000 \text{ (N)} (1)\)