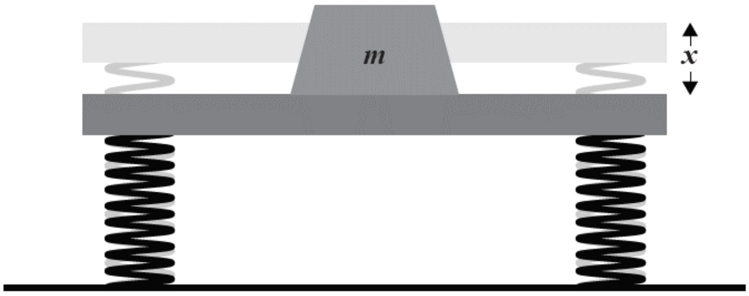
MECHANICS: HOOKES LAW QUESTIONS

THE BRIDGE (2020;3)

Jo and Alex need to cross a bridge to reach their destination.

(c) The bridge has an earthquake-protection system made up of springs. Before being put in place on the bridge, the springs are tested by being loaded with a mass m. When loaded with a mass m the springs compress by a distance x. Explain, in depth, how the size of the mass on the springs needs to change in order to compress the springs a distance 2x from the original length.



(d) Jo and Alex wonder whether a compressed spring from the bridge could accelerate their car once the spring is released, as in the diagram below. They decide to determine the effect of the spring on the car's motion. They estimate that for this spring, a force of 50 000 N would compress the spring length from 6.0 m to 4.2 m. The total mass of the car and occupants is 1600 kg.

(i) Calculate the maximum speed to which this spring could accelerate the car and its occupants if it was compressed to 4.2 m. You should start your answer by first determining the spring constant, k.

(ii) What assumption(s) have you made in this calculation?

THE HOCKEY MATCH (2019;1)

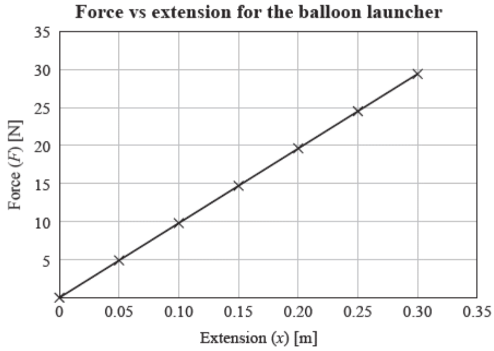
Nicole is playing for her school hockey team.

(c) Josie shoots a goal. The ball hits the back of the net with a horizontal speed of 22 m s^{-1}. The impact makes the net stretch by 15 cm. The ball has a mass of 160 g. By considering the transfer of energy from ball to net, calculate the spring constant of the net.

THE WATER BALLOON LAUNCHER (2018;1)

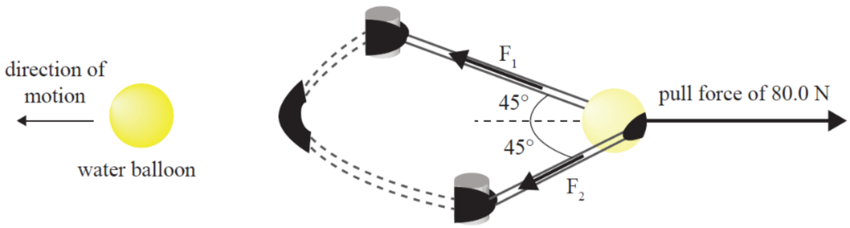
A water balloon launcher is made from stretchy rubber that approximates a spring, as shown in the photos below. To determine the spring constant, Oliver, a Year 12 pupil, measured the distance that one side of the rubber extended, when various masses were attached to it. Oliver's results are in displayed in the table and graph below.

Force (F) [N]	Extension from equilibrium position (x) [m]
4.9	0.05
9.8	0.10
14.7	0.15
19.6	0.20
24.5	0.25
29.4	0.30

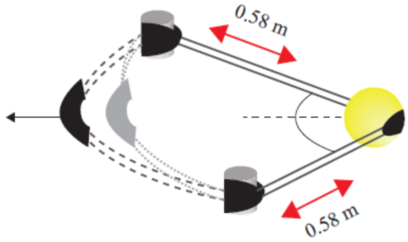


(a) Using the data and / or graph above, show that the spring constant (k) of one side of the stretchy rubber is 98 N m^{-1}.

Oliver then connected both sides of the water balloon launcher as shown. The launcher was held stationary with an 80.0 N pull force. The free body force diagram of the launcher is shown below.

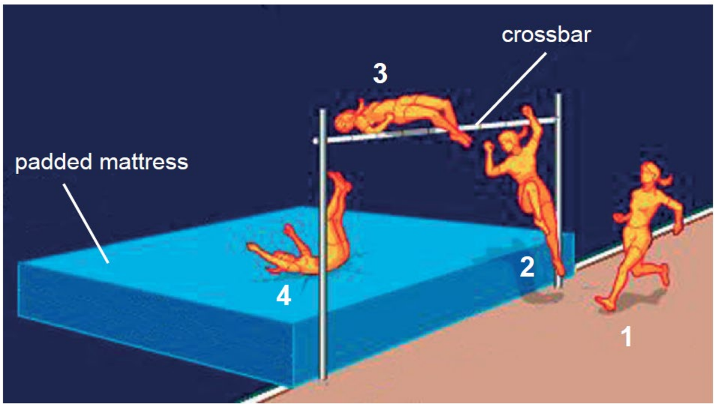


(c) The water balloon launcher is pulled back, so each stretchy rubber pair is extended by a distance of 0.58 m. Calculate the total elastic potential energy stored in the two sides of stretchy rubber.



High Jump (2017;2)

Sarah, a 55.0 kg athlete, is competing in the high jump where she needs to get her body over the crossbar successfully without hitting it. Where she lands, a padded mattress cushions her fall.



After Sarah has jumped, she lies motionless in position 4, as shown in the diagram. There are 20 springs evenly spaced in the area of the mattress where she lands. The average compression of each spring is 4.5 cm. Sarah's mass is 55.0 kg.

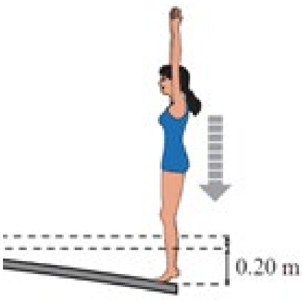
(c) Calculate the elastic potential energy stored in a single spring of the mattress.

Torques and energy (2016;3)

Sarah stands at the end of a diving board. Sarah's mass is 50 kg.

(c) The diving board sags 0.050 m when Sarah stands still on the end of the board. Calculate the spring constant of the board (assuming the board acts like a spring).

(d) Sarah then jumps up and lands on the board, depressing it by a further 0.20 m before she dives into water, as shown. Calculate Sarah's speed when she lands on the board, causing it to depress it by a **further** 0.20 m.



Janet's car and springs (2015;3)

(d) The sofa in Janet and Roy's house has springs. When Roy sits on the sofa, the springs compress by 0.075 m. Calculate the elastic potential energy stored in the springs. (Roy has a mass of 65 kg.)

Basketball (2014;1)

(d) When the ball is compressed, it acts like a spring with a spring constant of 1200 N m^{-1}. When Rachel throws the ball at the wall, the ball compresses a distance of 9.0 mm. The ball has a mass of 0.60 kg. Calculate the elastic potential energy stored in the ball when it is momentarily stationary against the wall. Calculate the maximum possible speed at which the ball rebounds. State any assumptions you make.

Momentum and energy (2013;3)

Each bumper car has a rubber bumper all round it.

(d) The rubber bumper in Jason's bumper car has a spring constant of 78 000 N m^{-1}. On one occasion he collides with the wall, causing a compression of 15 cm.

(i) Calculate the elastic potential energy stored in the rubber bumper.

THE ELASTIC ROPE (2012;3)

(c) An elastic rope is suspended from a beam so that it is hanging vertically down. Hannah hangs vertically down on the elastic rope. The rope is stretched 0.60 m below its normal position when Hannah hangs from it. Calculate the elastic potential energy stored in the elastic rope. (Hannah has a mass of 55 kg.)

ENERGY AND PROJECTILE MOTION (2011;3)

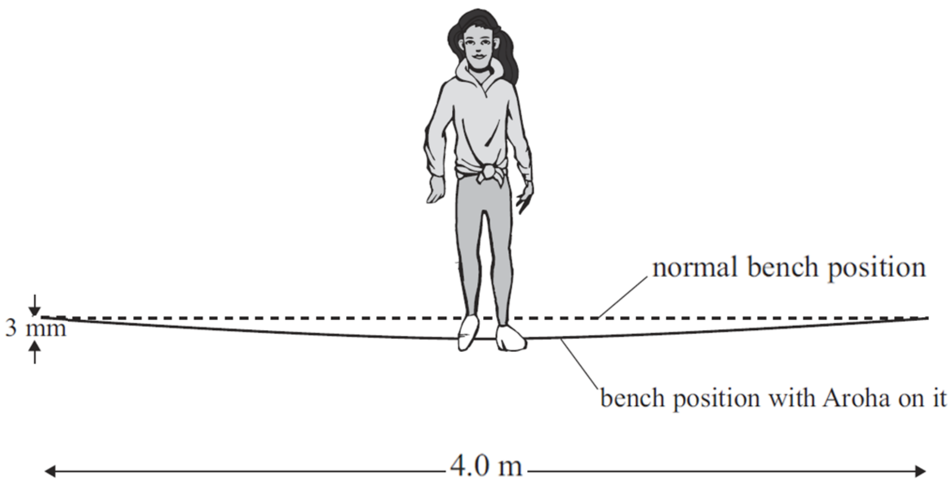
(d) A spider spins a web in the garden and a moth gets caught in the web. The web stretches downwards by 0.065 m when the moth of mass 0.003 kg is caught in it. A graph for force against extension for the spider's web is shown below.

Explain why the formula *W* = *F d* cannot be used to calculate the elastic potential energy stored in the web when the moth gets caught in it. Your explanation should include a statement of what should be used to calculate this energy.

(e) Calculate the elastic potential energy stored in the web when the moth is caught in the web.

THE SPECTATORS (2010;5)

Aroha has a mass of 55 kg. She steps onto a bench to get a better view. The bench is 4.0 m long.



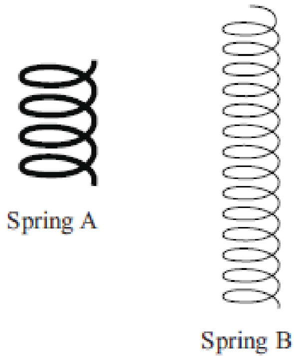
(a) When she gets on to the centre of the bench, it bends downwards 3.00 mm. Calculate the spring constant of the bench. Write your answer with the **correct SI unit.**

(b) Calculate the elastic potential energy stored in the bench

EQUILIBRIUM, MOMENTUM AND SPRINGS (2009;3)

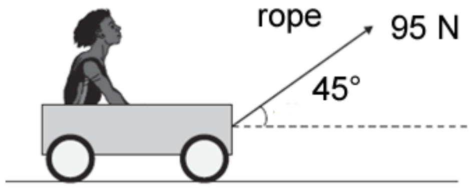
(g) The springs (A) used in Harry's car seats are different from the spring (B) that Jill uses to hang a toy spider from the ceiling of her room. The diagram shows two types of spring.

Compressing spring A by 0.20 m requires 150 J of work. Stretching spring B by 0.30 m requires 210 J of work. By using appropriate working and reasoning, show by calculation which spring is stiffer.



GOING TO THE PLAYGROUND (2008;2)

Rua then climbs onto a trolley and Tahi tows him with a rope, as shown in the diagram.



The rope stretches 1.0 cm with the 95 N tension force. Calculate the elastic potential energy stored in the stretched rope.

THE DUTY-FREE SHOP (2007;4)

At a duty-free shop at the airport, a toy teddy bear is hanging at the end of a spring. The spring is 51.0 cm long when hanging vertically.
When the teddy bear of mass 400 g is hung from the end of the spring, the length of spring becomes 72.0 cm.

(a) Calculate the spring constant. Write a unit with your answer.
(b) Calculate the energy stored in the spring when a second toy of mass 300 g is also hung along with the teddy bear on the spring.
(c) The 400 g teddy bear is now hung on a stiffer spring which has double the spring constant. Discuss how this affects the extension and the elastic energy stored in the spring.

TRAVELLING BY CAR (2005;1)

(h) One of the reasons why cars have suspension systems is to help provide a smooth ride. Part of the suspension system consists of four springs, one at each corner of the car.

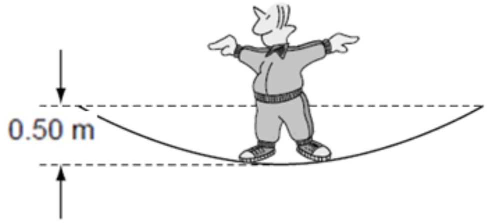
(i) The spring constant of each of the car's springs is 2.26×10^4 N m^{-1}. Assuming that the weight of the occupants is evenly shared between the four springs, calculate how much the car sinks down when the driver and passengers (total mass 357 kg) all get into the car.
(ii) Calculate how much energy is stored in ONE front spring if it is compressed by 0.12 m.

SCHOOL GYM (2004;3)

Where needed, use g = 10.0 ms^{-2} *(NB2S editors Note: They have asked you to use 10 and not 9.8!)*

Henry is bouncing on the elastic mat of a trampoline.

In order to gain the necessary height to perform a certain move, Henry has stretched the mat downwards by 0.50 m. The spring constant of the mat is 3500 Nm^{-1}.



(i) Calculate the size of the force supplied by the mat when stretched by this amount.