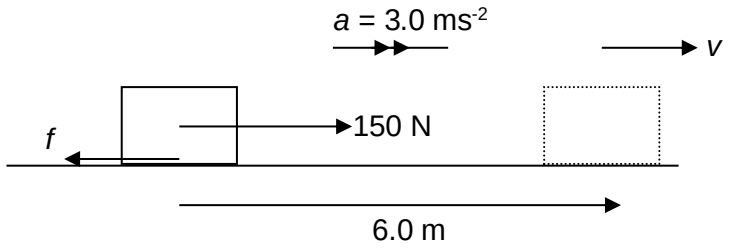
<u>Tutorial Questions</u> (Solutions to questions 1, 3, 7 and 14 are provided.)

Work

1. A horizontal force of 150 N is used to push a 40.0 kg box to a distance of 6.0 m resting on a rough, horizontal surface. If the box moves at a constant acceleration of 3.0 m s^{-2}, calculate



(a) the frictional force *f,*
(b) the work done by the 150 N force,
(c) the work done by friction, and
(d) the final speed of the box.

(30 N, 900 J, 180 J, 6.0 m s^{-1})

Ans:
(a)

$$F - f = ma$$
$$150 - f = 40.0 \times 3.0$$
$$\Rightarrow f = 30\ N$$

(b)

$$W = Fs$$
$$= 150 \times 6.0$$
$$= 900\ J$$

(c)

$$W = fs$$
$$= 30\text{x}6.0\ \cos 180°$$
$$= -180\,\text{J}$$

(d)

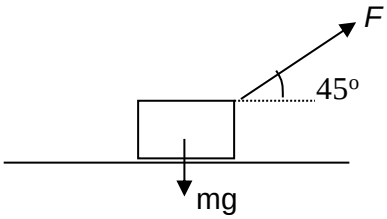
Gain in KE = Work done by F – Work done by friction

$$\frac{1}{2}(40.0)v^2 - 0 = 900 - 180$$
$$\Rightarrow v = 6.0\ \text{m s}^{-1}$$

OR

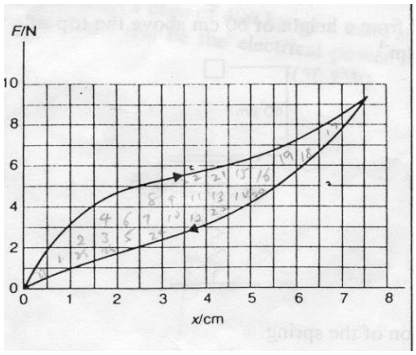
$$v^2 = u^2 + 2as$$
$$\Rightarrow v^2 = 2 \times 3.0 \times 6.0$$
$$\Rightarrow v = 6.0\ ms^{-1}$$

2. A 1.8 kg block is moved horizontally from rest through a displacement of 2.0 m by a constant force *F* directed at 45° to the horizontal as shown in the figure. Find



(a) the magnitude of the force *F* if there is no resultant vertical acceleration and no contact between block and surface,
(b) the work done by the force *F*,
(c) the final velocity of the block and
(d) the work done by gravity *mg*. (25 N, 35 J, 6.3 m s^{-1}, 0 J)

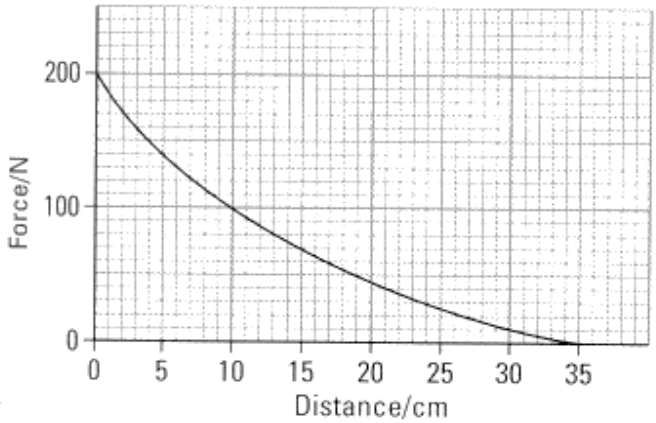
3. The graph in the figure shows how the extension of a rubber band changes when it is stretched and released. How much heat is generated each time the band is stretched and released? (0.14 J)



Ans:

1 *small square represents* 1.0 x (0.5 x 10^{-2}) = 0.0050 J
Estimated area enclosed = 28 *squares*
Heat generated = net work done by stretching force = 28 x 0.0050 = 0.14 J

4. A catapult fires an 80 g stone horizontally. The graph in the figure shows how the force on the stone varies with distance through which the stone is accelerated horizontally from rest.



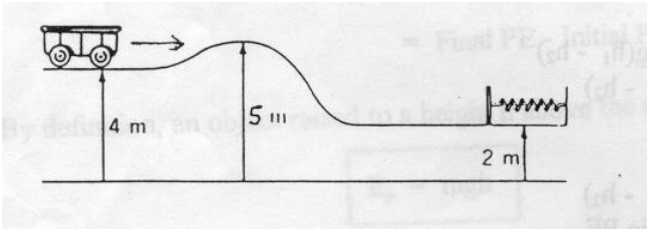
(a) Use the graph to estimate the work done on the stone by the catapult.
(b) Calculate the speed with which the stone leaves the catapult.

(24 J, 24.5 m s^{-1})

Energy

5. A 50 g ball is thrown from a window with an initial velocity of 8.0 ms^{-1} at an angle of 30° above the horizontal. Using energy methods, determine (a) the kinetic energy of the ball at the top of its flight and (b) its speed when it is 3.0 m below the window. Does the answer to (b) depend on the mass of the ball or the initial angle? (1.2 J, 11 m s^{-1})

6. A 3.2 kg trolley initially moving at 5.0 m s^{-1} at a height of 4.0 m encounters a hill of height 5.0 m, as shown in the figure. At a later point there is a horizontal spring (k = 120 N m^{-1}) at a height of 2.0 m.



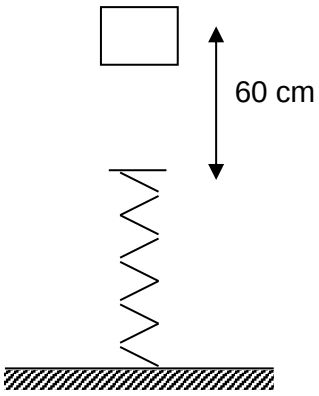
(a) Does the trolley reach the spring? Explain your answer.
(b) If so, what is the maximum compression of the spring? (1.31 m)

Ans:

(a) Trolley must have enough energy to climb hill before going downwards.
Gain in GPE required = 3.2 x 9.81 x 1.0 = 31.4 J
Initial KE = ½ x 3.2 x 5.0^2 = 40 J > 31.4 J
Therefore, yes.

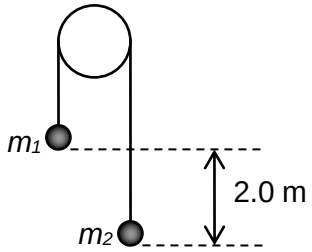
(c) Since some of the initial total energy of the trolley is converted to elastic potential energy of the spring,
$KE_i + GPE_i = KE_f + GPE_f + EPE_f$
$40 + 3.2(9.81)(4.0) = 0 + (3.2)(9.81)(2.0) + ½ k x^2$
x = 1.31 m

7. A 0.500 kg block is dropped from a height of 60.0 cm above the top of a vertical spring whose stiffness constant is k = 120 Nm^{-1}. Find the maximum compression of the spring. (26.6 cm)



8. A block of mass 3.0 kg initially at rest is pulled 5.0 m up a smooth plane, inclined at 30° to the horizontal, by a force of 25 N parallel to the plane. Find the speed of the block when it reaches the top of the plane. (5.9 m s^{-1})

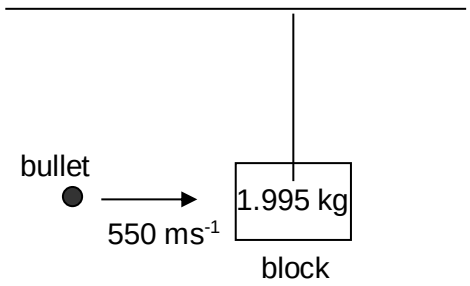
*9. The diagram shows two masses m_1 and m_2 attached by a light string hanging over a smooth pulley. Initially 2.0 m apart in height, the masses are released. When they are at the same height, their speed is 2.0 m s^{-1}.



What is the ratio of $\frac{m_1}{m_2}$?

A 0.50 **B** 0.67 **C** 1.5 **D** 2.0

*10. A bullet of mass 5.00 g moving at 550 ms^{-1} strikes a wooden block of mass 1.995 kg which is the bob of a ballistic pendulum.



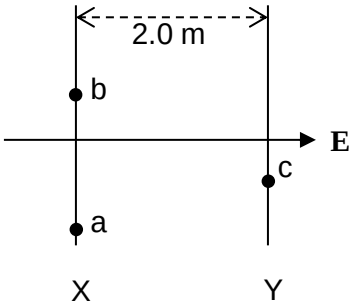
Determine

(a) the speed at which the block and bullet leave the equilibrium position,
(b) the loss in kinetic energy of the bullet, and
(c) the height that the c.g. of the bullet block system reaches above the initial c.g.

(1.38 m s^{-1}, 756 J, 0.0964 m)

Fields

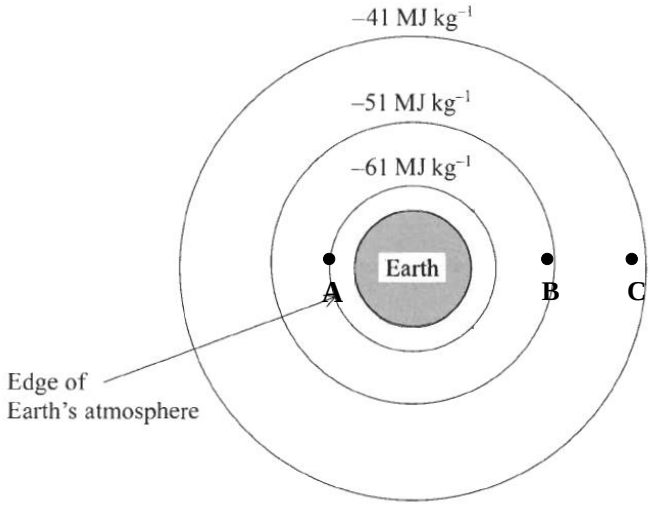
11. The figure shows two equipotential lines X and Y. The uniform electric field strength between X and Y is 5.0 V m^{-1} and points in the direction shown. The potential of X is – 10.0 V. The distance between X and Y is 2.0 m.



(a) Which is at a higher electric potential, X or Y? Hence find the potential of Y.
(b) Calculate the work done by external agent to bring a -5.0 C charge from
    (i) a to b, and
    (ii) a to c.

[- 20.0 V, 0 J, 50 J]

12. The diagram shows three equipotential surfaces centred about the Earth with their values marked. Points A, B and C are marked on the surfaces.



(a) State <u>two</u> deductions about the gravitational field strength of the Earth that can be made from the diagram.
(b) Calculate the energy needed to project a 10 kg mass from point A to point C.
(c) A 50 kg rock falls radially from rest towards the Earth from point C to point B. Calculate the final speed of the rock at point B.

[200 MJ, 4.5 x10^3 m s^{-1}]

Power

13. A car travels along a road at a constant speed of 20 m s^{-1}. Its power output is 23 kW. The total frictional force on the car is proportional to the square of its speed.

What power will be required to travel at a constant speed of 40 m s^{-1}?

N15/P1/Q8

A 46 kW **B** 92 kW **C** 184 kW **D** 368 kW

14. An electric motor is required to haul a cage of 400 kg up a mine shaft through a vertical height of 1200 m in 2.0 minutes. What will be the electrical power required if the overall efficiency is 80 %? (49 kW)

Ans:

$P_{out} = mgh / t = (400)(9.81)(1200) / (2.0 \times 60)$

$P_{in} = P_{out} / 0.80 = 49$ kW

15. A car has a mass of 800 kg and its efficiency is rated at 18% (i.e. 18% of the available fuel energy is delivered to the wheels). Calculate the mass of petrol used to accelerate the car from rest to 30 m s^{-1}. Use the fact that 1 kg of petrol supplies 5.0×10^7 J of energy. (0.040 kg)