Kinetic and gravitational potential energy

Worked solutions

GCSE science calculations

This topic online

1 Priya and her bike have a total mass of 80 kg. She cycles at a speed of 6 m/s.

Calculate the kinetic energy of Priya and her bike. (2 marks)

Kinetic energy = 0.5 x mass x speed^2

$E_k = 0.5 \times 80 \times 6^2$

$E_k = 0.5 \times 80 \times 36$

$E_k = 1440$ J

1440 J

2 A librarian lifts a book of mass 0.5 kg onto a shelf 1.8 m above the floor.

Gravitational field strength = 9.8 N/kg

Calculate the gain in gravitational potential energy of the book. (2 marks)

Gravitational potential energy = mass x gravitational field strength x height

$E_p = 0.5 \times 9.8 \times 1.8$

$E_p = 8.82$ J

8.82 J

3 A family car has a mass of 1200 kg. It travels along a road at 15 m/s.

Calculate the kinetic energy of the car. (2 marks)

Kinetic energy = 0.5 x mass x speed^2

$E_k = 0.5 \times 1200 \times 15^2$

$E_k = 0.5 \times 1200 \times 225$

$E_k = 135000$ J

135000 J

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4 Kofi serves a tennis ball of mass 58 g. The ball leaves his racket at 30 m/s.

Calculate the kinetic energy of the ball. (3 marks)

Kinetic energy = 0.5 × mass × speed^2

58 g = 0.058 kg

$E_k = 0.5 \times 0.058 \times 30^2$

$E_k = 0.5 \times 0.058 \times 900$

$E_k = 26.1$ J

26.1 J

5 In a Year 10 practical, Ellie lifts a 450 g mass from the bench to a height of 80 cm above the bench.

Gravitational field strength = 9.8 N/kg

Calculate the gain in gravitational potential energy of the mass. (3 marks)

Gravitational potential energy = mass × gravitational field strength × height

450 g = 0.45 kg

80 cm = 0.8 m

$E_p = 0.45 \times 9.8 \times 0.8$

$E_p = 3.528$ J

3.528 J

6 An e-scooter and its rider have a total mass of 90 kg. They travel at 18 km/h.

Calculate their kinetic energy. (3 marks)

Kinetic energy = 0.5 × mass × speed^2

Change km/h to m/s

18 km/h = 18 × 1000 ÷ 3600

= 5 m/s

$E_k = 0.5 \times 90 \times 5^2$

$E_k = 0.5 \times 90 \times 25$

$E_k = 1125$ J

1125 J

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7 Tomasz flies a drone of mass 2.0 kg straight upwards. The drone gains 588 J of gravitational potential energy.

Gravitational field strength = 9.8 N/kg

Calculate the height the drone rises.

(3 marks)

Gravitational potential energy = mass × gravitational field strength × height

$588 = 2 \times 9.8 \times h$

$588 = 19.6 \times h$

$h = 588 \div 19.6$

$h = 30$ m

30 m

8 A bowling ball rolls down a lane at 4 m/s. It has 12 J of kinetic energy.

Calculate the mass of the bowling ball.

(3 marks)

Kinetic energy = 0.5 × mass × speed^2

$12 = 0.5 \times m \times 4^2$

$12 = 0.5 \times m \times 16$

$12 = 8 \times m$

$m = 12 \div 8$

$m = 1.5$ kg

1.5 kg

9 **Higher tier**

Aisha bowls a cricket ball of mass 0.16 kg. Just after it leaves her hand the ball has 72 J of kinetic energy.

Calculate the speed of the ball.

(3 marks)

Kinetic energy = 0.5 × mass × speed^2

$72 = 0.5 \times 0.16 \times v^2$

$72 = 0.08 \times v^2$

$v^2 = 72 \div 0.08$

$v^2 = 900$

$v = \sqrt{900}$

$v = 30$ m/s

30 m/s

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10 Leon is on a trampoline. His mass is 60 kg. He leaves the trampoline moving straight upwards at 7.0 m/s.

Assume all of his kinetic energy is transferred to gravitational potential energy. Gravitational field strength = 9.8 N/kg

Calculate the maximum height Leon rises above the trampoline. Show your working. (4 marks)

Kinetic energy = 0.5 x mass x speed^2

$E_k = 0.5 \times 60 \times 7^2$

$E_k = 1470$ J

E_p gained = E_k lost

Gravitational potential energy = mass x gravitational field strength x height

$1470 = 60 \times 9.8 \times h$

$1470 = 588 \times h$

$h = 1470 \div 588$

$h = 2.5$ m

2.5 m

11 **Higher tier**

Hamza drops a stone of mass 0.25 kg from a bridge. The stone falls 20 m to the river below.

Ignore air resistance. Gravitational field strength = 9.8 N/kg

Calculate the speed of the stone just before it hits the water. Give your answer to 2 significant figures. Show your working. (4 marks)

Gravitational potential energy = mass x gravitational field strength x height

$E_p = 0.25 \times 9.8 \times 20$

$E_p = 49$ J

E_k gained = E_p lost

Kinetic energy = 0.5 x mass x speed^2

$49 = 0.5 \times 0.25 \times v^2$

$v^2 = 49 \div 0.125$

$v^2 = 392$

$v = \sqrt{392}$

$v = 19.799...$

Round to 2 significant figures

20 m/s

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12 A roller coaster car of mass 500 kg starts from rest at the top of a drop. It falls through a vertical height of 45 m. At the bottom of the drop its speed is 25 m/s.

Gravitational field strength = 9.8 N/kg

a. Calculate the gravitational potential energy lost by the car.

b. Calculate the kinetic energy of the car at the bottom of the drop.

c. Calculate the energy dissipated to the surroundings during the drop. Give your answer in kJ to 2 significant figures. Show your working.

(5 marks)

a)

Gravitational potential energy = mass × gravitational field strength × height

$E_p = 500 \times 9.8 \times 45$

$E_p = 220500 \text{ J}$

220500 J

b)

Kinetic energy = 0.5 × mass × speed^2

$E_k = 0.5 \times 500 \times 25^2$

$E_k = 0.5 \times 500 \times 625$

$E_k = 156250 \text{ J}$

156250 J

c)

Energy dissipated = Ep lost − Ek gained

dissipated = 220500 − 156250

dissipated = 64250 J

÷ 1000 to change J to kJ

dissipated = 64.25 kJ

64 kJ

13 Sami, of mass 55 kg, stands on a skateboard at the top of a ramp. The ramp is 4.0 m long and its top is 1.6 m above the ground.

Gravitational field strength = 9.8 N/kg

Calculate the gravitational potential energy Sami loses as he rolls to the bottom of the ramp.

(2 marks)

Use the vertical height (1.6 m), not the length of the ramp (4.0 m)

Gravitational potential energy = mass × gravitational field strength × height

$E_p = 55 \times 9.8 \times 1.6$

862.4 J

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