

## Work, gravitational potential energy, and kinetic energy

Work done (J) = force (N) x distance moved (m)

Gravitational Potential Energy (J) = mass (Kg) x gravity (10 N/Kg) x height (m)

To rearrange for mass =  $\frac{GPE}{gravity \times height}$  for height =  $\frac{GPE}{mass \times gravity}$

Kinetic energy (J) =  $\frac{1}{2}$  x mass (kg) x [velocity]<sup>2</sup> (m/s)

To rearrange for mass:  $m = \frac{2KE}{v^2}$  for velocity:  $v = \sqrt{\frac{2KE}{m}}$

### Work

1. Robert pushes a car for 50 metres with a force of 1000N. How much work has he done?
2. Gabrielle pulls a toy car 10 metres with a force of 200N. How much work has she done?
3. Jack drags a shopping bag for 1000 metres with a force of 150N. How much work?
4. Chloe does 2600J of work hauling a wheelbarrow for 3 metres. How much force is used?
5. A ball does 1400J of work being pushed with a force of 70N. How far does it travel?

### Gravitational potential energy (GPE)

6. A 5kg cat is lifted 2m into the air. How much GPE does it gain?
7. A larger cat of 7kg is lifted 5m in to the air. How much GPE does it gain?
8. A massively fat cat of mass 20kg is lifted 8m into the air. How much GPE does it gain?
9. A large block of stone is held at a height of 15m having gained 4500J of GPE. How much does it weigh?
10. A larger block of stone has been raised to a height of 15m has gained 6000J of GPE. What mass does it have?
11. A really big beast of a block of stone of weight 600kg gains 36000J of GPE. How high has it been raised?
12. A similarly huge block of stone has a mass of 650kg and gains 70000J of GPE. How high has it been raised?

## **Kinetic energy**

13. A raging bull of mass 700kg runs at 10 m/s. How much kinetic energy does it have?

14. A waddling armadillo of mass 500kg moves at 5 m/s. How much kinetic energy does it have?

15. A stroppy teenager throws their PS4 controller at the wall after losing at FIFA. It has 78.125J of kinetic energy and moves at 25 m/s before it hits the wall. How much mass does it have?

16. A slightly disturbed man of 80kg runs directly into a wall with a kinetic energy of 4000J. How fast is he running?

## **Combined questions**

17. A rather unbalanced goat jumps off a cliff. The goat has a mass of 50kg and the cliff is 450m high. At what speed will the goat be travelling just before it hits the ground?

a. Work out the GPE

b. How much KE? (GPE lost = KE gained)

c. Rearrange the KE formula to work out velocity

18. Sam leaps out of an aeroplane to see if he can fly but quickly finds he cannot. He has mass 90kg and the plane is cruising at 30,000m. Ignoring air resistance, at what speed will he be travelling before he lands on a large pile of pillows, avoiding his certain death?

a. Work out the GPE

b. How much KE?

c. Rearrange the KE formula to work out velocity

19. David has a mass of 90kg. He slides down a slide, which goes 15m down. Calculate the maximum speed he could reach at the bottom of the slide

a. Work out the GPE

b. How much KE? (GPE lost = KE gained)

c. Rearrange the KE formula to work out velocity

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Work done (J) = force (N) x distance moved (m)

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To rearrange for mass =  $\frac{GPE}{gravity \times height}$  for height =  $\frac{GPE}{mass \times gravity}$

Kinetic energy (J) =  $\frac{1}{2}$  x mass (kg) x [velocity]<sup>2</sup> (m/s)

To rearrange for mass:  $m = \frac{2KE}{v^2}$  for velocity:  $v = \sqrt{\frac{2KE}{m}}$

### Work

1. Robert pushes a car for 50 metres with a force of 1000N. How much work has he done?

$$50 \times 1000 = 50000J$$

2. Gabrielle pulls a toy car 10 metres with a force of 200N. How much work has she done?

$$10 \times 200 = 2000J$$

3. Jack drags a shopping bag for 1000 metres with a force of 150N. How much work?

$$1000 \times 150 = 150000J$$

4. Chloe does 2600J of work hauling a wheelbarrow for 3 metres. How much force is used?

$$= \frac{W}{D} \quad 2600 \div 3 = 866.6N$$

5. A ball does 1400J of work being pushed with a force of 70N. How far does it travel?

$$= \frac{W}{F} \quad 1400 \div 70 = 20m$$

Gravitational potential energy (GPE)

6. A 5kg cat is lifted 2m into the air. How much GPE does it gain?

$$5 \times 10 \times 2 = 100J$$

7. A larger cat of 7kg is lifted 5m in to the air. How much GPE does it gain?

$$7 \times 10 \times 5 = 350J$$

8. A massively fat cat of mass 20kg is lifted 8m into the air. How much GPE does it gain?

$$20 \times 10 \times 8 = 1600J$$

9. A large block of stone is held at a height of 15m having gained 4500J of GPE. How much does it weigh?

$$m = \frac{GPE}{(g \times h)} \quad 4500 \div (10 \times 15) = 30kg \quad (3000N)$$

10. A larger block of stone has been raised to a height of 15m has gained 6000J of GPE. What mass does it have?

$$6000 \div (10 \times 15) = 40kg$$

11. A really big beast of a block of stone of weight 600kg gains 36000J of GPE. How high has it been raised?

$$= \frac{GPE}{(m \times g)} \quad 36000 \div (600 \times 10) = 6m$$

12. A similarly huge block of stone has a mass of 650kg and gains 70000J of GPE. How high has it been raised?

$$70000 \div (650 \times 10) = 10.8m \quad (1.1d.p)$$

### Kinetic energy

13. A raging bull of mass 700kg runs at 10 m/s. How much kinetic energy does it have?

$$0.5 \times 700 \times 10 \times 10 = 35000 \text{ J}$$

14. A waddling armadillo of mass 500kg moves at 5 m/s. How much kinetic energy does it have?

$$0.5 \times 500 \times 5 \times 5 = 6250 \text{ J}$$

15. A strappy teenager throws their PS4 controller at the wall after losing at FIFA. It has 78.125J of kinetic energy and moves at 25 m/s before it hits the wall. How much mass does it have?

$$m = \frac{2KE}{v^2} \quad 2 \times 78.125 \div 25^2 = 0.25 \text{ kg}$$

16. A slightly disturbed man of 80kg runs directly into a wall with a kinetic energy of 4000J. How fast is he running?

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 4000}{80}} = 10 \text{ m/s}$$

### Combined questions

17. A rather unbalanced goat jumps off a cliff. The goat has a mass of 50kg and the cliff is 450m high. At what speed will the goat be travelling just before it hits the ground?

a. Work out the GPE

$$50 \times 10 \times 450 = 225000 \text{ J}$$

b. How much KE? (GPE lost = KE gained)

$$225000 \text{ J}$$

c. Rearrange the KE formula to work out velocity

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2 \times 225000}{50}} = 94.9 \text{ m/s}$$

18. Sam leaps out of an aeroplane to see if he can fly but quickly finds he cannot. He has mass 90kg and the plane is cruising at 30,000m. Ignoring air resistance, at what speed will he be travelling before he lands on a large pile of pillows, avoiding his certain death?

a. Work out the GPE

$$90 \times 10 \times 30000 = 27000000 \text{ J}$$

b. How much KE?

$$27000000 \text{ J}$$

c. Rearrange the KE formula to work out velocity

$$\sqrt{\frac{2 \times 27000000}{90}} = 774.6 \text{ m/s}$$

19. David has a mass of 90kg. He slides down a slide, which goes 15m down. Calculate the maximum speed he could reach at the bottom of the slide

a. Work out the GPE

$$90 \times 10 \times 15 = 13500 \text{ J}$$

b. How much KE? (GPE lost = KE gained)

$$13500 \text{ J}$$

c. Rearrange the KE formula to work out velocity

$$\sqrt{\frac{2 \times 13500}{90}} = 17.3 \text{ m/s}$$