Work done by forces

Name: _____ Class: _____ Date: _____

Start here

0-5 minutes

Today: Calculate work and explain energy transfer by a named force, including balanced situations and friction.

You need: Pen, different-coloured pen, ruler and calculator. Equations, reading, data and figure are supplied.

Work from memory. Write directly in this booklet with working and units.

1. A constant 12 N force acts along a movement of 3.0 m. Use W=Fs to calculate its work done.

Working and work done:

2. Convert a movement of 40 cm into metres.

Distance in metres:

3. State the SI unit of work done. Complete: one newton metre is equal to one ____.

Stop for check 1. Wait for your teacher before moving on.

Try again A

Only if directed. Use the first 2 reading minutes, then continue on page 2.

Help: Use page 2: divide centimetres by 100, multiply force by distance along it, and label transferred energy in joules.

(a) Convert 20 cm to metres. (b) Find work by an 8.0 N force along 2.0 m. (c) State the unit and complete 1 N m = __ J.

When your teacher says, turn to page 2.

Use the named force and its direction

5-15 minutes

For a constant force acting along a displacement, work done = force × distance moved along the force: W = Fs. F is in newtons and s in metres, giving joules. This is also the energy transferred mechanically.

Rule	How to apply it
Constant force along movement	W=Fs. Work W in J, force F in N, distance s in m.
Rearrange	F=W/s; s=W/F. Keep force and work as different quantities.
Conversions	Centimetres ÷100 = metres. 1 N m=1 J.
Perpendicular force	If motion has no displacement along a force, that force does zero work.
Balanced forces	Zero resultant means no change of velocity here. Each named force can still transfer energy.

Worked model - multiply, rearrange and choose the distance

A constant 20 N pull acts along 1.5 m: calculate work. A different test transfers 18 J by a constant force along 30 cm: find that force. Also explain the work by vertical gravity when a trolley moves horizontally at unchanged height.

Pulling work=20×1.5=30 J. In the separate test convert 30 cm to 0.30 m, then F=W/s=18/0.30=60 N. For horizontal motion at fixed height, distance along vertical gravity is zero, so gravity does zero work. Select the named force; total path length does not apply to every force.

Friction and energy

Work against friction can increase thermal stores of the trolley, surface and surroundings. An energy amount transferred by a brake is positive as an amount; it is not a positive gain of kinetic energy. Energy is transferred or dissipated, not destroyed. When a trolley moves at constant speed, pulling work can be matched by frictional transfers while its kinetic energy stays unchanged.

Adapted from Energy Calculations and Power, section 4 constant-force reading. Direction, friction and the rearranged model are supplied here. Optional online reading.

Turn to page 3 for question 4.

Check work in a balanced situation

15-20 minutes

4. A trolley moves 2.0 m horizontally at constant speed. Its weight is 100 N vertically down. A 10 N horizontal pull is balanced by 10 N friction. Which pair is correct? Choose a letter and explain both work values.

A. Gravity 200 J; pull 20 J

B. Gravity 0 J; pull 0 J

C. Gravity 0 J; pull 20 J

D. Gravity 20 J; pull 200 J

Chosen letter:

Gravity reason:

Pulling-work calculation and reason:

Stop for check 2. Wait for your teacher before moving on.

Try again B

Only if directed. Complete B instead of questions 5-6 on page 4; then answer 7-8.

Help: Use page 2's named-force rule. Match each force direction to the displacement; a zero resultant does not mean every force does zero work.

A different trolley moves 3.0 m horizontally at constant speed. Its weight is 80 N vertically down, pull is 6.0 N horizontally forward and friction is 6.0 N opposite. Find work by gravity and by the pull; justify both.

The later questions concern separate theatre trolley/lift tests. Use the force named in each question; no experiment is required.

Turn to page 4. If you used B, leave questions 5-6 blank.

Calculate and rearrange work done

20-30 minutes

Complete 5-8, or 7-8 only if you completed B. Each question is a separate test. For the brake, calculate the amount transferred.

5. A worker pushes horizontally with a constant force of 30 N while a trolley moves 5.0 m horizontally. Calculate work done by this force.

Equation and working:

Work done:

6. A brake exerts a constant 50 N force opposite the trolley motion over 0.40 m. Calculate the amount of energy transferred by the brake.

Working:

Energy amount transferred:

7. A constant 24 N force does 96 J of work while acting parallel to trolley motion. Calculate the distance moved.

Rearrangement and working:

Distance:

8. A force parallel to the motion transfers 5.0 J over 25 cm. Calculate the force.

Distance in metres:

Force equation, working and answer:

At about 30 minutes turn to page 5 for the independent check.

Pause and check units and direction

30-33 minutes

9. A constant horizontal force does 45 J of work along 75 cm of motion. Find the force. A separate vertical weight of 90 N acts during that same horizontal movement: state its work and explain.

Distance in metres:

Force equation, working and answer:

Work by weight and reason:

Stop for check 3. Wait for your teacher before moving on.

Try again C

Only if directed. Complete C instead of questions 10-11 on page 6. Then answer 12-15.

Help: Use page 2: convert cm to m, rearrange F=W/s, then check the direction of each separate force.

In another horizontal test a constant force does 32 J over 40 cm along the force. Find the force. State work by vertical gravity during the same movement and explain.

Continue on page 6. If you used C, leave questions 10-11 blank.

Compare lifting work and thermal transfers

33-45 minutes - continue practice

For question 10, a 24 kg load rises vertically by 2.5 m, as in Figure 1. The upward cable force is 240 N. Its GPE gain is 600 J (given). No GPE equation is needed. Questions 11 and 12 are separate tests.

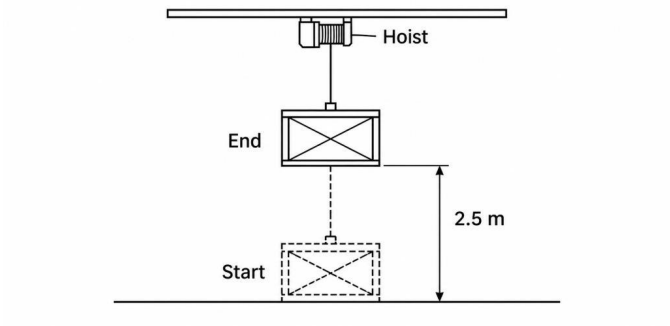

Figure 1: the supplied lift. The cable force acts upwards along the 2.5 m rise.

10. In the supplied lift, calculate the work done by the 240 N upward cable force through 2.5 m. Compare it with the given 600 J GPE gain.

Cable work:

Comparison with given GPE gain:

11. A trolley of weight 240 N moves 5.0 m horizontally at the same height. A trainee says its weight does 1200 J of work. Explain why gravity does no work in this movement.

12. In a separate lift the motor receives 750 J electrically. The load starts and finishes at rest and gains 600 J of GPE. All other transferred energy warms the hoist and surroundings. Calculate this amount and correct “the missing energy was destroyed”.

Energy amount and working:

Receiving thermal stores:

Why energy is not destroyed:

Finish practice with the constant-speed trolley on page 7.

Explain a useful transfer at constant speed

Finish practice by 45 minutes

Use this full context for questions 13-15. A trolley moves 4.0 m horizontally at constant speed. Pull is 18 N along the motion; friction is 18 N opposite. Friction warms the trolley and surface. These are paper-based data.

13. A trolley moves 4.0 m horizontally at constant speed. A pulling force of 18 N acts along the motion and friction is 18 N opposite. Calculate work done by the pull.

Equation and working:

Work by the pull:

14. For the same trolley, explain why zero resultant force does not mean zero work by the pull. Name the receiving energy stores when friction warms the trolley and surface.

15. Express your pulling-work answer from question 13 in newton metres. Explain why the numerical value is unchanged from the value in joules.

Value in N m:

Why it matches the value in J:

Check the meaning

Say which force does the work. Work by a pull can be nonzero even when resultant force is zero. Identify the receiving stores rather than saying energy vanished.

At 45 minutes turn to page 8 for review and the independent exit.

Review, then apply the rules independently

45-55 minutes review; 55-60 minutes independent exit

16. Correct practice in a different colour and explain one error using the named force, distance along that force or units. If all answers were correct, explain how pulling can transfer energy while a trolley's kinetic energy stays constant.

Independent exit - only when your teacher says

Cover earlier pages and answers. Complete question 17 independently.

17. A trolley moves 1.5 m horizontally at constant speed. A pull of 18 N acts along the motion; friction is 18 N opposite and weight is 90 N vertically down. (a) Find work by the pull. (b) State work by gravity and explain. (c) Explain where the pull's transferred energy goes despite zero resultant force. (d) In a separate test a pull does 36 J over 60 cm along its direction. Find that force.

(a) Pulling work - working and unit:

(b) Gravity work and reason:

(c) Receiving stores:

(c) Why kinetic energy stays unchanged:

(d) Distance in metres:

(d) Force - equation, working and unit:

Stop for check 4. Wait for your teacher before moving on.

Write your name on page 1. Hand in the complete booklet with working and corrections.

Try again D - next lesson

Leave this today. Your usual teacher may direct it next lesson.

Help: Next lesson revisit page 2's equations, units and named-force rules. Cover the models before the new independent attempt.

Next lesson: a trolley moves 2.0 m horizontally at constant speed. Pull is 12 N forward, friction 12 N opposite and weight 80 N vertically down. Find pulling work, explain gravity's work and identify receiving stores. In a separate test, 20 J is transferred by a force acting along 25 cm: find that force.

Hand your complete booklet to your teacher.