

Work done, energy conservation and power

Physics grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: _____ Date: _____ Class: _____

These twenty problems train you to calculate work with force at an angle, use the area under a force-displacement graph, apply the work-energy theorem and conserve energy on slopes and swings. The last problems combine power, efficiency and real machines such as a lorry, a lift and a wind turbine.

They suit A Level, IB physics and CBSE Class 11 students. Work in joules and watts, use $g = 9.81 \text{ N/kg}$, and write the formula before you substitute.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB A.3

Problem 1 Key relationships (easy)

Write each relationship.

1. Work done by a force F that moves an object a distance s at angle θ to the force.
2. Kinetic energy and the change in gravitational potential energy near Earth.
3. Power in terms of work and time, and in terms of force and speed.
4. Efficiency as a percentage.

Problem 2 Wheelbarrow of bricks (easy)

Ngozi in Enugu pushes a wheelbarrow of bricks with a horizontal force of 140 N for 25 m along a level yard.

1. Calculate the work she does.
2. Give the energy transferred in kilojoules.

Problem 3 Convert, then calculate (easy)

Convert before you calculate ($1 \text{ kWh} = 3.6 \text{ MJ}$).

1. Convert 72 km/h to m/s .
2. Convert 3.6 MJ to kWh .
3. A 450 W grinder runs for 2.0 h . Calculate the energy transferred in kWh and in MJ .

Problem 4 A footballer's kick (easy)

A football of mass 0.43 kg leaves a boot at 24 m/s .

1. Calculate its kinetic energy.
2. Predict the kinetic energy if the speed were doubled, then check by calculating it.

Problem 5 Rice on the shelf (easy)

Diego in Austin lifts a 15 kg sack of rice from the floor onto a shelf 1.4 m high. Use $g = 9.81$ N/kg.

1. Calculate the gain in gravitational potential energy.
2. State the work he does on the sack.
3. Calculate the gain if the shelf were 2.8 m high.

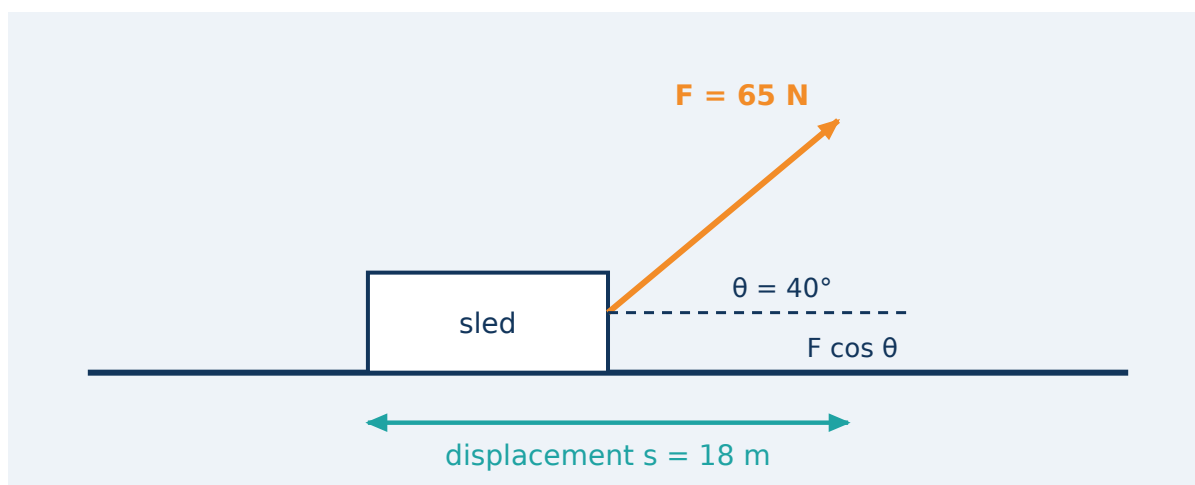
Problem 6 Lift motor (easy)

A lift motor takes 6.0 kW of electrical power. It does 48 kJ of useful work in 12 s.

1. Calculate its useful power output.
2. Calculate its efficiency.

Problem 7 Dragging a sled (medium)

Haruto in Sapporo drags a sled with a rope that makes 40° with level snow. The rope force is 65 N and the sled moves 18 m.



Haruto drags a sled across level snow.

1. Calculate the component of the rope force along the snow.
2. Calculate the work done by the rope.
3. Explain why pulling with a lower rope angle at the same force does more work over the same distance.

Problem 8 Positive, negative or zero (medium)

State whether the work done is positive, negative or zero, and give a reason.

1. Friction on a crate sliding to a stop.
2. Gravity on a book carried along a level corridor.
3. Tension in a string on a stone whirled in a horizontal circle.
4. Gravity on a ball while it falls.
5. Calculate the work done by a 35 N friction force on a crate that slides 6.0 m.

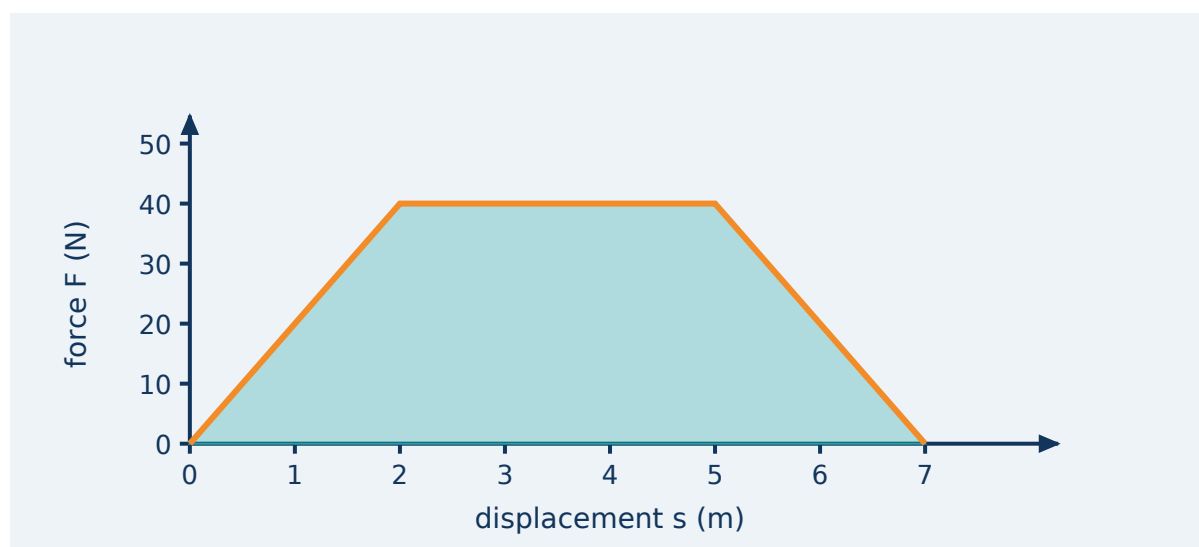
Problem 9 Hockey stick strike (medium)

A hockey puck of mass 0.17 kg is at rest. A stick is in contact with it while the puck moves 0.12 m and leaves at 30 m/s . Ignore friction.

1. Calculate the net work done on the puck.
2. Calculate the average force of the stick.

Problem 10 Force on a runway (medium)

A trolley of mass 4.0 kg starts from rest on a smooth runway. The graph shows the force on it.



Force on a trolley as it moves along a runway.

1. Calculate the work done between 0 and 2 m .
2. Calculate the work done between 2 m and 5 m .
3. Calculate the total work done over 7 m .
4. Calculate the speed of the trolley at 7 m .

Problem 11 Swinging bob (medium)

A pendulum bob of mass 0.50 kg is pulled aside until it is 0.35 m above its lowest point, then released from rest. Ignore air resistance. Use $g = 9.81 \text{ N/kg}$.

1. Calculate its speed at the lowest point.
2. Calculate its kinetic energy there.
3. State what happens to the speed if the bob's mass is 1.0 kg , and explain.

Problem 12 Motorbike thrust (medium)

A motorbike engine delivers a useful power of 18 kW to the wheels while the bike travels at a steady 25 m/s .

1. Calculate the driving force.
2. Calculate the work done by the driving force in 5.0 minutes.

Problem 13 Solar water pump (medium)

A solar pump takes 750 W from its panel and raises 540 kg of water through 6.0 m in 60 s. Use $g = 9.81 \text{ N/kg}$.

1. Calculate the useful work done on the water.
2. Calculate the useful power output.
3. Calculate the efficiency.
4. Suggest where the wasted energy goes.

Problem 14 Braking distance (medium)

A car of mass 950 kg travels at 15 m/s and brakes with a constant force of 4750 N.

1. Calculate the car's kinetic energy.
2. Calculate the stopping distance.
3. Calculate the stopping distance from 30 m/s with the same force.

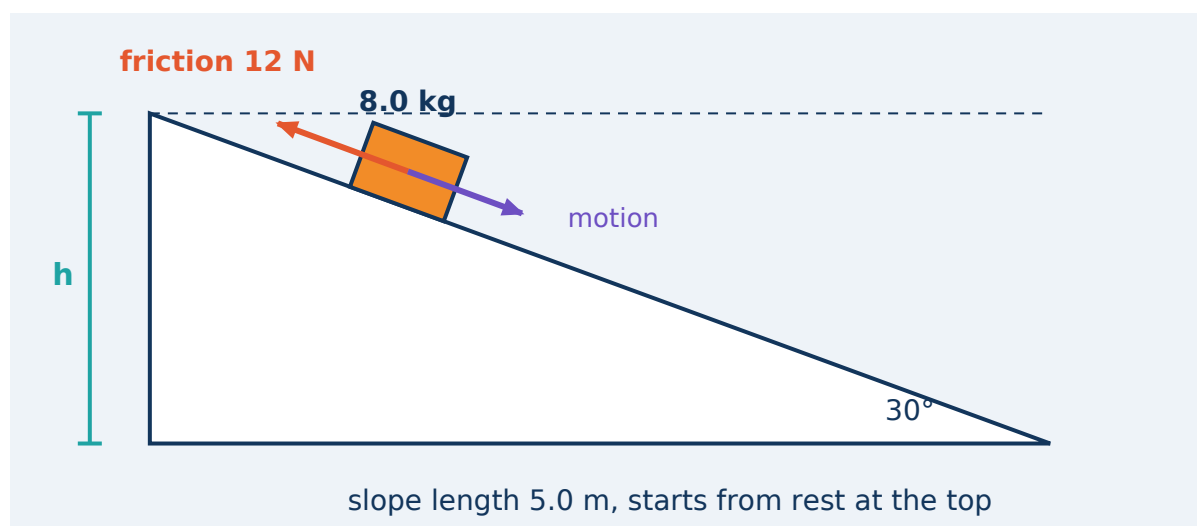
Problem 15 Find the errors (medium)

Sipho writes this solution: "A hoist lifts a 20 kg crate through 3.0 m in 4.0 s. Work = $20 \times 3.0 = 60 \text{ J}$. Power = $60 \times 4.0 = 240 \text{ W}$."

1. Identify two errors.
2. Calculate the correct work done and the correct power. Use $g = 9.81 \text{ N/kg}$.

Problem 16 Sliding down a slope (hard)

A box of mass 8.0 kg starts from rest at the top of a rough slope 5.0 m long, inclined at 30° to the horizontal. A constant friction force of 12 N opposes the motion. Use $g = 9.81 \text{ N/kg}$.



The box starts from rest at the top of the slope.

1. Show that the box falls a vertical height of 2.5 m.
2. Calculate the gravitational potential energy lost.
3. Calculate the work done against friction.
4. Calculate the speed at the bottom.

Problem 17 A bouncing ball (hard)

Mei in Singapore drops a ball of mass 0.060 kg from 1.5 m onto a hard floor. It rebounds to 1.1 m. Use $g = 9.81 \text{ N/kg}$ and ignore air resistance.

1. Calculate its speed just before it hits the floor.
2. Calculate its speed just after leaving the floor.
3. Calculate the energy lost in the bounce.
4. Calculate the percentage of energy lost.

Problem 18 Lorry on a hill (hard)

A lorry of mass 12 000 kg climbs a road that rises 1 m for every 20 m travelled along the road ($\sin \theta = 0.050$). It moves at a constant 15 m/s against a resistive force of 6000 N. Use $g = 9.81 \text{ N/kg}$.

1. Calculate the component of weight down the slope.
2. Calculate the driving force.
3. Calculate the useful power of the engine.
4. The engine takes 450 kW from the fuel. Calculate its efficiency.

Problem 19 Lift with a load (hard)

A lift and passengers have a total mass of 1500 kg. Starting from rest, the lift rises 30 m and reaches a steady speed of 2.0 m/s at the top. There is no counterweight. Use $g = 9.81 \text{ N/kg}$.

1. Calculate the gain in gravitational potential energy.
2. Calculate the gain in kinetic energy.
3. Calculate the total work done by the cable.
4. The journey takes 18 s. Calculate the average useful power.
5. The motor is 85 % efficient. Calculate the electrical power it takes on average.

Problem 20 Wind turbine power (hard)

Wind of density 1.2 kg/m^3 blows at 8.0 m/s through the circular area swept by turbine blades of radius 20 m.

1. Show that the kinetic energy carried by the air each second is $P = \frac{1}{2} \rho A v^3$.
2. Calculate the power of the wind through the blades.
3. The turbine generates 150 kW. Calculate its efficiency.
4. Predict the available wind power if the wind speed doubles, and calculate it.