

KWV EDUCATION



KWV PHYSICS GRADE 12

WORK, ENERGY & POWER NOTES

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WHERE TO START IN MATHS AND SCIENCE

❖ WORK, ENERGY AND POWER

➤ WORK

- ✓ Work is the transfer of energy.
- ✓ Work done on an object by a force is the product of the displacement and the component of the force parallel to the displacement.
- ✓ Define the work done on an object by a constant force F as:

$$\text{✚ } W = F\Delta x \cos\theta$$

WHERE:

- $F \rightarrow$ is the magnitude of the force
 - $\Delta x \rightarrow$ the magnitude of the displacement
 - $\theta \rightarrow$ the angle between the force and the displacement.
-
- ✓ Work is a scalar quantity, *i.e. no direction*
 - ✓ The joule is the amount of work done when a force of one newton moves its point of application one metre in the direction of the force.

❖ WORK ALWAYS INVOLVES TWO THINGS

- A force which acts on a certain object.
- The displacement of that object.

KEY!

- ✓ When a resultant force is applied to an object, the resultant force **accelerates** the block across distance Δx . Work has been done to increase the **kinetic energy** of the block.
- ✓ If a resultant force is applied to an object vertically, the resultant force **lifts** the block through distance Δy .
- ✓ Work has been done to increase the **potential energy** of the block.
- ✓ Work is only done in the direction of the displacement.
- ✓ Work is done by the component of the force that is parallel to the displacement.
- ✓ The angle between the force and the displacement is θ .

❖ ZERO WORK

- ✓ No work done on an object moving at a constant velocity, if the force and displacement are perpendicular to each other.
- ✓ No force in the plane of the displacement, hence, no work is done and no energy is transferred.
- ✓ We can also say that the applied force does not change the potential energy or kinetic energy of the object.

❖ POSITIVE WORK

- ✓ A force/force component in the direction of the displacement does positive work on the object.
- ✓ The force increases the energy of the object.
- ✓ Positive work means that energy is added to the system.

❖ NEGATIVE WORK

- ✓ A force/force component in the opposite direction of the displacement does negative work on the object.
- ✓ The force decreases the energy of the object.
- ✓ Negative work means that energy is being removed from the system.

➤ NET WORK ON AN OBJECT

- ✓ A number of forces can act on an object at the same time.
- ✓ Each force can do work on the object to change the energy of the object.
- ✓ The net work done on the object is the sum of the work done by each force acting on the object.
 - If W_{net} is **positive**, energy is **added** to the system.
 - If W_{net} is **negative**, energy is **removed** from the system.

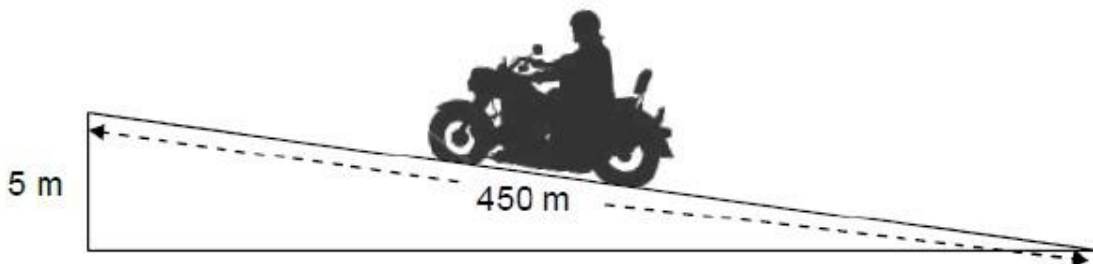
➤ WORK-ENERGY THEOREM

✓ WORK-ENERGY THEOREM

- ✚ The net/total work done on an object is equal to the change in the object's kinetic energy
- ✚ The work done on an object by a resultant/net force is equal to the change in the object's kinetic energy.

KEY!

- ✓ The work-energy theorem can be applied to the objects on horizontal, vertical and inclined planes for both frictionless and rough surfaces
- ✓ Starting from rest means the velocity initial is **zero**
- ✓ Comes to rest means the velocity final is **zero**.
- ❖



- ✓ Angle can be calculated using trigonometric relation: **sine**
- ✓ Can be used to calculate any unknown since you are given the height.

WORK, ENERGY AND POWER/ARBEID, ENERGIE EN DRYWING

$W = F\Delta x \cos \theta$	$U = mgh$ or/of $E_p = mgh$
$K = \frac{1}{2}mv^2$ or/of $E_k = \frac{1}{2}mv^2$	$W_{\text{net}} = \Delta K$ or/of $W_{\text{net}} = \Delta E_k$ $\Delta K = K_f - K_i$ or/of $\Delta E_k = E_{kf} - E_{ki}$
$W_{\text{nc}} = \Delta K + \Delta U$ or/of $W_{\text{nc}} = \Delta E_k + \Delta E_p$	$P = \frac{W}{\Delta t}$
$P_{\text{ave}} = Fv_{\text{ave}}$ / $P_{\text{gemid}} = Fv_{\text{gemid}}$	

❖ CONSERVATIVE FORCE

- ✓ **Conservative force** is a force for which the work done in moving an object between two points is independent of the path taken.

✚ **Examples** are gravitational force, the elastic force in a spring and electrostatic forces.

KEY!

- ✓ **A force is a conservative force if:**

- ✚ The work done by the force in moving an object from point A to point B is independent of the path taken.
- ✚ The net work done in moving an object in a closed path which starts and ends

❖ NON-CONSERVATIVE FORCE

- ✓ **Non-conservative force** is a force for which the work done in moving an object between two points depends on the path taken.

✚ **Examples** are frictional force, air resistance, tension in a chord, etc.

KEY!

- ✓ **A force is a non-conservative force if:**

- ✚ The work done by the force in moving an object from point A to point B is dependent of the path taken.
- ✚ The net work done in moving an object in a closed path which starts and ends at the same point is not zero.

✚ $W_{nc} = \Delta K + \Delta U$ or/of $W_{nc} = \Delta E_k + \Delta E_p$

❖ PRINCIPLE OF CONSERVATION OF MECHANICAL ENERGY

✚ **Principle of conservation of mechanical energy:** The **total** mechanical energy in an **isolated system** **remains constant**.

- ✓ Mechanical energy is sum of gravitational potential energy and kinetic energy.
- ✓ A system is isolated when the resultant/net external force acting on the system is zero.
- ✓ Be in the position to use the principles of energy to show that in the absence of nonconservative forces, mechanical energy is conserved.
- ✓ The mechanical energy of a system is conserved when **only** conservative forces are present in the system.
- ✓ The mechanical energy of a system is **not conserved** when non-conservative forces are present in the system (e.g. friction, air resistance, applied forces and tension).
- ✓ The work done by these non-conservative forces is equal to the change in the total mechanical energy of the system.

➤ POWER

- ✓ Power is the rate at which work is done or energy is expended.

$$P = \frac{W}{\Delta t}$$

P → Power in Watts(W)

W → work done in Joules (J).

Δt → change in time in seconds (s).

- ✓ Be in the position to calculate the power involved when work is done.
- ✓ Perform calculations using when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.

➤ AVERAGE POWER (CONSTANT VELOCITY)

- ✓ We can calculate the average power needed to keep an object moving at constant speed.
- ✓ If the car is driven at a constant speed, the magnitude of the forward force is equal to the magnitude of the frictional force.
- ✓ If the car is driven at constant speed then the force of the engine up the slope must be equal in magnitude to the force down the slope.
- ✓ Be in a position to calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).

❖ Velocity is given by displacement over time:

$$\text{✚} \quad V_{ave} = \frac{\Delta x}{\Delta t}$$

$$\text{✚} \quad P_{ave} = f \cdot V_{ave}$$

NOTE:

P → Average Power

F → Force

V → Constant Velocity