🤔Mechanical work

🔑work done) is another way of saying energy is being transferred from one object to another or transformed from one type to another.

Work done = energy transferred

🔑work done is measured in joules(J).

(The joule is the SI derived unit of energy).

🔑The more energy transferred the more work has been done.

🔑Work is a scalar quantity, just like energy.

🤔Calculating work done

Mechanical work is defined as the amount of energy transferred by a force acting through a distance.

🔑We can calculate work done using the following equation:

$$W = F s$$

W = work done in(J)

F = average force applied (it is assumed to be constant) in (N)

S= the distance moved in the direction of the force in(m)

🔑A more complex version of the work equation can be seen below.

- $W = F s \cos \theta$

S=is the distance travelled

θ=is the angle between the force and the direction of movement

🤔Doing work against gravity, friction, and gravity and friction

🤔Gravity

🔑Work is often done against gravity.

We can adapt our work done equation for working against gravity:

- $W = F s$
- Work done against gravity = weight × vertical distance moved

(or $W_{gravity} = w \times h$)

🤔Friction

- $F_{friction} = \mu_{kinetic} N$

$F_{friction}$: is the force of kinetic friction.

$\mu_{kinetic}$: is the coefficient of kinetic friction (a unitless value that depends on the two surfaces in contact).

N=is the normal force (the force perpendicular to the surface).

🔑This is the force you are working against. We can adapt our work done equation for working against frictional forces:

- Work done against friction = force due to kinetic friction ×

distance moved

- **$W_{friction} = \mu_{kinetic} N \times s$**

$F_{friction}$: is the force of kinetic friction.
$\mu_{kinetic}$: is the coefficient of kinetic friction (a unitless value that depends on the two surfaces in contact).
N=is the normal force (the force perpendicular to the surface)
S=distance

🤔Gravity and friction

In this case the total work done could be found using the following equation:

- **Total work done = work done against gravity + Total work done = work done against friction**

$$W_{total} = (w \times h) + (\mu_{kinetic} N \times s)$$

W_{total}=total Work done
w=weight
h=vertical distance moved
$\mu_{kinetic}$ = force due to kinetic friction

🤔+W or –W

🔑**The work is positive or negative depends on whether or not the object gains or loses energy.**

✔️**Negative less than zero**

✔️**Positive greater than zero**

🤔Work–energy theorem

Energy vs. work?

🔑**The energy of an object is a mathematical representation of the amount of work an object can do.**

🔑**work is any energy transferred to or from the object, energy refers to the total amount of work the object could theoretically do.**

In algebraic terms:

- **$\Delta E = W$**

🔑**Both energy and work are scalar quantities measured in joules.**

🤔Forms of energy

There are several different forms of energy. These include:

✔️**Kinetic energy**

✔️**Gravitational potential energy**

✔ Heat energy

✔ Elastic potential energy (strain)

✔ Sound energy Chemical energy

✔ Electromagnetic energy (light)

✔ Nuclear energy

✔ Electrical energy

🤔 Kinetic energy(KE)

🔑 The amount of energy depends on the mass of the moving object.

🔑 Kinetic energy is calculated using the equation below:

$$\text{kinetic energy} = \tfrac{1}{2}mv^2$$

🔑 The faster an object moves, the more kinetic energy it has.

🔑 The greater the mass, the more kinetic energy it has.

🔑 If velocity doubles, kinetic energy increases four times (because is squared).

🔑 As a result it will change its kinetic energy and this change will be equal to the energy transferred (or work done).

🤔 In terms of equations we have:

In terms of equations we have:

- Work done = change in kinetic energy
- $W = \Delta Ek = Ek_2 - Ek_1$
- $W = \tfrac{1}{2}mv^2_2 - \tfrac{1}{2}mv^2_1$
- $W = \tfrac{1}{2}m(v^2_2 - v_1{}^2)$

🤔 Potential energies

🔑 potential energy the ability of an object to do work as a result of its relative position.

🔑 The potential energy of an object is usually given the symbol (U).

🤔 Gravitational potential energy

🔑 The most common potential energy is gravitational potential energy (GPE).

🔑 GPE depends on three factors, its mass, the gravitational field strength (g) and its position in the field

🔑 We usually deal with GPE with reference to the surface of the Earth. Therefore, on the ground an object has 0 J of GPE.

$$GPE = mgh$$

GPE=Gravitational potential energy

m = mass in kg.

g = gravitational field strength (on Earth this is 10 N/kg or more precisely 9.81 N/kg).

h = height above the ground

🤔Elastic potential energy

🔑**Another common potential energy is elastic potential energy (EPE), sometimes called strain energy.**

🔑**Elastic potential energy the energy stored in a spring as a result of it being stretched or compressed.**

🔑**This gives us the equation for EPE:**

- **Elastic potential energy = ½ F Δx**

F = force in (N)

Δx = extension of spring in (m)

🤔Total energies and energy changes

🔑**The total mechanical energy of a system is the sum of all the possible kinetic and potential energies**

$$E_{total} = KE + PE$$

Etotal=total mechanical energy

KE=kinetic energy

PE=potential energy

🤔Conservation of energy

🤔The law of conservation of energy

🔑**Law of conservation of energy, states:the total energy of a closed system must remain constant.**

🔑**this means energy cannot be created or destroyed only transferred from one place to another or transformed from one type to another.**

🤔Kinetic energy and momentum

🤔**Kinetic Energy (KE):Kinetic energy is the energy an object possesses due to its motion. The formula for kinetic energy is:**

$$KE = \frac{1}{2}mv^2$$

KE= Kinetic energy (in Joules, J)

M= Mass of the object (in kilograms, kg)

V = Velocity of the object (in meters per second, m/s)

🔑**Kinetic energy is a scalar quantity.**

🔑**It depends on the square of the velocity, which means that even small increases in velocity lead to significant increases in kinetic energy.**

🤔**Momentum (p):Momentum is the product of an object's mass and its velocity. The**

formula for momentum is

$$P = m\,v$$

P = Momentum (in kg·m/s)

M = Mass of the object (in kg)

V = Velocity of the object (in m/s)

🔑**Momentum is a vector quantity,**

🔑**The direction of the momentum is the same as the direction of the velocity.**

🔑**, if the velocity doubles, the momentum doubles, but the kinetic energy goes up by four.**

🤔**The Relationship of Kinetic energy and momentum**

$$KE = P^2/2m$$

🤔**Elastic and inelastic collisions**

😕**Collisions are events where two or more objects come into contact, and energy and momentum are transferred between them.**

😕**Elastic Collisions**

🔑**An elastic collision is a type of collision where both momentum and kinetic energy are conserved.**

🔑**This means that after the collision, the total kinetic energy of the system is the same as it was before the collision.**

🔑**Momentum is conserved:Momentum before = momentum after; momentum has been conserved**

🔑**Kinetic energy before = kinetic energy after; kinetic energy has**
been conserved and therefore it is a perfectly elastic collision.

😕**Before Collision**

🔑**Momentum (Before)**

👌$P_{total} = m_1v_1 + m_2v_2$

🔑**Kinetic energy (Before)**

👌$KE_{total} = \frac{1}{2}m_1v_1^2 + m_2v_2^2$

😕**After Collision**

Momentum (After)

👌$P_{total} = m_1v_1 + m_2v_2$

Kinetic energy (After)

👌$KE_{total}=\frac{1}{2}m_1v_1^2+m_2v_2^2$

🤔Inelastic Collisions

🔑An inelastic collision is a type of collision in which momentum is conserved, but kinetic energy is not conserved.

🔑Pbefore = Pafter; momentum has been conserved.

🔑KEbefore > KEafter; kinetic energy is not conserved

🤔Before Collision

Momentum

👌$P_{total}=m_1v_1+m_2v_2$

Kinetic energy

👌$KE_{total}=\frac{1}{2}m_1v_1^2+m_2v_2^2$

🤔After Collision

Momentum

👌$P_{total}=m_1v_1+m_2v_2$

Kinetic energy

👌$KE_{total}=\frac{1}{2}m_1v_1^2+m_2v_2^2$

🤔Energy in oscillating systems

🔑GPE is converted into kinetic energy. The same is true if you throw an object into the air. Here the kinetic energy is transformed into GPE as it rises.

👌The total mechanical energy = kinetic energy + potential energy

🤔Energy resources

🔑Energy resource a source of energy that can be used by a country or its population.

🔑Globally the most common method for generating electricity involves the burning of fossil fuels such as coal, oil and natural gas.

🤔Renewable energy resources

🔑Resources that do not involve a fuel that will eventually run out are referred to as renewable.

🔑Wind, solar, geothermal and hydroelectric energy resources all offer significant benefits; however, they each have their drawbacks.

🤔Mechanical power

What is power?

- Power is the rate of doing work.

🔑power is the work done per second.

🔑**A greater power means more work is done per second or more energy is transferred per second.**

🤔**An equation for average power is:**

- **Power = work done / time taken**
- **P = W/t**

P = average power in W.

W = work done in J.

t = time in s.

🔑**Power is measured in watts (or kilowatts, etc).**

👌**1watt=1J/s**

🔑**The watt is the SI derived unit of power.**

🤔**Comparing the joule and the kilowatt-hour**

👌**Joule**

- **Work done = power × time**
- **[J] = [W] x [s]**

Work done in J

Power in W

Time in s

👌**Kilowatt-hour**

- **Work done = power × time**
- **[kWh] = [kW] x [h]**

Work done in kWh

Power in kW

Time in hr

🤔**Power and velocity**

🔑**We can look at this process more mathematically by combining the equations for mechanical work and power and we get:**

- **Power = work done / time**
- **Power = force × distance moved against force /time**
- **Average velocity = distance moved against force /time**

So

- **Power = force × velocity**
- **P = F v**