

Topic: Energy - Forces Doing Work	Duration: 2 Lessons	Composite: Unit test
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Key vocabulary:	Core knowledge Components Powerful knowledge components crucial to commit to long term memory (IN RED BOX)	Links to previous and future topics
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Energy
Work
Power
System
Watt
Sankey
Chemical
Thermal
Gravitational
Kinetic
Radiation
Conservation

ENERGY – FORCES DOING WORK

Systems

- A system is an object or group of objects being studied that are energy stores
- A closed system is a system which experiences no external forces
 - E.g. a circuit, or a skydiver
- In a closed system, the total energy remains the same at all times

Work Done

- Measured in Joules (J)
- The term used to describe the energy involved when an external force transfers energy to a system (e.g. a person pushing a ball up a hill)
- Have to have a force moving an object

Power

- Power is the rate of energy transfer.
- Measured in Watts (W)
- 1 Watt = 1 Joule of energy transferred in 1 second

Energy Stores & Transfers

- Useful energy is energy that has been transferred to a desired store
- Wasted energy is energy that has not been transferred to a useful store
- Mechanical processes are wasteful when they get hot (usually due to friction)
 - Energy is dissipated as heat, causing a rise in temperature
 - So the energy is lost to the surrounding
- Sankey diagrams show: the input and output energy stores; state useful and wasted energies; state amounts of energy
- Efficiency is a measure of how good a machine is at transferring energy into useful stores.

Energy Transfer Diagram for Filament Lamp

Sankey diagram: e.g. washing machine

Formula for the Efficiency of a Device:

USEFUL ENERGY OUT

÷

TOTAL ENERGY IN

× 100 =

PERCENTAGE EFFICIENCY

USEFUL WORK DONE

÷

TOTAL ENERGY SUPPLIED

× 100 =

PERCENTAGE EFFICIENCY

Principle of the Conservation of Energy: Energy cannot be created or destroyed but can be transferred from one store to another.

- Gravitational Potential Energy = energy involved when an object changes height**

Potential Energy

$$E_p = mgh$$

m = mass of object (kg), *g* = gravity (9.8 newton), *h* = height object raised (m)

KINETIC ENERGY

Objects that are moving have kinetic energy, equation:

$$E_k = \frac{1}{2} \times \text{mass (kg)} \times \text{speed}^2 (\text{m/s}^2)$$

- Energy Stores: Chemical, Thermal, Kinetic, Gravitational Potential, Elastic Potential, Nuclear, Magnetic, Electrostatic**
- Energy transfers: transfer energy from one store to another:**
 - Electrical – through electric currents
 - Mechanical – through forces or particles
 - Heating – through differences in temperature from hotter to colder
 - Radiation – as electromagnetic waves e.g. visible light, ultraviolet, infrared etc.

W
Work Done
(J)

F
Force
(N)

d
Distance
(m)

J
Joules
Energy

P
Power
(Watts)

T
Time
(seconds)

Y7: Energy
Y8: Heating & Cooling
Y9: Energy, Force in a Newtonian World, Motion
KS4: Conservation of Energy, Forces, Forces and their Effects
KS5 Physics: Forces in Action, Work, Energy and Power

Impressive reading	Impressive speaking	Impressive writing	Resilience	Employability via:
In this experiment, students follow written instructions calculate their own work done and power in a simple timed lifting exercise. Students lift the object and return it to the floor 20 times, to allow a reasonable period for timing purposes.	Explain ways of reducing unwanted energy transfer through lubrication.	Ask students, in small groups, to write down any equations or definitions they already know for forces and/or energy, and their units. The groups should classify their ideas into 'definitely correct' and 'hopefully correct'	Determine own work done using practical work and calculations.	Heating Engineers, Product Design, Mechanical and Aeronautical Engineering, Manufacturing, Environmental Science and Design

CULTURAL CAPITAL: <https://www.youtube.com/watch?v=G8yKFVPOD6o&:text=http%3A%2F%2Fwww.ted.com,found%20in%20a%20library%20book>. William Kamkwamba – 14 year old boy from Malawi – designed and built windmill from spare parts (links to following topic on Forces and Effects also due to short length of topics).

SEND

- Opening activity/theme paired/groups equation recall from previous topics to ensure learner buy in
- Opportunities for retrieval practice and building on prior knowledge via starter activity and knowledge recall slides
- Multi-sensory approach using video, practical work, teacher explanation, calculations
- William Kamkwamba case study chosen to support cultural capital at KS4/KS5
- William Kamkwamba case study chosen as relatable
- William Kamkwamba case study chosen as it shows life skills to support the pathway into adulthood
- William Kamkwamba case study chosen due to cross curricular links with Geography and DT
- Repetition of key vocabulary in every lesson
- Curriculum time allocated for the explicit teaching of key vocabulary
- Skills ordered logically and sequenced with an increase in complexity
- Links to prior learning explicitly highlighted to support non-verbal reasoning

Topic: KS4 FORCES AND THEIR EFFECTS

Duration: 3
LESSONS

Composite:
Unit test

Key
vocabulary

Core knowledge Components
Powerful knowledge components crucial to commit to long term memory (IN RED BOX)

Links to previous
and future topics

Contact
Non-contact
Force
Friction
Action
reaction
Field
Gravitational
Magnetic
Electrostatic
Resultant
Free body
Scalar
Vector
Scale
lubrication

KS4: FORCES & THEIR EFFECTS

Object Interactions

• 2 types of interactions: contact & non-contact

Non-contact Interactions:-

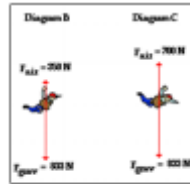
- Gravitational attraction - always an attraction between two objects with mass
 - larger mass gives greater attraction
- Electrostatic attraction/repulsion
 - A larger charge gives greater force
 - Like charges repel, opposite charges attract
- Magnetic attraction/repulsion
 - A stronger magnet gives stronger field, having a greater force
 - Like poles repel, opposite poles attract

Contact Interactions:-

- Normal contact force - the force is perpendicular to the plane of contact
- Friction - Surfaces that are rough cause friction when moved

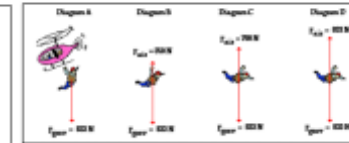
Scale Drawings

- Length of each arrow represents its size
- Direction with larger arrows shows resultant force
- If arrows are in opposite directions with equal length (Equal in magnitude but opposite in direction):-
 - The forces cancel out
 - So the object is in equilibrium
 - So travels at a constant velocity
- At B, the drag is a lot less than the weight, as shown by the arrows, so the resultant force causes him to accelerate
- At C, the difference in arrow lengths is less, so the resultant force is smaller, so smaller acceleration



Skydiver - Forces that act are air resistance and weight

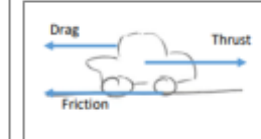
- Initially, the skydiver has no air resistance and the only force acting on him is weight
- As he falls, he accelerates, increasing his speed
- This makes air resistance increase
- Therefore, the resultant force decreases
- Therefore, acceleration decreases as $F=ma$, so he is not speeding up as quickly
- Eventually weight and air resistance are equal and balanced, so there is no resultant force



- So there is no acceleration and terminal velocity is reached

Vehicle

- Initially, low air resistance and thrust is only hindered by friction
- Air resistance increases, decreasing resultant force
- Eventually the car is travelling at terminal velocity, where the thrust is balanced by drag and friction, so no resultant force acts
- This is immediately changed when more thrust is added, as it now becomes the resultant force until the drag increases to balance it again



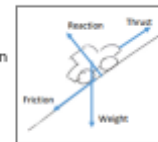
Vectors

- A vector has size and direction – e.g. a force of 10N directed downwards
 - Weight, velocity, force, displacement, acceleration
- Scalar has just size – so direction plays no part in describing the value
 - Mass, distance, speed, temperature

Vector diagrams

Free body diagrams:-

- Shows the direction of forces that are present in a situation
- The reaction force always acts at 90° to the surface from the point of contact
- Friction acts in the opposite direction to movement, along line of contact
- Weight always acts downwards, acting from Centre of Mass



Lubrication – reduces friction, so reduces unwanted energy transfer (so less heat loss etc.) and increases efficiency

Y7: Forces & Space

Y9: Forces in a Newtonian World, Motion

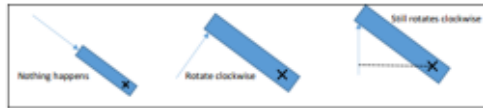
KS4: Forces and Motion, Forces and Matter, Magnetism and Electromagnetism, Static Electricity, Astronomy

KS5 Physics: Gravitational, Magnetic and Electric Fields, Forces and Motion

PHYSICS GCSE ONLY

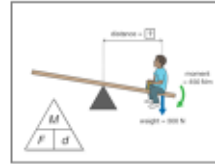
Rotation:-

- Occurs if an object is:-
 - attached to a **pivot point**
 - (Pivot = a point which it can rotate about, but cannot move away from)
 - And a **force is applied not towards the point** (see diagram)
 - If the force is applied perpendicular to the object it will move about the pivot in this direction
 - If the Force is applied not perpendicular to the object
 - Need to find perpendicular distance from pivot to line of force
 - See which direction it will turn

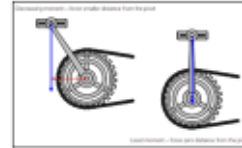


Moments

- Moment of a force = force (newton, N) × distance perpendicular to the direction of the force (metre, m) (newton metre, N m)



- Bike Riding – pressing your foot down on the pedal, causes a moment about the pivot, turning the pedal arms

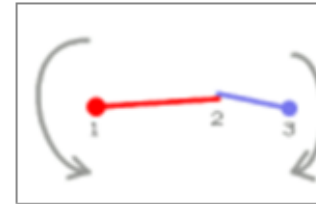


- equilibrium occurs when: sum of anticlockwise moments = sum of clockwise moments

Levers and Gears

- Gears can change speed, force or direction by rotation
- E.g. when the **first gear** is supplying the force:-
 - If connected to a gear with fewer teeth (i.e. a smaller gear)
 - The second gear will turn faster
 - But with less force
 - In opposite direction to first gear
 - If connected to a gear with more teeth (i.e. a larger gear)
 - Turns slower
 - More force
 - In opposite direction

- The **second** gear will always turn in the opposite direction
 - The blue gear is supplying the power
 - To increase the power, a larger gear is used for the secondary (red)
 - As the force on the red gear is a further distance from its pivot, the momentum of the larger gear is greater



Impressive reading	Impressive speaking	Impressive writing	Resilience	Employability via:
Reading information relating to multiple forces and translating information into a mathematical diagram.	Show examples of aeroplanes landing in strong cross-winds, ideally clips taken from the end of the runway so it is clear that the aeroplane is not pointing along the runway as it lands. Ask how the landing would look different if the wind was a different strength.	Explain why a satellite orbiting Earth at constant speed is accelerating.	Use scale drawings to work out the resultant of forces at different angles	Mechanical and Aeronautical Engineering, Astrophysics, Product Design, Sports Science,

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SEND	<ul style="list-style-type: none"> • Opportunities for retrieval practice and building on prior knowledge – Knowledge recall slide in each lesson • Multi-sensory approach using practical work, watching clips, listening to teacher explanations/models, use of diagrams as representations • Repetition of key vocabulary in every lesson • Curriculum time allocated for the explicit teaching of key vocabulary • Skills ordered logically and sequenced with an increase in complexity • Links to prior learning explicitly highlighted to support non-verbal reasoning
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