# IGCSE Physics

## Forces and their effects

# Forces and their effects

## Part 1

- Contact and Non-contact Forces
- Gravity
- Resultant Forces

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# LearnIT!
# KnowIT!

**Part 1**

- **Contact and Non-contact Forces**
- **Gravity**
- **Resultant Forces**

# Contact and Non-contact Forces

**Forces can be placed into two groups. There are forces that act on contact and there are forces that act at a distance.**

| Contact Forces | Non-Contact Forces |
|---|---|
| Air Resistance | Gravity |
| Friction | Magnetism |
| Tension | Electrical Force |
| Normal Force | Nuclear Force |

# Scalar and Vector Quantities

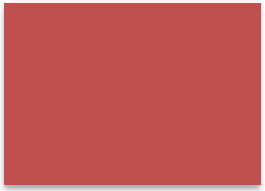
**Materials in a classroom can be grouped into two groups – metals and non-metals.**

**Things we measure can be put into two groups as well – scalars and vectors.**

**Scalars: Things that we measure that have a magnitude (size) only are scalars.**

**Vectors: Things that we measure that have both magnitude and direction are vectors.**

**Sometimes direction is really important. In a crash the direction, as well as the speed, of the vehicles will determine how much damage is caused.**



# Scalar and Vector Quantities

**Some examples of scalars and vectors are shown in the table below.**

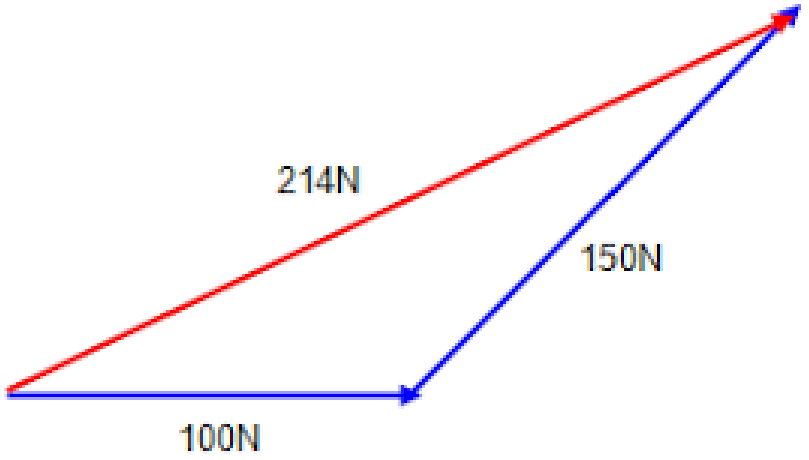
| Scalars | Vectors |
|---|---|
| Direction | Displacement |
| Speed | Velocity |
| Mass | Forces (including weight) |
| Temperature | Acceleration |
| Energy | Momentum |

From topic 2

# Representing Vectors

**Vectors can be shown by arrows.**

**The length of the arrow shows the size, or magnitude, of the force.**



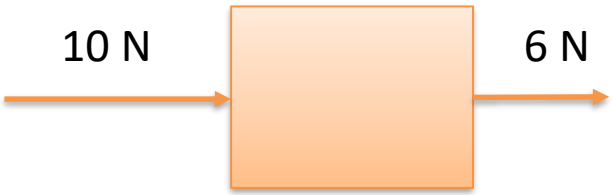

**The direction of the arrow shows the direction of the force.**

**The vector arrows can be added together to show the resultant of two of more vectors.**

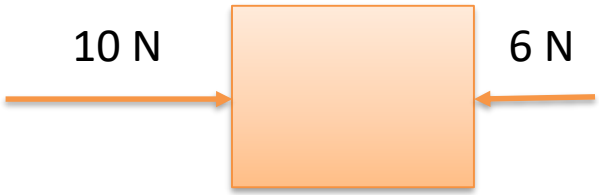
# Resultant Forces

**A number of forces acting on an object may be replaced by a single force that has the same effect as all the original forces acting together. This single force is called the resultant force.**

**When two forces act in a line the resultant force is the vector addition of the two vectors. Remember the direction is important.**




**R = 16 N to the right**




**R = 4 N to the right**

# Calculating Resultant Force

**Example 1:**

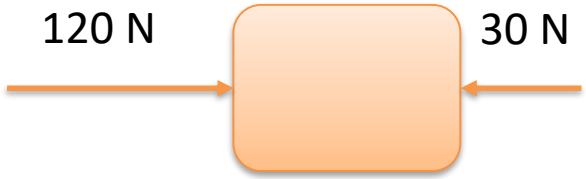
**A box is pushed along the floor with a force of 120 N. There is a resistive force of 30 N. Work out the resultant force on the box.**

**Solution:**

**Resistive forces act in the opposing direction to motion.**

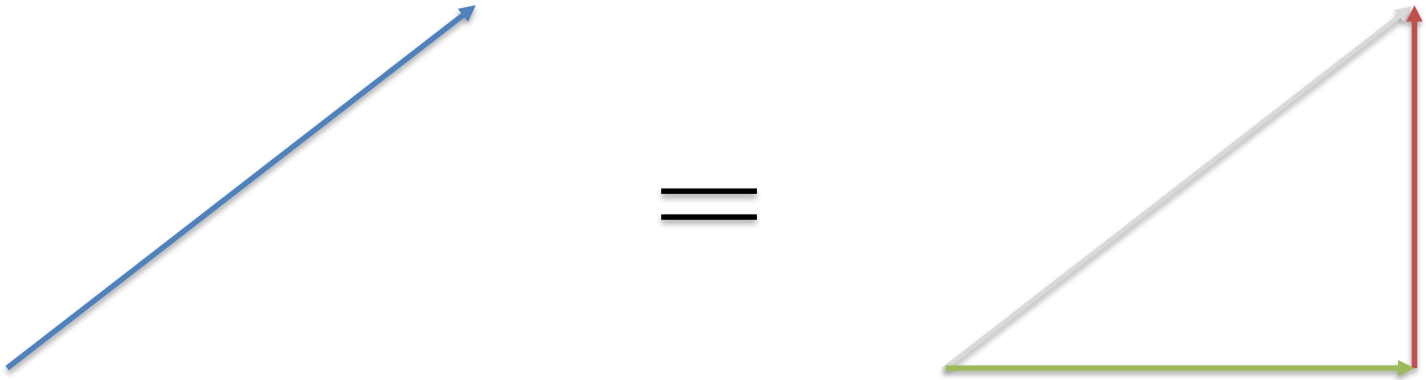
**Addition of the forces gives:**

**120 N + -30 N = 90 N in direction of 120 N force**



# Calculating Resultant Force… continued

**A single force can be resolved into two components acting at right angles to each other. The two component forces together have the same effect as the single force.**



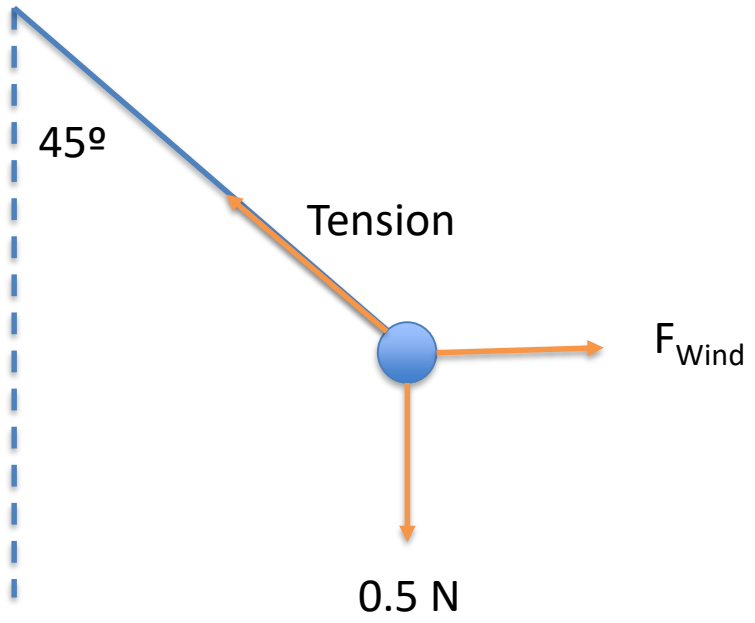
# Example

A pendulum has a weight of 0.5 N.

On a windy day the pendulum is hung outside and the pendulum now hangs at an angle of 45º.

Assuming the wind hits the pendulum moving horizontally, draw a free body diagram to represent the forces acting.

## Solution



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# QuestionIT!

## Part 1

- Forces
- Resultant force

1. Gravity is a force that acts at a distance.
   Name two other forces that act at a distance.

2. Name three contact forces.

3. A boy has a mass of 40 kg. Calculate the boy's weight.
   Take g = 10 N/kg.

4. What is a scalar quantity?

5. Explain how a car can be moving at a constant speed but have changing velocity.

6. State whether the following quantities are scalars or vectors:

**acceleration** **mass** **momentum** **time**

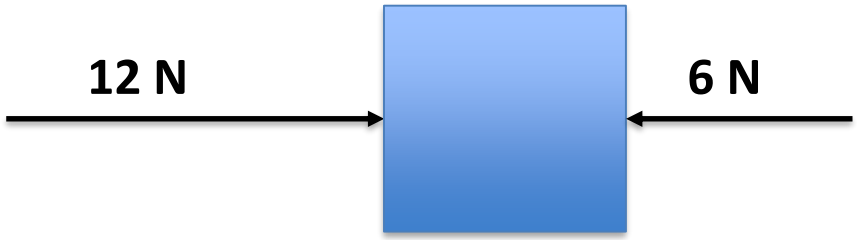
7. Name a piece of scientific equipment that you would use to find the weight of a block in a science laboratory.

8. The object below has two forces acting on it, shown by the arrows.

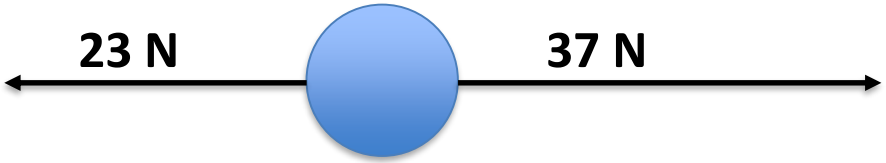
Draw an arrow to show the resultant force on the object

9. Calculate the resultant force acting on the objects below:

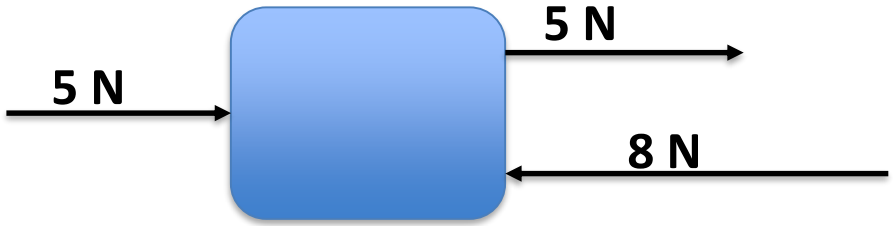
a)




b)




c)



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# AnswerIT!

## Part 1

- Forces
- Resultant force

1. Gravity is a force that acts at a distance.
   Name two other forces that act at a distance.
   Magnetism  Electrical Force  Nuclear Force

2. Name three contact forces.
   Tension  Friction (including air resistance)  Normal Force

3. A boy has a mass of 40 kg. Work out the boy's weight.
   Take g = 10 N/kg.
   Using

   $$W = m \times g$$

   Substitution gives

   $$W = 40 \times 10$$

   Answer

   $$W = 400 \text{ N}$$

4. What is a scalar quantity?

Scalars quantities have magnitude ONLY i.e. no direction.

5. Explain how a car can be moving at a constant speed but have changing velocity.

As velocity is a vector if the direction of the car changes the velocity will change, at a constant speed.

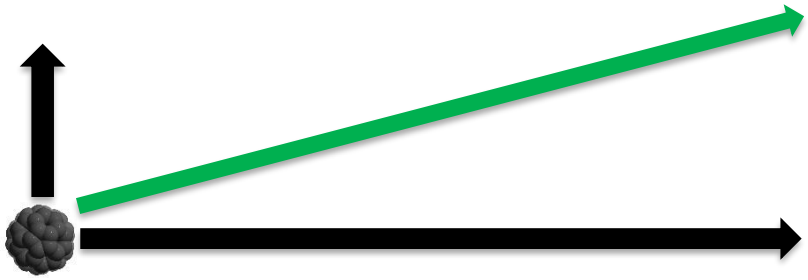
6. State whether the following quantities are scalars or vectors:

| acceleration | mass | momentum | time |
|---|---|---|---|
| vector | scalar | vector | scalar |

7. Name a piece of scientific equipment that you would use to find the weight of a block in a science laboratory.

A newtonmeter

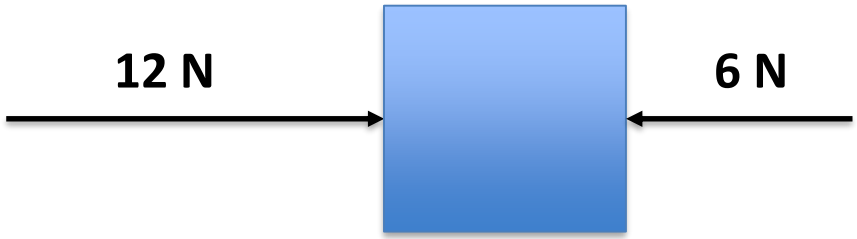
8. The object below has two forces acting on it, shown by the arrows.



Draw an arrow to show the resultant force on the object

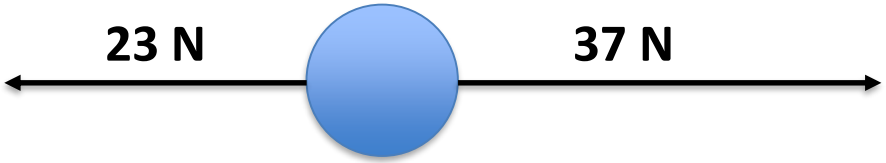
## 9. Calculate the resultant force acting on the objects below:

a)



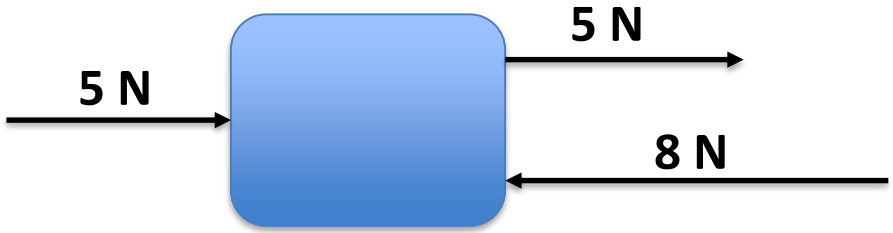

Resultant Force = 6 N Right

b)




Resultant Force = 14 N Right

c)




Resultant Force = 2 N Right

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## Part 2

- Moments (physics only)

# Moments. Levers and Gears

**Moments: A force or a system of forces may cause an object to rotate.**

**Everyday examples of force causing a rotation motion include door handles, steering wheels and see-saws.**

**The turning effect of a force is called the moment of the force.**
**The size of the moment is determined by the equation:**

**moment of a force (Nm) = force (N) × distance (m)**

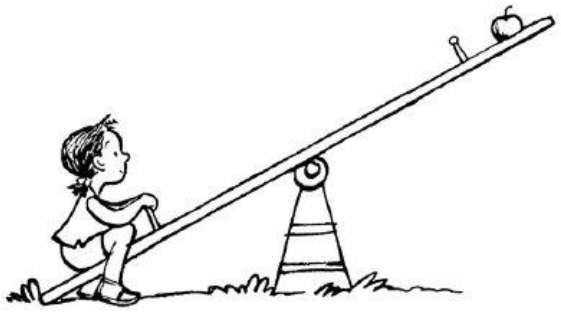
$$M = F \times x$$

**The distance, $x$, is normal to the direction of the force**

# Moment Calculations

**A child with a weight of 400 N sits on see-saw.**

**The child sits a distance of 1.2 m from the pivot.**



**Work out the moment of the turning force.**

**Solution:**

**Equation:** moment of a force (Nm) = force (N) × distance (m)

$$M = F \times x$$

**Substitution :** moment of a force = 400 x 1.2

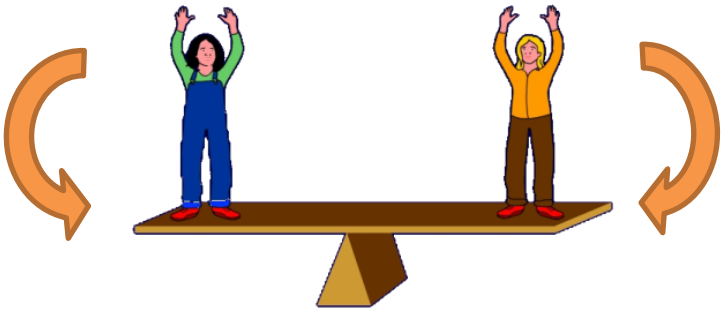
Click to reveal answer

# Balanced Moments

**When two children are on a see-saw the see-saw may be balanced and the children will not move.**

**In this case the clockwise moment is balanced by the anti-clockwise moment – so the two moments are equal.**

**anti-clockwise moment**



**clockwise moment**

**As both the clockwise moment and anti-clockwise moment are balanced:**

$$F_c x_c = F_a x_a$$

**Where the subscript denotes the direction (clockwise or anti-clockwise).**

# Balanced Moments Calculations

**A see-saw has two children sat either side of the pivot.**

**The child on the left-hand side has a weight of 370 N and site 1.3 m from the pivot.**

**The child on the right sits 2.0 m from the pivot.**

**Work out the weight of the child on the right-hand side of the pivot if the see-saw is balanced.**

**Solution:**

**As both the clockwise and anti-clockwise moments are balanced:**

$$F_c \, x_c = F_a \, x_a$$

$$370 \times 1.3 = F_a \times 2.0$$

$$481 / 2.0 = F_a$$

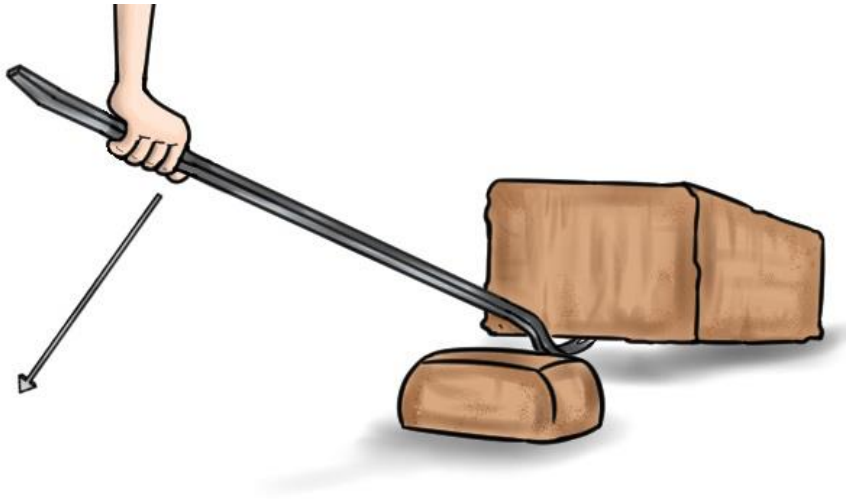
Click to reveal answer

# Levers

**Levers are used to increase the force applied to an object, usually to lift it up from a surface.**

**A crowbar is an example of a lever. Crowbars can be used to lift up floorboards that have been nailed down.**

**Levers must have a pivot to rotate around and will work on the principle of moments.**



By pushing down on the crowbar the object is lifted upwards.

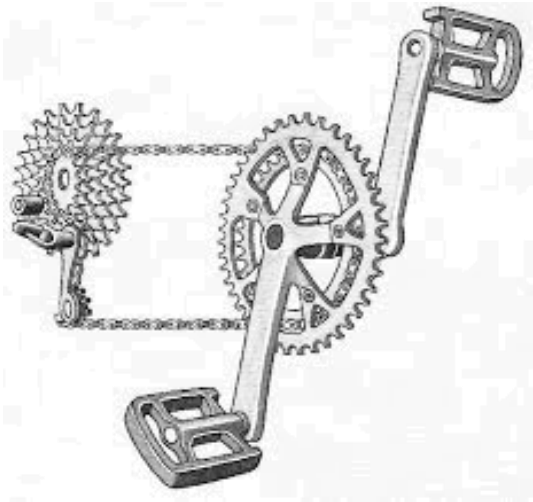
# Gears

**A gear is a wheel that has teeth on it (also known as a cog), as shown in the diagram opposite. For gears to do work you need at least two gears.**

**Gears are used to transmit rotational forces from one place to another.**

**On a bicycle the gears are connected through a chain, though gears can be connected together so that the teeth of the gears interlock.**

When the large gear rotates once the smaller gear may rotate many times.

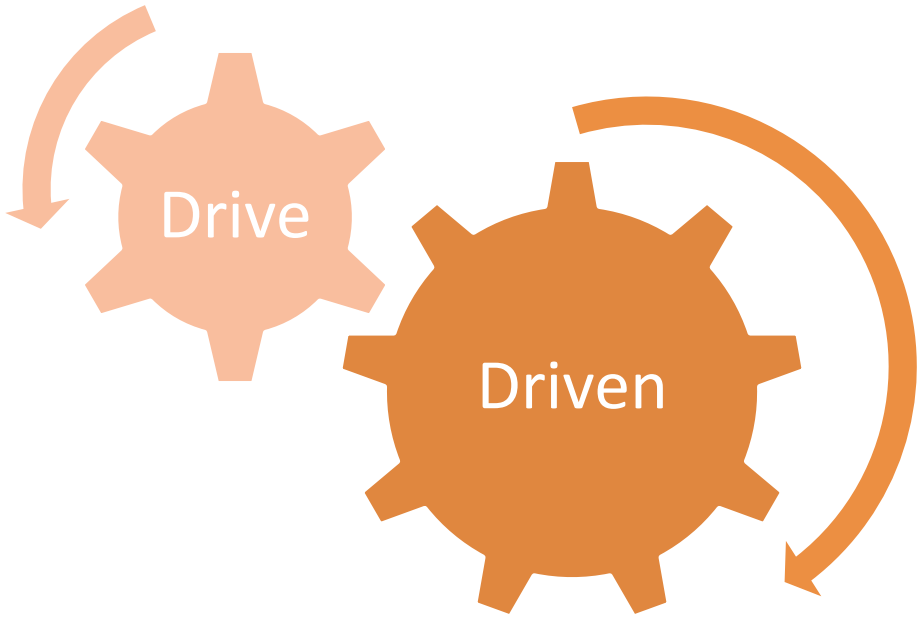


Sometimes gears are connected by a chain.

# Rotating Gears

**When two cogs are in contact with their teeth interlocking, the driven cog will rotate in the opposite direction to the drive cog.**

**If the drive cog in a gear spins clockwise then the driven cog will spin anti-clockwise.**



# Speed of Gears

**When a large cog is driving a small cog, then the small cog will rotate faster than the large cog.**

**Halving the number of teeth on the small cog will double the speed of the small cog.**

**Going from a large cog to a smaller cog will increase the speed of rotation.**


Speed 2 will be faster than Speed 1 as there are fewer teeth on the cog.

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# QuestionIT!

## Part 2

- Moments (physics only)

## Part 2 - QuestionIT

1. State the equation used to find the moment of a force.

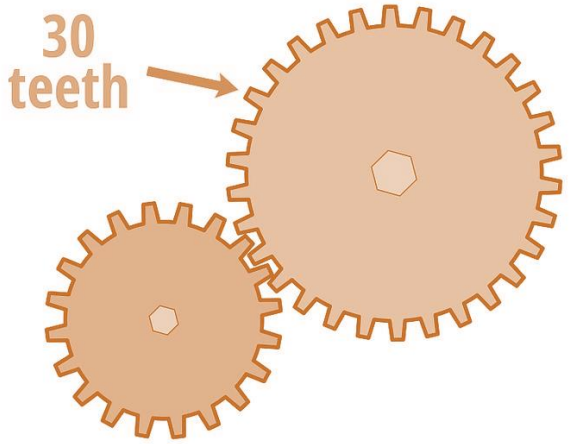
2. A 30 cm long spanner is used to undo a nut. A force of 20 N is applied to the end of the spanner.
   Calculate the moment of force applied to the spanner.

3. Two children sit on a see-saw on opposite sides of the pivot.
   One child has a weight of 340 N and sits 1.2 m from the pivot.
   If the other child has a weight of 420 N how far does this child need to sit from the pivot for the see-saw to be balanced?

4. A crowbar is used to lift up a floor board. The crowbar has a length of 40 cm from the pivot to the end of the crowbar, and the distance from the bend to the lifting point is 12 cm.
If the force applied to the end of the crowbar is 300 N, work out the size of the force applied to the floor board.

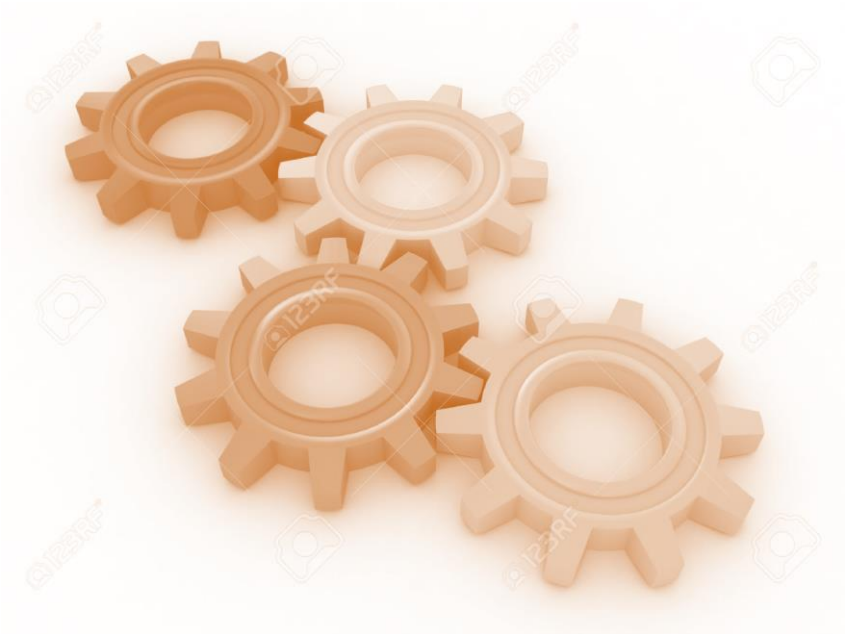
5. A box with a weight of 400 N is raised using a lever 2 m long. The lever rotates around a pivot 50 cm from the lifting end of the lever. Work out the force applied to the end of the lever.

6. The 30 tooth large cog is made to rotate in a clockwise direction. In which direction will the smaller cog rotate?




7. In the gear system shown above, the 30 tooth cog rotates once every 5 seconds. The smaller cog has 20 teeth. Calculate how long it will take to the smaller cog to complete one revolution.

8. Look at the following gear system. In which direction will the yellow cog rotate if the red cog is made to rotate anti-clockwise?



# AnswerIT!

## Part 2

- Moments (physics only)

# Part 2 - AnswerIT

1. State the equation used to find the moment of a force.
   Moment = force x distance

2. A 30 cm long spanner is used to undo a nut.
   A force of 20 N is applied to the end of the spanner.
   Work out the moment of force applied to the spanner.
   Moment = force x distance
   Moment = 20 x 0.3
   Moment = 6 Nm

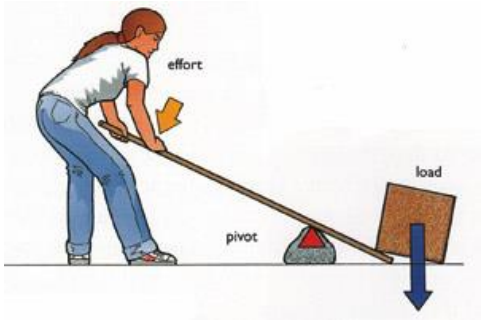
3. Two children sit on a see-saw on opposite sides of the pivot.
   One child has a weight of 340 N and sits 1.2 m from the pivot.
   If the other child has a weight of 420 N how far does this child need to sit from the pivot for the see-saw to be balanced?
   Clockwise and anti-clockwise moments must be balanced
   so, 340 x 1.2 = 420 x distance from pivot
   so, distance from pivot = 0.97 m

# Part 2 - AnswerIT

4. **A crowbar is used to lift up a floor board. The crowbar has a length of 40 cm from the pivot to the end of the crowbar, and the distance from the bend to the lifting point is 12 cm.**
**If the force applied to the end of the crowbar is 300 N, work out the size of the force applied to the floor board.**

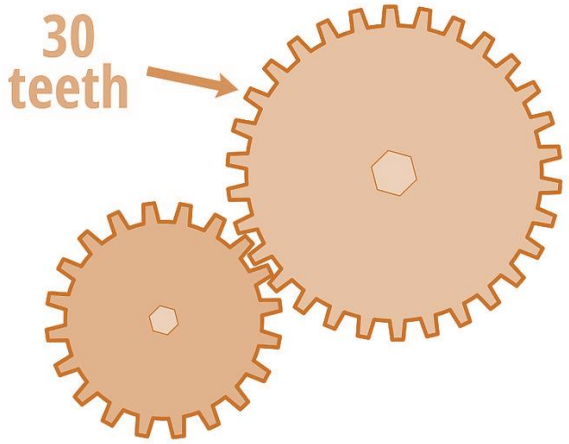
As the moment on either side of the pivot is equal
300 x 0.4 = force x 0.12
So, force applied to the floor board = 1000 N

5. **A box with a weight of 400 N is raised using a lever 2 m long. The lever rotates around a pivot 50 cm from the lifting end of the lever. Work out the force applied to the end of the lever.**




As the moment on either side of the pivot is equal
Force Applied x 1.5 = 400 x 0.5
Force applied = 133.3 N

6. The 30 tooth large cog is made to rotate in a clockwise direction. In which direction will the smaller cog rotate?



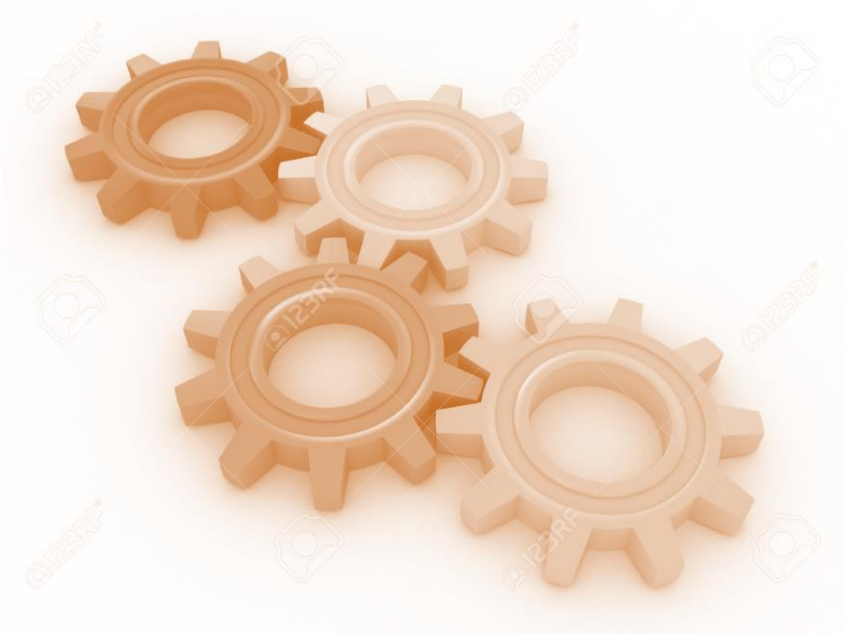

Anti-clockwise

7. In the gear system shown above, the 30 tooth cog rotates once every 5 seconds. The smaller cog has 15 teeth. Calculate how long it will take to the smaller cog to complete one revolution.

2.5 seconds

As there are half the number of teeth the cog will spin twice as fast.

8. **Look at the following gear system.**
**In which direction will the yellow cog rotate if the red cog is made to rotate anti-clockwise?**



**Clockwise**
**If red spins anti-clockwise then the green will spin clockwise, blue anti-clockwise making the red cog spin clockwise.**