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SESSION 1: FORCES

Key Concepts

In this session we

- Define the concept of a force
- Represent forces using vector diagrams
- Solve problems when two or more forces acting on an object
- Identify different forces including friction and the normal force

X-planation

What is a force?

A force is a push or a pull exerted by one object on another object. Force is a vector quantity.

A vector is a mathematical tool we use in Physics when quantities have size (magnitude), direction and a specific S.I unit. Quantities that have size (magnitude) and a specific S.I unit but no direction, are called **scalar quantities**.

How do we represent a force acting on an object?

We use an arrow to represent a force. We say the arrow has a head and a tail.

The length of the arrow – from tail to head - indicates the size (magnitude)
The direction of the force is shown by the direction in which the arrow head points

What are co-linear forces?

When forces act in the same line or are parallel to each other they are co-linear. We can provide a sign for direction. E.g to the left is negative and to the right is positive or Up is positive and down is negative.

We can calculate the overall effect of co-linear forces by adding them together using the sign convention.

Free-body diagrams

We draw diagrams to show all the forces acting on an object. Draw the object as a dot and the forces as arrows with the tail on each arrow on the object.

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Adding two Forces together

When we add two or more forces together we call the single force that can replace all the forces the resultant or net force

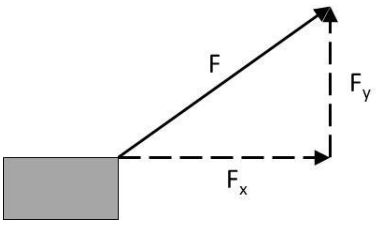
There are two methods you must know:

- Scale diagram
- By calculation using Pythagoras and trigonometry

Components of a Force

Any force can be broken down into two components, namely a horizontal component (F_x) and a vertical component (F_y)
Where:

$$Fx = F \cos \theta$$
$$Fy = F \sin \theta$$



Common Forces

- Force of Friction
- Normal force – acts at 90^0 to any surface

Static Friction

The equation is $f_s = \mu_s F_N$

Where: f_s = static friction (N)
μ_s = coefficient of static friction
F_N = normal force (N)

Kinetic Friction

The equation is $f_k = \mu_k F_N$

Where: f_k = kinetic friction (N)
μ_k = coefficient of kinetic friction
F_N = normal force (N)

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X-ample Questions

Question 1

A young boy with a mass of 58 kg uses a rope to climb a wall. When he reaches a height of 8,5m above the ground, he stops to take a rest. He is still pulling on the rope with his hands but at the same time his feet are pushing against the wall.

a.) Identify all the forces acting on the boy
b.) Draw a free body diagram to show these forces

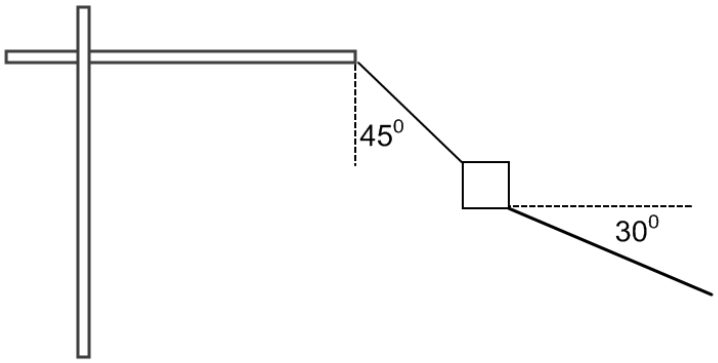
Question 2

Two boys attach a rope to a box, placed on a smooth horizontal surface.
The one boy exerts a force of 8N on the rope and the other boy exerts a force of 6N at 900 to the other force, using his rope.
Find the resultant of these two forces.

Question 3

A crane is used to lift a load with a mass of 525kg from the ground onto the top of a building. The tension in the cable of the crane is 5500N at an angle of 450 to the vertical

A construction worker guides the load into position by pulling it, using a strong rope. The rope makes and angle of 300 to the horizontal. The tension in the rope is 2400N.



Calculate the resultant force applied to the load

Question 4

What is the minimum force required to move a cupboard with a mass of 430kg that is resting on a carpet? The co-efficient of static friction for these surfaces is μ = 0,56

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X-ercises

Question 1

James exerts a force of 12N on a box placed on a horizontal frictionless surface. At the same time, precious exerts a force of 5N at an angle of 90^0 to the force James applies. Calculate the magnitude and direction of the resultant of these two forces.

Question 2

A 50 kg crate is placed on a slope that makes an angle of 30^o with the horizontal. The box does **not** slide down the slope. Calculate the magnitude and direction of the frictional force and the normal force.

Question 3

A frictional force of 15 N acts on a box while it is slowing down from an initial speed of 5 $m.s^{-1}$.The box has a mass of 25 kg. Calculate the co-efficient of kinetic friction.

Answers to X-ercises

1. F_{net} = 13N at an angle of 67.38^0 to the 5N force
2. F_f = 245N up the slope and F_N = 424,35N away from the slope at 90^0
3. u_k = 0,06