Resolving Forces 1i

A Level

Three coplanar forces of magnitudes $5.00\,\mathrm{N}$, $8.00\,\mathrm{N}$ and $8.00\,\mathrm{N}$ act at the origin O of rectangular coordinate axes. The directions of the forces are as shown in **Figure 1**.

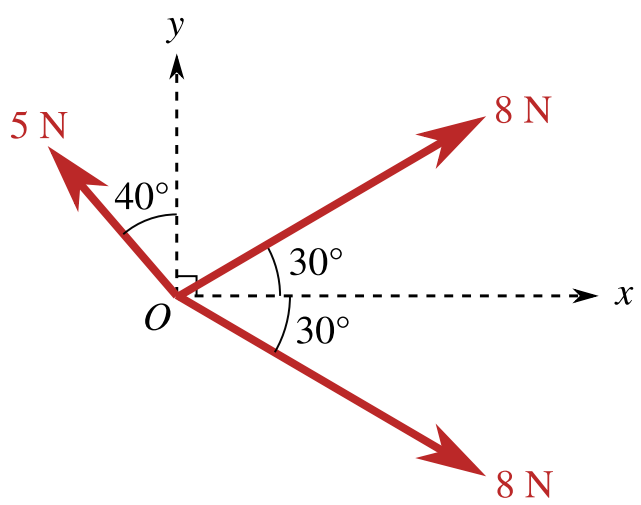

Figure 1: The magnitudes and directions of the three forces.

Part A The x component

Find the component of the resultant of the three forces in the x-direction.

Part B The y component

Find the component of the resultant of the three forces in the y-direction.

Part C The magnitude

Find the magnitude of the resultant.

Part D The direction

Find the direction of the resultant, as an anti-clockwise angle from the positive x-axis. Give your answer in degrees to 3 significant figures

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Used with permission from UCLES, A Level Maths, January 2005, OCR M1, Question 3

Resolving Forces 2i

A Level

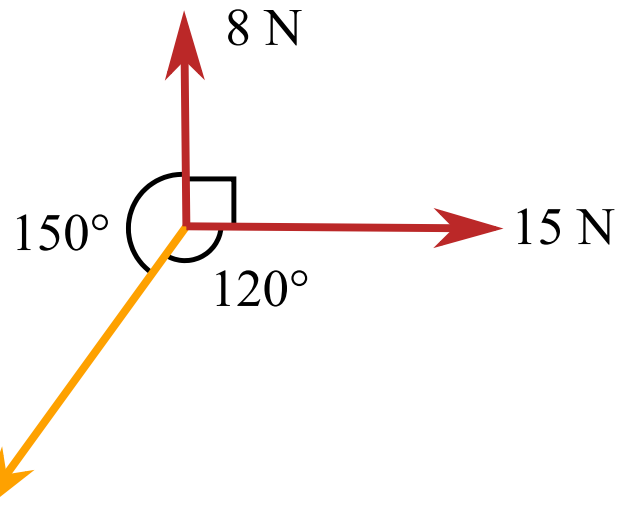

Figure 1: Three horizontal forces of magnitudes $8\,\mathrm{N}$, $15\,\mathrm{N}$ and $20\,\mathrm{N}$ acting at a point

Three horizontal forces of magnitudes $8\,\mathrm{N}$, $15\,\mathrm{N}$ and $20\,\mathrm{N}$ act at a point. The $8\,\mathrm{N}$ and $15\,\mathrm{N}$ forces are at right angles. The $20\,\mathrm{N}$ force takes an angle of $150\,^\circ$ with the $8\,\mathrm{N}$ force and an angle of $120\,^\circ$ with the $15\,\mathrm{N}$ force.

Part A Resultant force

Calculate the component of the resultant of the three forces, along the direction of the $15\,\mathrm{N}$ force.

Calculate the component of the resultant of the three forces, along the direction of the $8\,\mathrm{N}$ force. Give your answer to 3 significant figures.

Part B Magnitude and angle

Calculate the magnitude of the resultant force to 3 significant figures.

Calculate the angle it makes with the direction of the $8\,\mathrm{N}$ force to 3 significant figures.

Part C Greatest and least

The directions in which the three horizontal forces act can be altered.

State the greatest possible magnitudes of the resultant force to 2 significant figures.

State the least possible magnitudes of the resultant force.

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Friction 2ii

A Level

A block B of mass $0.8\,\mathrm{kg}$ is pulled across a horizontal surface by a force of $6\,\mathrm{N}$ inclined at an angle of $60\,^\circ$ to the upward vertical. The coefficient of friction between the block and the surface is 0.2.

Part A Vertical component

Calculate the vertical component of the force exerted on B by the surface. Give your answer to 3 significant figures.

Part B Acceleration of B

Calculate the acceleration of B correct to 3 significant figures.

Part C Time taken for B

The $6\,\mathrm{N}$ force is removed when B has speed $4.9\,\mathrm{m\,s^{-1}}$.

Calculate the time taken for B to decelerate from a speed of $4.9\,\mathrm{m\,s^{-1}}$ to rest. Give your answer correct to 2 significant figures.

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

General Contact Force 1ii

A Level

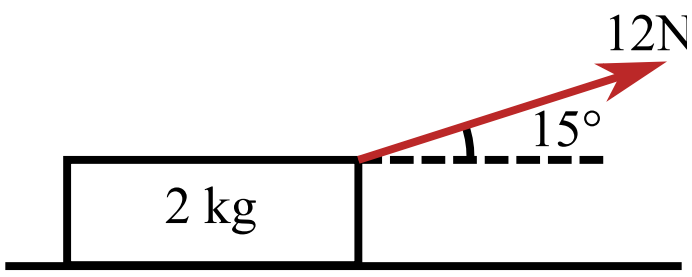

Figure 1: A block resting on a rough horizontal plane acted on by a force of $12\,\mathrm{N}$ at an angle of 15° to the horizontal.

A block of mass $2\,\mathrm{kg}$ is at rest on a rough horizontal plane, acted on by a force of magnitude $12\,\mathrm{N}$ at an angle of 15° upwards from the horizontal.

Part A Frictional component

Find the frictional component of the contact force exerted on the block by the plane. Give your answer to 3 significant figures.

Part B Magnitude of normal component

Find the magnitude of the normal component of the contact force exerted on the block by the plane, correct to 3 significant figures.

Part C Coefficient of friction

It is given that the block is on the point of sliding.

Find the coefficient of friction between the block and the plane.

Part D Acceleration of block

The force of magnitude $12\,\mathrm{N}$ is now replaced by a horizontal force of magnitude $20\,\mathrm{N}$. The block starts to move.

Assuming that the frictional force due to the rough plane has the same coefficient of friction as that found in Part C, find the acceleration of the block correct to 3 significant figures.

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

General Contact Force 1i

A Level

A particle P of mass $0.6\,\mathrm{kg}$ is projected up a line of greatest slope of a plane inclined at $30\,^\circ$ to the horizontal. P moves with deceleration $10\,\mathrm{m\,s^{-2}}$ and comes to rest before reaching the top of the plane.

Part A Frictional force

Calculate the frictional force acting on P to 3 significant figures.

Part B Finding μ

Calculate the coefficient of friction between P and the plane to 3 significant figures.

Part C P in motion

For when P is **in motion**, find the magnitude of the contact force exerted on P by the plane. Give your answer to 3 significant figures.

For when P is **in motion**, find the angle between the contact force and the upward direction of the line of greatest slope. Give your answer to 3 significant figures.

Part D P at rest

For when P is **at rest**, find the magnitude of the contact force exerted on P by the plane. Give your answer to 3 significant figures.

For when P is **at rest**, find the angle between the contact force and the upward direction of the line of greatest slope. Give your answer to 2 significant figures.

Adapted with permission from UCLES, A Level, January 2011, OCR M1, Question 7

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Motion on Inclined Planes 1i

A Level

A and B are two points on a line of greatest slope of a plane inclined at $45\,^\circ$ to the horizontal and $AB = 2.0\,\mathrm{m}$. A particle P of mass $0.40\,\mathrm{kg}$ is projected from A towards B with speed $5.0\,\mathrm{m\,s^{-1}}$. The coefficient of friction between the plane and P is 0.20.

Part A Speed of P

Given that the level of A is above the level of B, calculate the speed of P when it passes through the point B.

Part B Time taken by P

What is the time taken for P to travel from A to B?

Part C P reaching B

Given instead that the level of A is below that of B, will P reach B?

- Yes, it reaches B with a speed of $2\,\mathrm{m\,s^{-1}}$.
- No, it does does not reach B. It only travels $1.5\,\mathrm{m}$ up the incline.
- No, it does not reach B. It only travels $0.5\,\mathrm{m}$ up the slope.
- Yes, it just reaches B, but no further.

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Motion on Inclined Planes 3i

A Level

A particle P of mass $0.3\,\mathrm{kg}$ is projected upwards along a line of greatest slope from the foot of a plane inclined at 30° to the horizontal. The initial speed of P is $4\,\mathrm{m\,s^{-1}}$ and the coefficient of friction is 0.15. The particle P comes to instantaneous rest before it reaches the top of the plane.

Part A Moving up the plane

Calculate the distance P moves up the plane.

Part B Time taken

Find the time taken by P to return from its highest position on the plane to the foot of the plane. Give your answer to 3 significant figures.

Used with permission from UCLES, A Level, January 2012, OCR M1, Question 6

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Friction: Inclined Planes 1ii

A Level

A particle of mass $0.5\,\mathrm{kg}$ is held at rest at a point P, which is at the bottom of an inclined plane. The particle is projected up a line of greatest slope of the plane and starts to move with initial speed $3.6\,\mathrm{m\,s^{-1}}$.

Part A Speed of particle

The particle subsequently moves up the plane to a point Q, which is $0.3\,\mathrm{m}$ above the level of P.

Given that the plane is smooth, find the speed of the particle at Q. Give your answer to 3 significant figures.

Part B Frictional force

It is given instead that the plane is rough. The particle is now projected up the plane from P with initial speed $3\,\mathrm{m\,s^{-1}}$, and comes to rest at a point R which is $0.2\,\mathrm{m}$ above the level of P.

Given that the plane is inclined at 30° to the horizontal, find the magnitude of the frictional force on the particle to 3 significant figures.

Adapted with permission from UCLES, A Level, January 2013, OCR M2, Question 6

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Friction on Inclined Planes 1i

A Level

A board is fixed so that it makes an angle of $11\,^\circ$ with the horizontal. A block of mass $0.2\,\mathrm{kg}$ is placed on the board and then set in motion with an initial speed of $2\,\mathrm{m\,s^{-1}}$ down a line of greatest slope of the board. The block comes to rest in $4\,\mathrm{s}$. The coefficient of friction between the block and the board is μ.

Part A Deceleration

Find the deceleration of the block.

Part B Frictional force

Find the frictional force on the block while the block is in motion. Give your answer to 3 significant figures.

Part C Finding μ

Find the value of μ to 3 significant figures.

Part D Finding α 1

With the block at rest on the board, the inclination of the board is gradually increased. The angle that the board makes with the horizontal is α.

Find α when the block starts to slide. Give your answer to 3 significant figures.

Part E Finding α 2

Find α when the block is moving with acceleration of $g(1-\mu)\cos\alpha$.

Used with permission from UCLES, A Level, January 2004, OCR M1, Question 7

Gameboard:

STEM SMART Single Maths 37 - Forces & Friction

Friction on Inclined Planes 3i

A Level

A sledge of mass $25\,\mathrm{kg}$ is on a plane inclined at $30\,^\circ$ to the horizontal. The coefficient of friction between the sledge and the plane is 0.2.

Part A Tension in cable

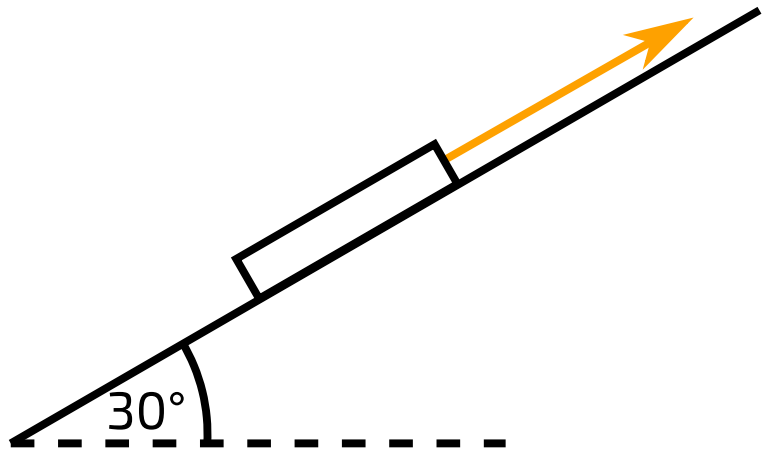

Figure 1: A sledge being pulled up an inclined plane.

The sledge is pulled up the plane, with constant acceleration, by means of a light cable which is parallel to a line of greatest slope. The sledge starts from rest and acquires a speed of $0.8\,\mathrm{m\,s^{-1}}$ after being pulled for $10\,\mathrm{s}$.

Ignoring air resistance, find the tension in the cable correct to 3 significant figures.

Part B Least value of P

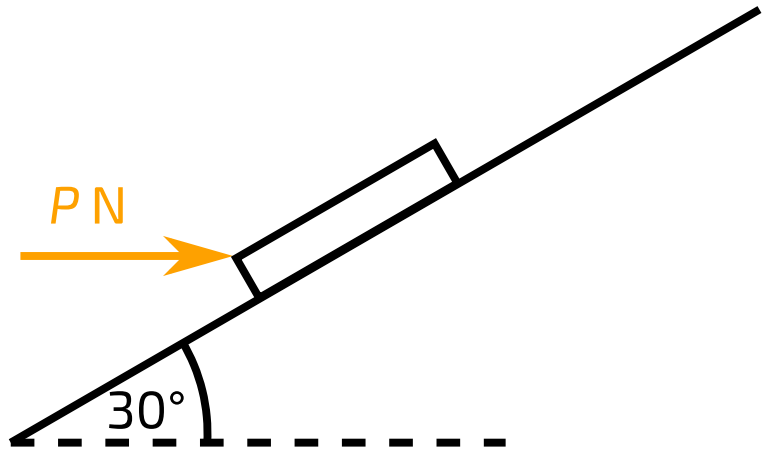

Figure 2: A sledge held at rest by a horizontal force on an inclined plane.

On a subsequent occasion the cable is not in use and two people of total mass $150\,\mathrm{kg}$ are seated in the sledge. The sledge is held at rest by a horizontal force of magnitude P newtons, as shown in Fig. 2.

Find the least value of P which will prevent the sledge from sliding down the plane. Give your answer correct to 3 significant figures.
