2D Vectors & NII 1ii

A Level

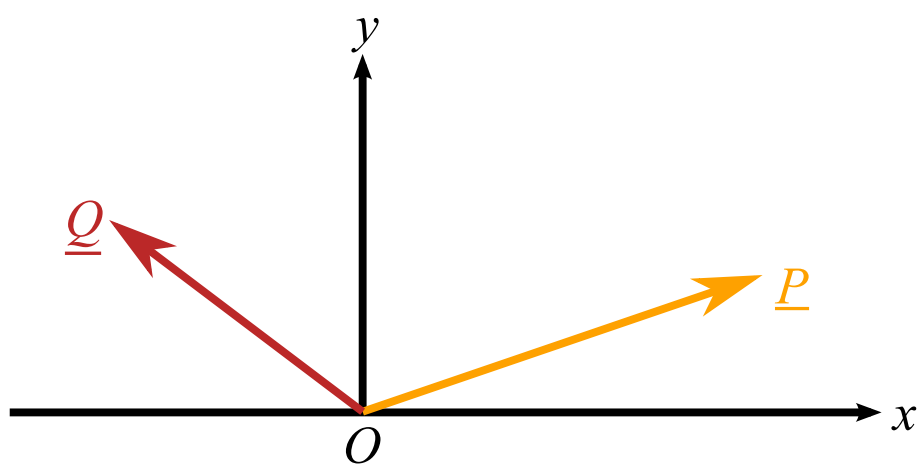

Figure 1: Two horizontal forces P and Q acting at the origin of a point O as viewed from above.

Two horizontal forces P and Q act at the origin O of rectangular coordinates Oxy. The components of P in the x- and y-directions are $14\,\mathrm{N}$ and $5\,\mathrm{N}$ respectively. The components of Q in the x and y directions are $-9\,\mathrm{N}$ and $7\,\mathrm{N}$ respectively as shown in **Figure 1**

Part A Resultant force 1

Write down the x-component of the resultant of P and Q.

Write down the y-component of the resultant of P and Q.

Part B Resultant force 2

Find the magnitude of this resultant of resultant force.

Find the angle the resultant makes with the positive x-axis to 3 significant figures.

Part C Acceleration

The two forces P and Q act on a particle of mass $0.2\,\text{kg}$. Express the acceleration of the particle using ijk notation.

The following symbols may be useful: `a, i, j, k`

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2D Vectors & NII 2ii

A Level

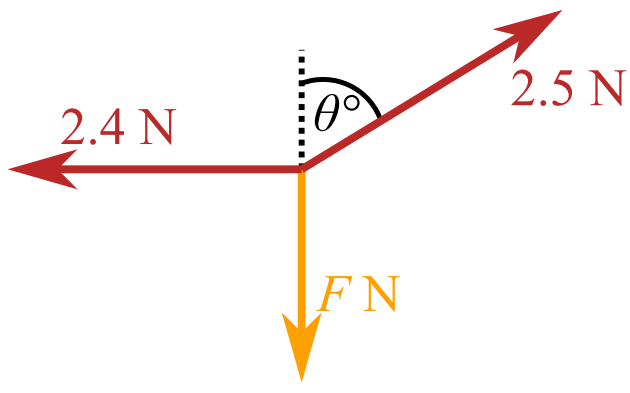

Figure 1: Diagram showing three forces acting on a particle.

A particle rests on a smooth horizontal surface. Three horizontal forces of magnitudes $2.5\,\mathrm{N}$, $F\,\mathrm{N}$ and $2.4\,\mathrm{N}$ act on the particle on bearings $\theta\,^\circ$, $180\,^\circ$ and $270\,^\circ$ respectively. The particle is in equilibrium.

Part A Vector notation

The $2.5\,\mathrm{N}$ force may be written in the form $(p\,\underline{\boldsymbol{i}} + q\,\underline{\boldsymbol{j}})\mathrm{N}$. Write down the value of p.

Part B Finding F

Hence, find F.

Part C Finding θ

Find θ to 3 significant figures.

Part D Acceleration

The $2.4\,\mathrm{N}$ force suddenly ceases to act on the particle, which has mass $0.2\,\mathrm{kg}$.

Find the magnitude of the acceleration of the particle.

Find the direction of the acceleration of the particle in the form of a bearing.

Gameboard:

STEM SMART Single Maths 21 - Forces and Motion

Friction 2i

A Level

P P P

A particle of mass $2\,\mathrm{kg}$ is propelled in a straight line across a rough surface with an initial velocity $\underline{\boldsymbol{u}} = 12\underline{\boldsymbol{i}} + 9\underline{\boldsymbol{j}}\,\mathrm{m\,s^{-1}}$. It comes to rest in 3 seconds.

Assuming that the frictional force is constant throughout the motion and no other forces are acting, what is the magnitude of the frictional force?

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STEM SMART Single Maths 21 - Forces and Motion

Friction 1ii

A Level

A block of mass $4\,\mathrm{kg}$ is in equilibrium on a rough surface under the influence of a horizontal force, X, of $11.8\,\mathrm{N}$.

Part A Diagram

In addition to X there are three other forces on the block. Each of these forces is a different type. Choose the three types from the list below.

- [ ] Electrostatic
- [ ] Friction
- [ ] Magnetic
- [ ] Normal reaction
- [ ] Tension
- [ ] Weight

Part B Ratio of forces

Find the ratio of the frictional force, F, to the normal reaction, R. Give your answer to one decimal place.

Part C Finding M

A different block, of mass M, is placed on the same surface. A force of $16.8\,\mathrm{N}$ is applied in place of force X. Again the system is in equilibrium.

Assuming the same ratio applies to the frictional and normal forces, find the value of M to 3 significant figures.

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Newton's Laws 2i

A Level

A trailer of mass $500\,\mathrm{kg}$ is attached to a car of mass $1250\,\mathrm{kg}$ by a light rigid horizontal tow-bar. The car and trailer are travelling along a horizontal straight road. The resistance to motion of the trailer is $400\,\mathrm{N}$ and the resistance to motion of the car is $900\,\mathrm{N}$. Find both the tension in the tow-bar and the driving force of the car in each of the following cases.

Part A Driving force 1

The car and trailer are travelling at constant speed.

What is the driving force?

Part B Tension 1

What is the tension in the tow-bar?

Part C Driving force 2

The car and trailer have acceleration $0.6\,\mathrm{m\,s^{-2}}$.

What is the driving force of the car? Give your answer to 4 significant figures.

Part D Tension 2

What is the tension in the tow-bar?

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Normal Reaction 2i

A Level

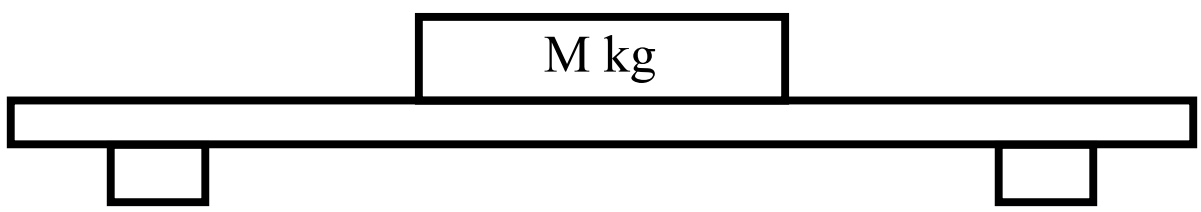

Figure 1: Diagram showing a block of mass $M\,\mathrm{kg}$ on a platform which is raised by a hoist.

A box of mass $M\,\mathrm{kg}$ is loaded onto a platform which can be raised by a hoist. The platform, which consists of 2 vertical supports and a horizontal plate, has a total mass of $30\,\mathrm{kg}$. Before the hoist is attached, the box and platform are on horizontal ground and the thrust in each support is $350\,\mathrm{N}$.

Part A Mass of box

Find the mass of the box to 3 significant figures.

Part B Normal reaction 1

The platform is now connected to the hoist cable, raised slowly by a short distance so that it leaves the ground, and brought to a halt.

Find the normal reaction on the box in this stationary position to 3 significant figures.

Part C Tension

Find the tension in the hoist cable.

Part D Normal reaction 2

The hoist suddenly jerks the platform upwards, with an initial acceleration of $1.5\,\mathrm{m\,s^{-2}}$.

Find the normal reaction on the box to 3 significant figures.

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Gameboard:

STEM SMART Single Maths 21 - Forces and Motion

Analysing Systems and Forces 2i

A Level

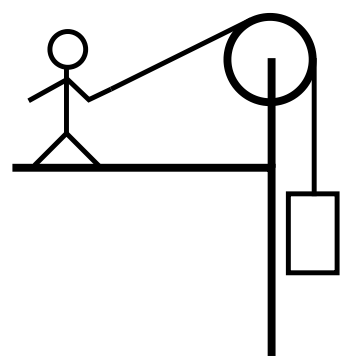

Figure 1: Man preparing to lower a box down a cliff.

A man is preparing to lower a box down a cliff. He sets up a fixed pulley with a rope as shown in **Figure 1**. He pulls on the rope with a force $-(100\,\underline{\boldsymbol{i}} + 75\,\underline{\boldsymbol{j}})\,\mathrm{N}$ and the box settles into a stationary position with the rope between the box and pulley vertical.

Part A Force in rope

The force **on the man's hand from the rope** can be written as

$$\underline{\boldsymbol{F}} = \begin{pmatrix} F_1 \\ F_2 \end{pmatrix}$$

Find F_1.

Find F_2.

Part B Magnitude of tension

What is the magnitude of the tension in the rope?

Part C Assumptions

In order to model the system mathematically, it is necessary to make assumptions. From the list below choose one assumption you need to make about the pulley and two assumptions about the rope.

- The pulley is [ ].
- The rope is [ ] and [ ].

Items:

inextensible **light** **slack** **smooth**

Part D Force diagrams

Choose the correct labels for the diagrams below, which show the forces in the rope at the pulley, and the forces on the box.

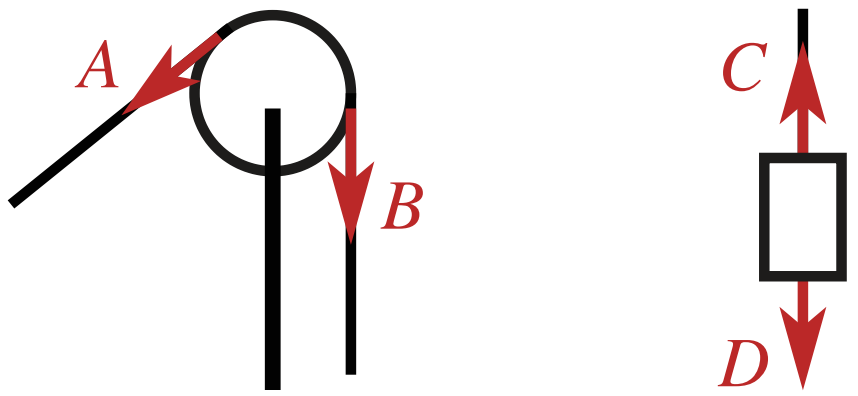

Figure 2: Force diagrams showing the forces in the rope at the pulley, and the forces on the box.

Force A: [ ]

Force B: [ ]

Force C: [ ]

Force D: [ ]

Items:

Tension, $75\,\mathrm{N}$ | **Tension,** $100\,\mathrm{N}$ | **Tension,** $125\,\mathrm{N}$ | **Weight,** mg

Part E Mass of box

Find the mass of the box to 3 significant figures.

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Gameboard:
STEM SMART Single Maths 21 - Forces and Motion

Analysing Systems and Forces 1i

A Level

P P P

A small, smooth pulley is suspended from a fixed point by a light chain. A light inextensible string passes over the pulley. Particles P and Q, of masses $0.30\,\mathrm{kg}$ and m respectively, are attached to the opposite ends of the string. The particles are released from rest at a height of $0.20\,\mathrm{m}$ above horizontal ground with the string taut; the portions of the string not in contact with the pulley are vertical. P strikes the ground with speed $1.4\,\mathrm{m\,s^{-1}}$. Subsequently P remains on the ground and Q does not reach the pulley.

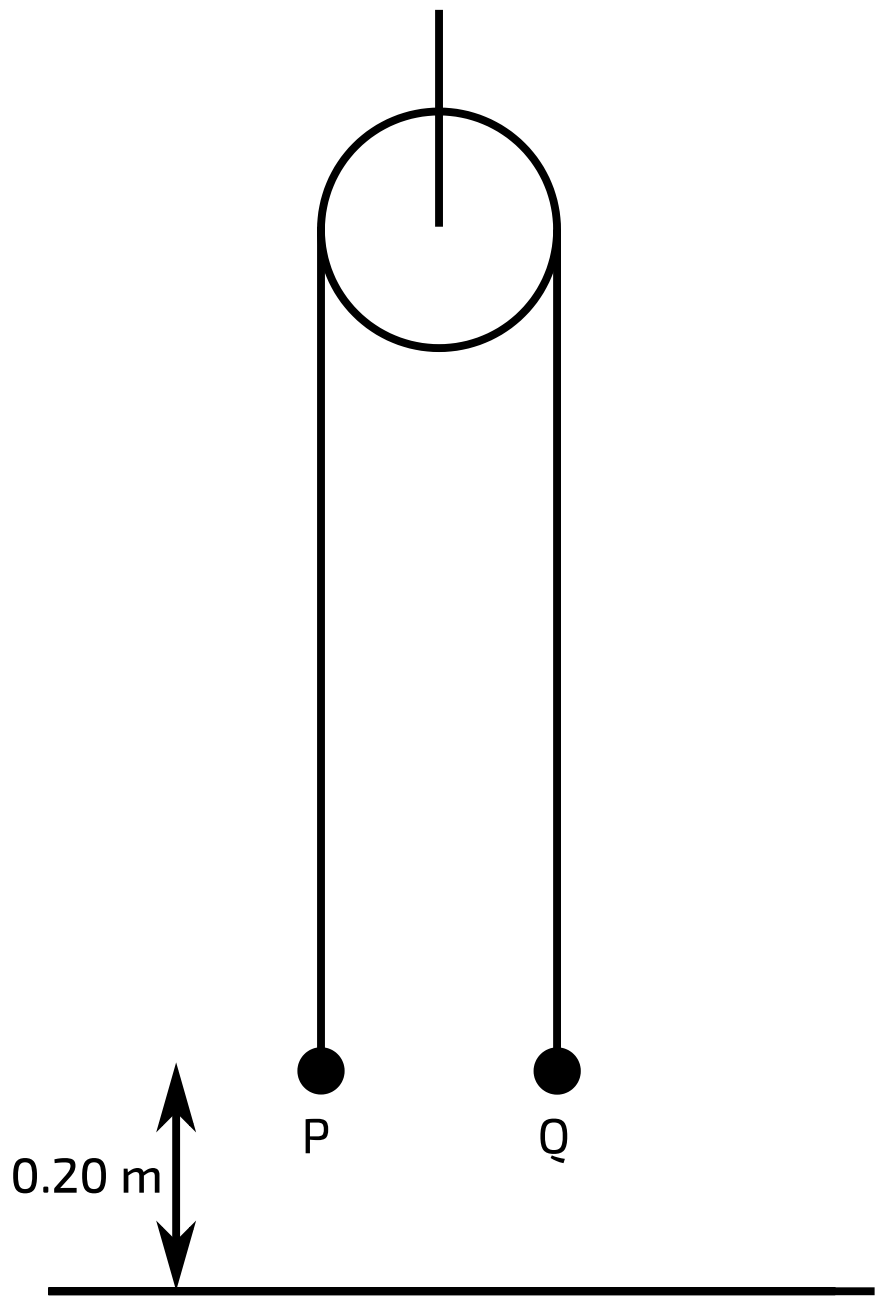

Figure 1: Diagram showing string with P and Q on either end passing over a pulley.

Part A Acceleration of P

Calculate the acceleration of P while it is in motion to 2 significant figures.

Part B Tension in the string

Calculate the tension in the string to 2 significant figures.

Part C Mass of Q

Find the mass of Q.

Part D Height of Q

Calculate the greatest height of Q above the ground.

Part E Tension in the chain

It is given that the mass of the pulley is $0.50\,\mathrm{kg}$.

State the magnitude of the tension in the chain which supports the pulley when P **is in motion**. Give your answer to 2 significant figures.

Part F Tension when Q moving upwards

State the magnitude of the tension in the chain which supports the pulley when P **is at rest on the ground and** Q **is moving upwards**. Give your answer to 2 significant figures.

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