Projectiles and a Lift

A Level

C C C

Part A Height of A

Two particles A and B are projected vertically upwards from horizontal ground at the same instant. The speed of projection of A and B are $7.0\,\mathrm{m\,s^{-1}}$ and $10.5\,\mathrm{m\,s^{-1}}$ respectively.

Give an expression for the height above the ground of A at time t seconds after projection.

The following symbols may be useful: `g`, `t`

Part B Height of B

Give an expression for the height above ground of B at time t seconds after projection.

The following symbols may be useful: `g`, `t`

Part C Height difference

Hence find a simplified expression for the difference in the heights of A and B at time t seconds after projection.

The following symbols may be useful: `g`, `t`

Part D Difference in maxima

Find the difference in the heights of A and B when A is at its maximum height. Give your answer to 2 significant figures.

Part E Up or down

At the instant when B is $3.5\,\mathrm{m}$ above A, find whether A is moving upwards or downwards.

- Upwards
- It's impossible to tell
- Downwards

Part F Height above ground

At the instant when B is $3.5\,\mathrm{m}$ above A.

Find the height of A above the ground. Give your answer to 2 significant figures.

Part G Stationary lift

A person of mass $70.0\,\mathrm{kg}$, and carrying a parcel of mass $5.00\,\mathrm{kg}$, stands in a lift.

Find the magnitude of the normal reaction force exerted by the floor of the lift on the person when the lift is stationary. Give your answer to 3 significant figures.

Part H Accelerating lift

Find the magnitude of the normal reaction force exerted by the floor of the lift on the person in the following situations.

(i) When the lift is moving upwards with acceleration $2.00\,\mathrm{m\,s^{-2}}$. Give your answer to 3 significant figures.

(ii) When the lift is moving downwards with acceleration $2\,\mathrm{m\,s^{-2}}$. Give your answer to 3 significant figures.

Part I Accelerating upwards

The person puts down the parcel on the floor of the lift and repeats the upward journey.

Does the person experience any change in the normal reaction force? Give your answer to 2 significant figures.

If your answer is no, then enter zero below. otherwise enter the amount that the normal reaction force has changed compared with when they were holding the parcel.

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Forces in Vector Form

A Level

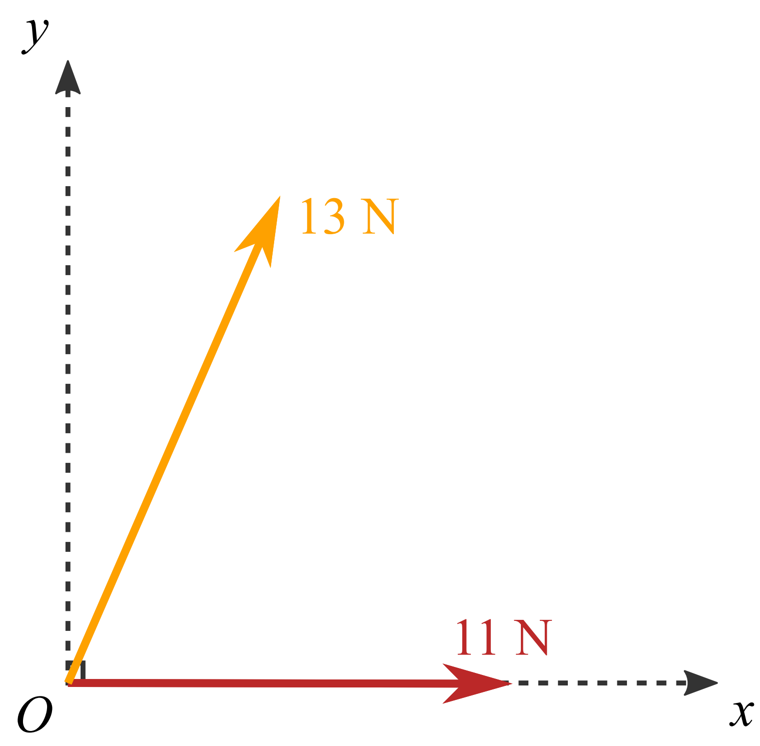

Figure 1: Forces of magnitudes $11\,\mathrm{N}$ and $13\,\mathrm{N}$ acting at the origin O.

Forces of magnitudes $11\,\mathrm{N}$ and $13\,\mathrm{N}$ act at the origin O. The force of magnitude $11\,\mathrm{N}$ acts along the x-axis. The resultant of the two forces has components $16\,\mathrm{N}$ in the x-direction and $Y\,\mathrm{N}$ in the y-direction.

Part A Find Y

By representing the two forces and their resultant in the form $\vec{F} = (F_1, F_2)$, calculate the magnitude of Y.

Part B Magnitudes

Find the magnitude of the resultant of the two forces.

Part C Angles

Find the angle between the resultant of the two forces and the x-axis. Give your answer to 3 significant figures.

Part D Particle acceleration

The two forces act upon a particle of mass $2\,\mathrm{kg}$.

Find the acceleration of the particle, expressing your answer in the form $a = xi + yj$ where i and j are the unit vectors in the x and y directions respectively.

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

Part E Third force

At a time t, a third force $\vec{F_3}$ is applied so that the particle continues its motion at constant velocity.

Write down $\vec{F_3}$ in the form $\vec{F_3} = pi + qj$ where i and j are the unit vectors in the x and y directions respectively.

The following symbols may be useful: `F_3, i, j`

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Gameboard:
STEM SMART Double Maths 16 - Mechanics Revision

Motion of a Train

A Level

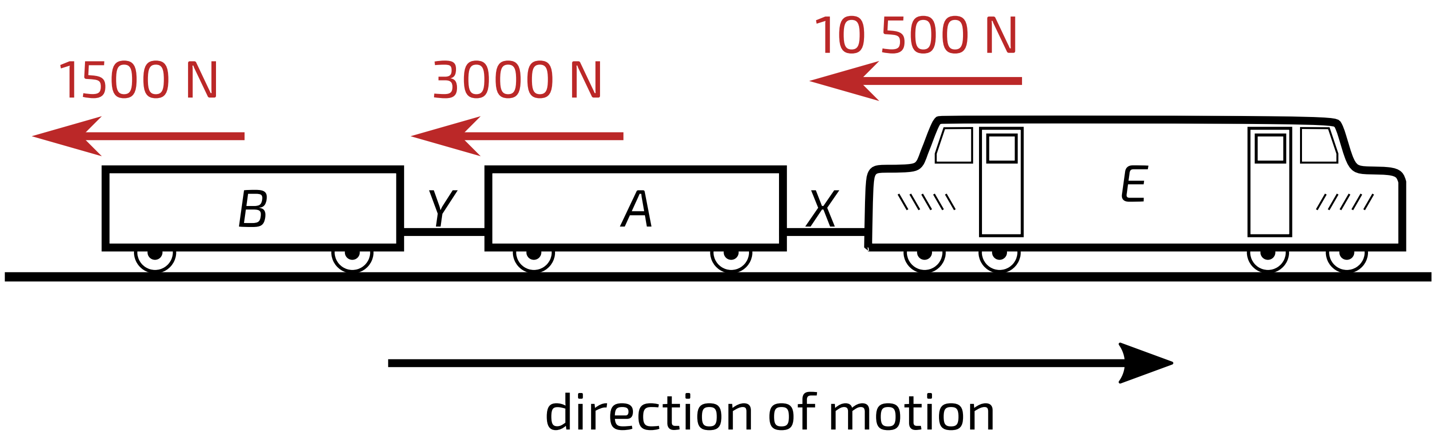

Figure 1: Diagram of a train of total mass $80,000\,\mathrm{kg}$ consisting of an engine E and two trucks A and B.

A train of total mass $80\,000\,\mathrm{kg}$ consists of an engine E and two trucks A and B. The engine E and truck A are connected by a rigid coupling X, and trucks A and B are connected by another rigid coupling Y. The couplings are light and horizontal. The train is moving along a straight horizontal track. The resistances to motion acting on E, A and B are $10\,500\,\mathrm{N}$, $3\,000\,\mathrm{N}$ and $1\,500\,\mathrm{N}$ respectively.

Part A Driving force

By modelling the whole train as a single particle.

Calculate the minimum driving force that the engine must provide so that the train does not decelerate.

Part B Force to accelerate

Calculate the acceleration of the train, when the magnitude of the driving force is $35\,000\,\mathrm{N}$.

Part C Mass of the engine

Hence find the mass of E, if the tension in the coupling X is $8\,500\,\mathrm{N}$ when the magnitude of the driving force is $35\,000\,\mathrm{N}$.

Part D Mass of B

The driving force is replaced by a braking force of magnitude $15\,000\,\mathrm{N}$ acting on the engine. The force exerted by the coupling Y is zero.

Find the mass of B.

Part E Force of coupling X

Under the same braking force, calculate the forward force the coupling X exerts on the engine.

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STEM SMART Double Maths 16 - Mechanics Revision

Kinematics Graphs

A Level

A man drives a car on a horizontal straight road. At $t = 0$ where the time t is in seconds, the car runs out of petrol. At this instant the car is running at $12\,\mathrm{m\,s^{-1}}$. The car decelerates uniformly, coming to rest when $t = 8$. The man then walks back along the road at $0.7\,\mathrm{m\,s^{-1}}$ until he reaches a petrol station a distance of $420\,\mathrm{m}$ from his car. After his arrival at the petrol station it takes him $250\,\mathrm{s}$ to obtain a can of petrol. He is then given a lift back to his car on a motorcycle. The motorcycle starts from rest and accelerates uniformly until its speed is $20\,\mathrm{m\,s^{-1}}$; it then decelerates uniformly, coming to rest at the stationary car at time $t = T$.

Part A (t, v) graph

Sketch the shape of the (t, v) graph for the man for $0 \leq t \leq T$. [Your sketch need not be drawn to scale yet numerical values should be shown].

To see an example sketch, answer the following question: What is the largest positive value of v on the graph?

Part B Finding deceleration

Find the deceleration of the car for $0 < t < 8$.

Part C Finding T

Find the value of T.

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Physics. You work it out.

Learning Zone: Resolving Forces

A Level

Year 1 Mechanics teaches how to combine 2 mutually perpendicular components of a force to find the magnitude and direction of the force.

Applications include finding the bearing of a force, where the perpendicular components are taken in directions East and North, and study of a mass on a horizontal surface where the components are taken parallel to the surface and vertically.

Resolving a force is the opposite process, where the components of the force are found in two mutually perpendicular directions: the force is represented as the hypotenuse of a right-angled triangle and trigonometry is used to find the components. This process is covered in the Isaac Physics concept page resolving vectors.

The key to using resolving of forces efficiently is to make the optimum decision for the orientation of the resolving directions. The problems below cover two common situations of increasing complexity:

1. Standard horizontal and vertical axes.
2. Inclined planes, where the axes are still parallel and perpendicular to the plane but the inclination of the plane means that weight must be resolved.

In some other situations resolving is most efficient by specifically choosing axes so that one axis is in the direction of one of the forces.

When you have completed the following examples there are other questions to try.

Part A y-component of resultant force

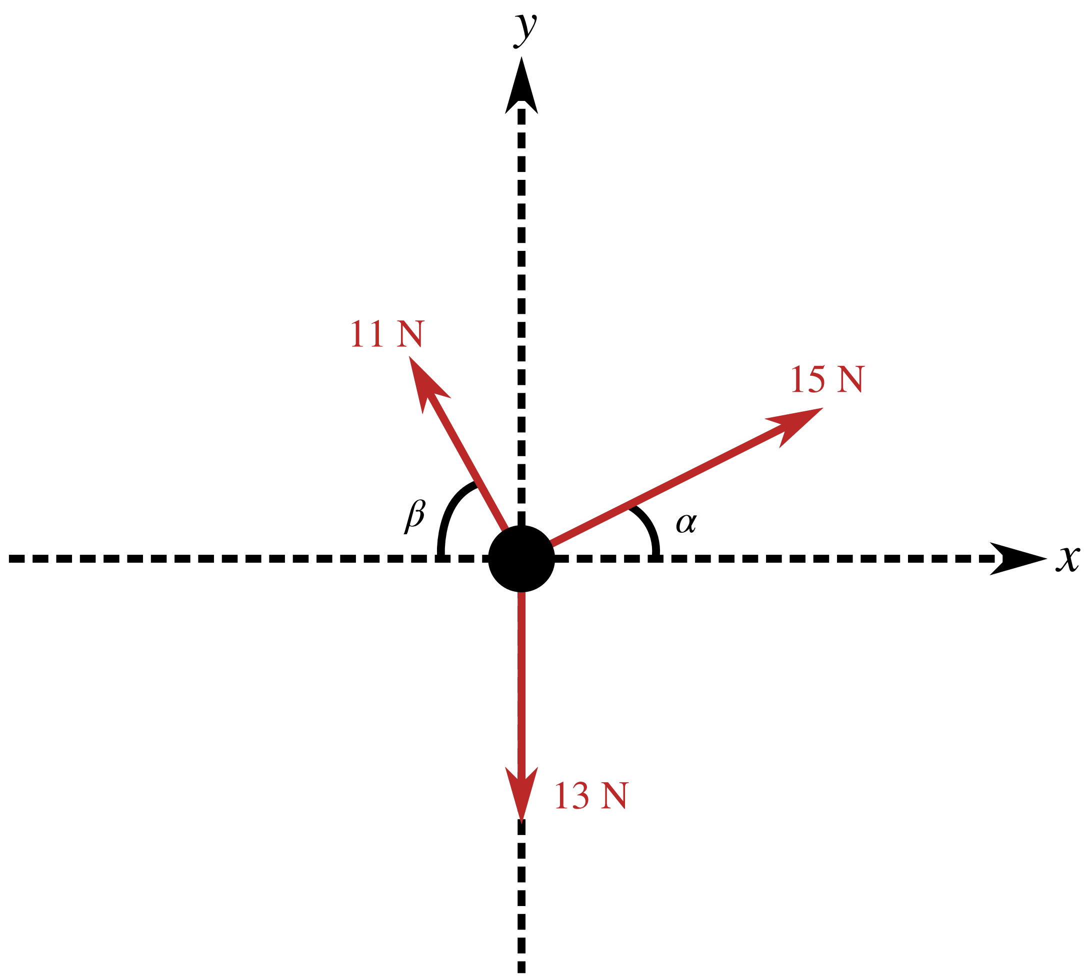

Figure 1: Three forces acting on a particle P.

Three horizontal forces of magnitudes $15\,\mathrm{N}$, $11\,\mathrm{N}$ and $13\,\mathrm{N}$ act on a particle P in the directions shown in the diagram.The angles α and β are such that $\sin\alpha = 0.28$, $\cos\alpha = 0.96$, $\sin\beta = 0.8$ and $\cos\beta = 0.6$.

What is the component in the y-direction of the resultant of the three forces?

Part B Magnitude and direction of the resultant force

Find the magnitude of the resultant of the three forces.

State the direction of the resultant of the three forces.

- Along the negative y-axis.
- Along the positive x-axis.
- Along the negative x-axis.
- Along the positive y-axis.

Part C Force diagram

A block of mass $2\,\mathrm{kg}$ is at rest on a rough plane which is inclined at $25\,^{\circ}$ to the horizontal.

Draw a labelled diagram showing the forces acting on the block.

Easier question?

Part D Resolving forces 1

By resolving the weight of the block parallel and perpendicular to the plane, find the...

magnitude of the frictional force F to 3 significant figures.

the normal reaction R to 3 significant figures.

Part E Direction of resultant force 2

Which direction does the resultant of the normal reaction and frictional force act

- Downwards normal to the plane
- Horizonally right
- Downwards parallel to the plane
- Upwards normal to the plane
- Vertically down
- Vertically up
- Upwards parallel to the plane
- Horizontally left

What is the magnitude of the resultant of the normal reaction and frictional force? Give your answer to 3 significant figures.

Part F Resolving forces 2

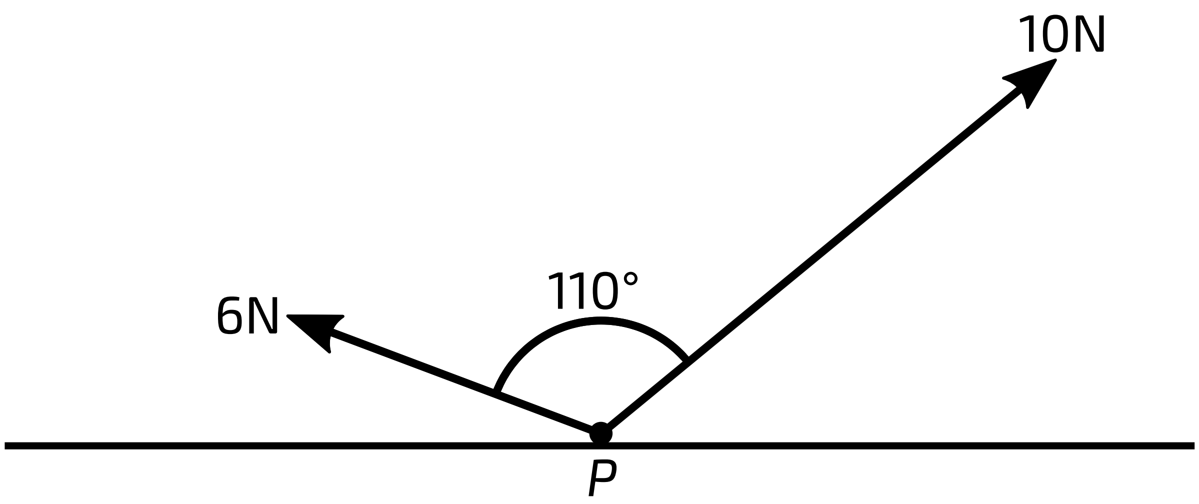

Figure 3: Two forces of magnitude $6\,\mathrm{N}$ and $10\,\mathrm{N}$ acting on a particle P.

Two forces of magnitudes $6\,\mathrm{N}$ and $10\,\mathrm{N}$ separated by an angle of 110° act on a particle P, which rests on a horizontal surface.

Find the component of the $6\,\mathrm{N}$ force along the line of the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.

Find the total force in the direction of the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.

Part G Resolving forces 3

Find the component of the $6\,\mathrm{N}$ force perpendicular to the line of action of the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.

Part H Magnitude and direction of resultant force

Find the magnitude of the resultant of the $6\,\mathrm{N}$ and $10\,\mathrm{N}$ forces. Give your answer to 3 significant figures.

Calculate the angle between the resultant force and the $10\,\mathrm{N}$ force. Give your answer to 3 significant figures.