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.

- Downwards
- It's impossible to tell
- Upwards

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.

Motion of a Train

A Level

C C C

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.

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.