Linear Motion Exam Questions

Note These exam questions are given in reverse chronological order as they appear in exam papers; 2023 paper, Sample paper, 2022 (deferred), 2022, and so on back to 2015. All questions from the old syllabus papers are included as they are relevant to the new syllabus. In the accompanying solutions the explanation for including 2016 (despite its apparent reference to relative velocity) is given.

Question — 2023 Q5 (b).

(b) Áine travels by car from her house to work each morning. On Monday morning she starts her car and accelerates uniformly for 40 s to a speed of 22.5 m s^{-1}. Áine then travels at this speed for 8 minutes until decelerating uniformly to rest at her work. She reaches her work at exactly 08: 30.

On Tuesday morning Áine leaves her house 140 s later than the day before. She takes the same route to work. She starts her car and accelerates at 1.5 m s^{-2} for 20 s, then maintains this steady speed for 6 minutes before decelerating uniformly to rest at her work. She again reaches her work at exactly 08: 30.

Calculate the time when Áine leaves her house on Tuesday morning.

Question — Sample Q3 (b).

(b) Two athletes, Brian and Clara, are taking part in a relay race. Brian is preparing to hand over the baton to Clara. During the hand-over of the baton the athletes need to be running in the same straight line and at the same velocity.

As Brian approaches Clara's position at a constant speed of 11 m s^{-1}, Clara starts running from rest with constant acceleration f.

A short time later Brian begins to decelerate at 2 m s^{-2}.

Clara receives the baton 2.5 s after she starts running.

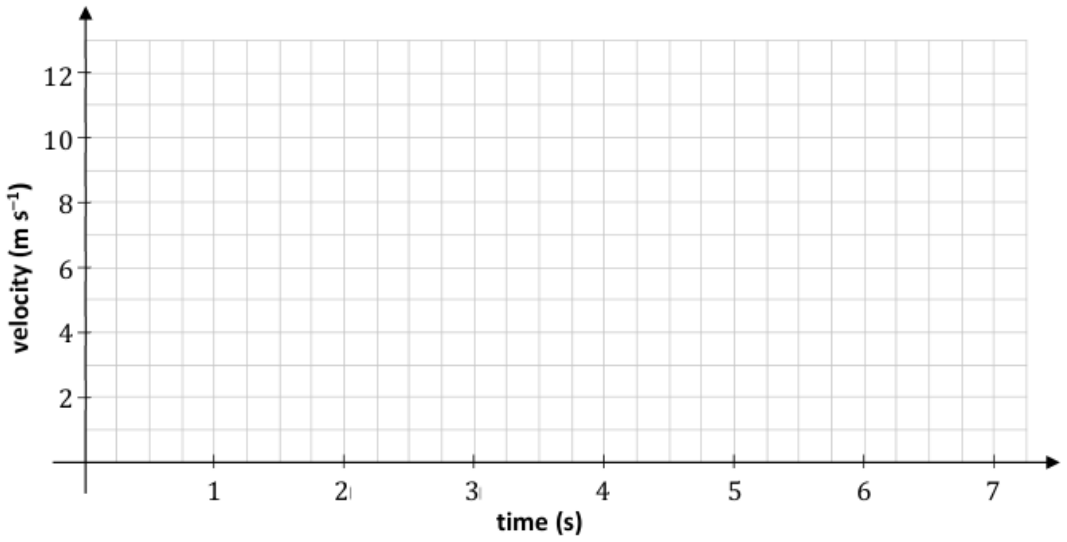
The baton is exchanged when Clara is 75 cm ahead of Brian and when both athletes have a speed of 8 m s^{-1}.

After the baton is exchanged, Brian continues to decelerate at 2 m s^{-2} until he comes to rest. Clara continues to accelerate at f until she reaches her maximum speed of 12 m s^{-1}, which she then maintains.

(i) Calculate the time it takes for Brian to decelerate before he exchanges the baton.

(ii) Using the axes below, draw an *accurate* velocity-time graph for the motion of each runner. Time is measured from the instant that Clara begins to run.

Relevant calculations should be shown in the space below.



(iii) Calculate the distance between the two athletes when Clara begins to run.

Question — 2022 (Deferred) Q1.

(a) Two cars, A and B, travel along a straight level road in opposite directions. A passes point P with speed 4 m s^{-1} and uniform acceleration 2 m s^{-2}. Three seconds later B passes point Q with speed 5 m s^{-1} and uniform acceleration 4 m s^{-2}.

The distance from P to Q is 1143 m.

The cars meet t seconds after A passes P.

(i) Find the value of t.

(ii) Find the distance from P to the meeting point.

(iii) Find the distance between the cars when A is 160 m from the meeting point, before the cars meet.

(b) An object falls vertically, from rest, from a height h metres. It travels $\frac{15}{64}h$ metres during its final second of motion before hitting the ground.

(i) Find the time it takes to fall to the ground.

(ii) Find the value of h.

Question — 2022 Q1.

(a) A train takes 40 minutes to travel from rest at station A to rest at station B. The distance between the stations is 20 km. The train left station A at 10:00. At 10:15 the speed of the train was 32 km h^{-1} and at 10:30 the speed was 48 km h^{-1}.

The speed of 48 km h^{-1} was maintained until the brakes were applied, causing a uniform deceleration which brought the train to rest at B.

During the first and second 15-minute intervals the accelerations were constant.

(i) Draw a speed-time graph of the motion.

(ii) Find the time taken for the first 16 km.

(iii) Find the deceleration of the train.

(b) A ball E is thrown vertically upwards with a speed of 42 m s^{-1}.

T (< 8) seconds later another ball, F, is thrown vertically upwards from the same point with the same initial speed.

(i) Find where ball E is after 5 s and the total distance it has travelled in this time.

(ii) Prove that when E and F collide, they will each be travelling with speed $\frac{1}{2}gT$.

Question — 2021 Q1.

(a) A ball is thrown vertically downwards from the top of a building of height h m. The ball passes the top half of the building in 1.2 s and takes a further 0.8 s to reach the bottom of the building.
Find

(i) the value of h

(ii) the speed of the ball at the bottom of the building.

(b) Car C, moving with uniform acceleration f passes a point P with speed u (> 0).
Two seconds later car D, moving in the same direction with uniform acceleration $2f$ passes P with speed $\frac{6}{5}u$. C and D pass a point Q together. The speeds of C and D at Q are 6.5 m s^{-1} and 9 m s^{-1} respectively.

(i) Show that C travels from P to Q in $(\frac{3}{2f} + 5)$ seconds.

(ii) Find the value of f.

Question — 2020 Q1.

1. **(a)** A car is travelling on a straight level road at a uniform speed of 26 m s^{-1} when the driver notices a tractor 91·2 m ahead.
The tractor is travelling at a uniform speed of 6 m s^{-1} in the same direction as the car.
The driver of the car hesitates for t seconds before applying the brake.
The maximum deceleration of the car is 5 m s^{-2}.

Find the maximum value of t which would avoid a collision between the car and the tractor.

(b) A 60 gram mass is projected vertically upwards with an initial speed of 15 m s^{-1} and half a second later a 40 gram mass is projected vertically upwards from the same point with an initial speed of 22·65 m s^{-1}.

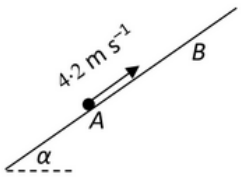
(i) Calculate the height at which the masses will collide.

The masses coalesce on colliding.

(ii) Find the greatest height which the combined mass will reach.

Question — 2019 Q1.

1. **(a)** A particle P, of mass 3 kg, is projected along a rough inclined plane from the point A with speed 4·2 m s^{-1}. The particle comes to instantaneous rest at B.
The plane is inclined at an angle α to the horizontal where $\tan\alpha = \frac{9}{40}$.
The coefficient of friction between the particle and the plane is $\frac{3}{20}$.



(i) Show that the deceleration of P is $\frac{15g}{41}$.

(ii) Find $|AB|$.

After reaching B the particle slides back down the plane.

(iii) Find the speed of P as it passes through A on its way back down the plane.

(b) Train A and Train B are on parallel tracks and travelling in opposite directions.
Train A starts from rest at Maynooth and accelerates uniformly at 0·5 m s^{-2} towards Leixlip to a speed of 25 m s^{-1}. It then continues at this constant speed.

At the same instant as train A is leaving Maynooth Train B passes through Leixlip heading towards Maynooth at a constant speed of 30 m s^{-1}.
Three minutes after leaving Leixlip train B starts to decelerate at 0·25 m s^{-2} and comes to rest at Maynooth.

(i) Find the distance between Maynooth and Leixlip.

(ii) At what distance from Maynooth do the trains meet?

After travelling at 25 m s^{-1} for a time, train A decelerates and comes to rest at Leixlip 36 seconds after train B stops at Maynooth.

(iii) Find the deceleration of train A.

Question — 2018 Q1.

(a) A parcel rests on the horizontal floor of a van.
The van is travelling on a level road at 14 m s^{-1} .
It is brought to rest by a uniform application of the brakes.
The coefficient of friction between the parcel and the floor is $\frac{2}{5}$.
Show that the parcel is on the point of sliding forward on the floor of the van if the stopping distance is 25 m.

(b) A car C moves with uniform acceleration a from rest to a maximum speed u.
It then travels at uniform speed u.
Just as car C starts, it is overtaken by a car D moving in the same direction with constant speed $\frac{3u}{4}$.
Car C catches up with car D when car C has travelled a distance d.

(i) Show that, at the instant car C catches up with car D, car C has been travelling with speed u for a time $\frac{4d}{3u} - \frac{u}{a}$.

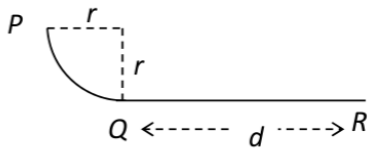
(ii) Find d in terms of u and a.

Question — 2017 Q1.

(a) A car passes four collinear markers *A*, *B*, *C*, and *D* while moving in a straight line with uniform acceleration. The car takes *t* seconds to travel from *A* to *B*, *t* seconds to travel from *B* to *C* and *t* seconds to travel from *C* to *D*.

If $|AB| + |CD| = k|BC|$, find the value of *k*.

(b) A baggage chute has two sections, *PQ* and *QR*, as shown in the diagram.
PQ is smooth and is a quarter circle of radius *r*.
QR, of length *d*, is rough and horizontal.
The coefficient of friction between the bag and section *QR* is μ.



A bag of mass *m* kg is released from rest at *P* and comes to rest at *R*.

Find
(i) the speed of the bag at *Q* in terms of *r*
(ii) *d* in terms of μ and *r*.

The speed of the bag when it is halfway along *QR* is 7 m s^{-1}.

(iii) Find the value of *r*.

Question — 2016 Q1.

(a) A car has an initial speed of u m s^{-1}. It moves in a straight line with constant acceleration f for 4 seconds. It travels 40 m while accelerating.
The car then moves with uniform speed and travels 45 m in 3 seconds.
It is then brought to rest by a constant retardation $2f$.

(i) Draw a speed-time graph for the motion.

(ii) Find the value of u.

(iii) Find the total distance travelled.

(b) A particle is projected vertically upwards with a velocity of u m s^{-1}.
After an interval of $2t$ seconds a second particle is projected vertically upwards from the same point and with the same initial velocity.

They meet at a height of h m.

Show that $h = \dfrac{u^2 - g^2t^2}{2g}$.

Question — 2015 Q1.

(a) A particle starts from rest and moves with constant acceleration.

If the particle travels 39 m in the seventh second, find the distance travelled in the tenth second.

(b) A train of length 66.5 m is travelling with uniform acceleration $\frac{4}{7}$ m s^{-2}.
It meets another train of length 91 m travelling on a parallel track in the opposite direction with uniform acceleration $\frac{8}{7}$ m s^{-2}.
Their speeds at this moment are 18 m s^{-1} and 24 m s^{-1} respectively.

(i) Find the time taken for the trains to pass each other.
(ii) Find the distance between the trains 1 second later.