Pearson Edexcel

Additional Assessment Materials

Summer 2021

# Pearson Edexcel GCE in Mathematics

# 8MA0_22 (Public release version)

## Resource Set 1: Topic 7

## Kinematics

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Additional Assessment Materials, Summer 2021

**General guidance to Additional Assessment Materials for use in 2021**

**Context**

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an optional part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

**Purpose**

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

**1.** A car is moving along a straight horizontal road with constant acceleration. There are three points $A$, $B$ and $C$, in that order, on the road, where $AB = 22$ m and $BC = 104$ m. The car takes 2 s to travel from $A$ to $B$ and 4 s to travel from $B$ to $C$. Find

(i) the acceleration of the car,

**(7)**

A — 22m, $t = 2$ — B — 104m, $t = 4$ — C

AB: $s = 22$, $u$, $v$, $a$, $t = 2$ → $s = ut + \frac{1}{2}at^2$

$22 = 2u + 2a$

$11 = u + a$ (1)

AC: $s = 126$, $u$, $v$, $a$, $t = 6$ → $s = ut + \frac{1}{2}at^2$

$126 = 6u + 18a$

$21 = u + 3a$

$21 - 3a = u$

$11 = (21 - 3a) + a$

$2a = 10$

$a = 5 \text{ ms}^{-2}$

(ii) the speed of the car at the instant it passes $A$.

AB: $s = 22$, $u = ?$, $v$, $a = 5$, $t = 2$

$s = ut + \frac{1}{2}at^2$

$22 = 2u + \frac{1}{2}(5)4$

$22 = 2u + 10$

$12 = 2u$

$u = 6 \text{ ms}^{-1}$

$\therefore$ speed at $u = 6 \text{ ms}^{-1}$

**(Total for Question 1 is 7 marks)**

**2.** A train travels along a straight horizontal track between two stations, $A$ and $B$.

In a model of the motion, the train starts from rest at $A$ and moves with constant acceleration $0.3 \text{ m s}^{-2}$ for 80 s. The train then moves at constant velocity before it moves with a constant deceleration of $0.5 \text{ m s}^{-2}$, coming to rest at $B$.

(a) For this model of the motion of the train between $A$ and $B$,

(i) state the value of the constant velocity of the train, → $v = u + at$ → $v = 0.3 \times 80$

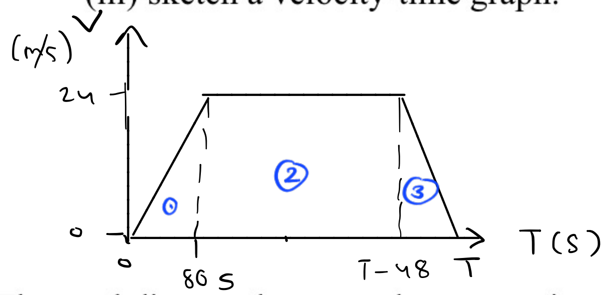
$v = 24 \text{ ms}^{-1}$

(ii) state the time for which the train is decelerating, → $v = u + at$

$t = \frac{v}{a} = \frac{24}{0.5} = 48$ seconds

(iii) sketch a velocity-time graph.

**(3)**




The total distance between the two stations is 4800 m.

distance is the area under the graph

(b) Using the model, find the total time taken by the train to travel from $A$ to $B$.

**(3)**

$4800 = \frac{1}{2}(24 \times 80) + (24 \times (T - 48 - 80)) + \frac{1}{2}(24 \times 48)$

$4800 = 960 + 24(T - 128) + 576$

$3264 = 24(T - 128)$

$136 = T - 128$

$T = 264$ seconds.

(c) Suggest one improvement that could be made to the model of the motion of the train from $A$ to $B$ in order to make the model more realistic.

**(1)**

It could considerthe mass and dimensions of the train.

- It is unlikely for the train to undergo constant acceleration and constant velocity due to factors such as air resistance.

**(Total for Question 2 is 7 marks)**

**3.**

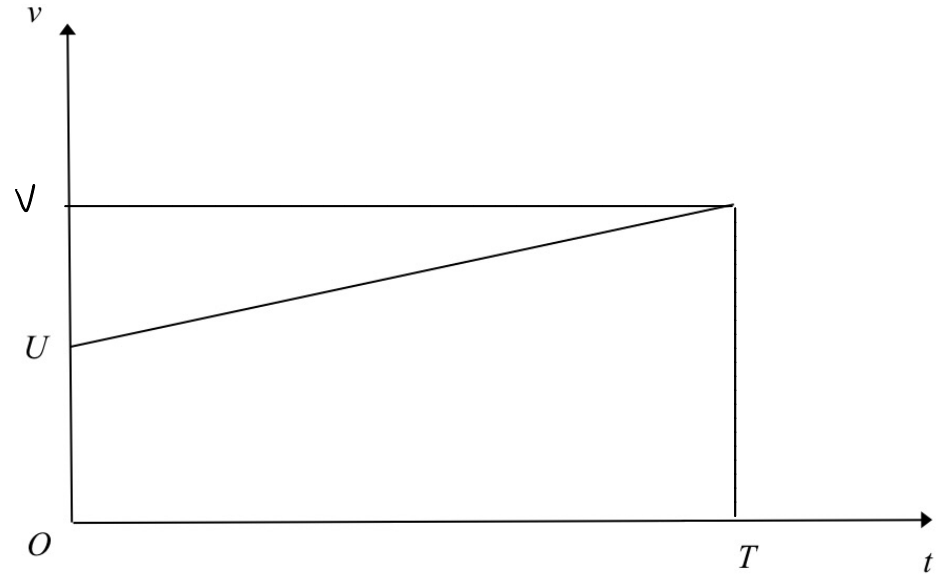



**Figure 1**

A car moves along a straight horizontal road. At time $t = 0$, the velocity of the car is $U$ m s$^{-1}$. The car then accelerates with constant acceleration $a$ m s$^{-2}$ for $T$ seconds. The car travels a distance $D$ metres during these $T$ seconds.

Figure 1 shows the velocity-time graph for the motion of the car for $0 \leq t \leq T$.

Using the graph, show that $D = UT + \frac{1}{2}aT^2$.

(No credit will be given for answers which use any of the kinematics (*suvat*) formulae listed under Mechanics in the AS Mathematics section of the formulae booklet.)

**(4)**

① Area underneath the graph is the distance travelled (D)

$\Rightarrow D = \frac{1}{2}(u + v)T$

② gradient of the graph is the acceleration

$\Rightarrow a = \frac{v - u}{T}$

③ $v = u + at$

$\Rightarrow$ ① $D = \frac{1}{2}(u + u + aT)T = \frac{1}{2}(2uT + aT^2)$

$\therefore D = uT + \frac{1}{2}aT^2$

**(Total for Question 3 is 4 marks)**

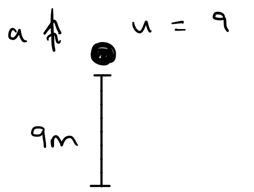
**4.** A man throws a tennis ball into the air so that, at the instant when the ball leaves his hand, the ball is 2 m above the ground and is moving vertically upwards with speed 9 m s$^{-1}$.

The motion of the ball is modelled as that of a particle moving freely under gravity and the acceleration due to gravity is modelled as being of constant magnitude 10 m s$^{-2}$.

The ball hits the ground $T$ seconds after leaving the man's hand.

Using the model, find the value of $T$.

**(4)**




$s = -2$
$u = 9$
$v = 0$
$a = -10$
$t = ?$

$s = ut + \frac{1}{2}at^2$

$-2 = 9t - 5t^2.$

$5t^2 - 9t - 2 = 0$

$(t-2)(5t+1) = 0$

$t = -\frac{1}{5}$ → not possible

$t = 2$

$\therefore T = 2$ seconds

**(Total for Question 4 is 4 marks)**

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**5.** At time $t = 0$, a small ball is projected vertically upwards with speed $U$ m s$^{-1}$ from a point $A$ that is 16.8 m above horizontal ground.

The speed of the ball at the instant immediately before it hits the ground for the first time is 19 m s$^{-1}$

The ball hits the ground for the first time at time $t = T$ seconds.

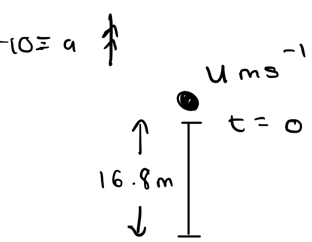
The motion of the ball, from the instant it is projected until the instant just before it hits the ground for the first time, is modelled as that of a particle moving freely under gravity.

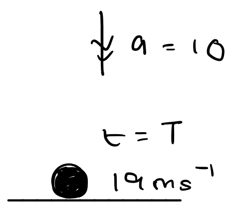
The acceleration due to gravity is modelled as having magnitude 10 m s$^{-2}$

Using the model,

(*a*) show that $U = 5$

**(2)**




$s = -16.8$
$u = u$
$v = 19$
$a = -10$
$t = T$

$v^2 = u^2 + 2as$

$19^2 = u^2 + 2(-10)(-16.8)$

$361 = u^2 + 336$

$25 = u^2$

$u = 5$

(*b*) find the value of *T*, **(2)**

$s = -16.8$
$u = 5$
$v = 19$
$a = -10$
$t = T$

$s = ut + \frac{1}{2}at^2$

$-16.8 = 5T - 5T^2$

$5T^2 - 5T - 16.8 = 0$

$25T^2 - 25T - 84 = 0$

$(5T - 12)(5T + 7) = 0$

$T = 2.4$ OR $T = -1.4$

$\therefore T = 2.4s$    not possible

(*c*) find the time from the instant the ball is projected until the instant when the ball is 1.2 m below *A*.

**(4)**

$s = -1.2$
$u = 5$
$v = ?$
$a = -10$
$t = T$

$s = ut + \frac{1}{2}at^2$

$-1.2 = 5T - 5T^2$

$5T^2 - 5T - 1.2 = 0$

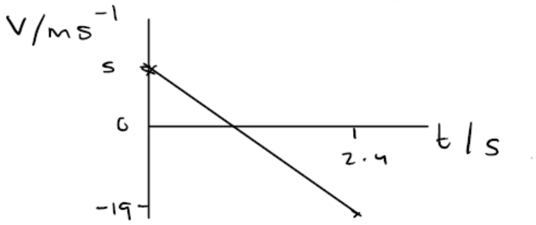
$25T^2 - 25T - 6 = 0$

$(5T - 6)(5T + 1) = 0$

$T = \frac{6}{5} = 1.2s$    $T = -\frac{1}{5}$ → not possible

(*d*) Sketch a velocity-time graph for the motion of the ball for $0 \leq t \leq T$, stating the coordinates of the start point and the end point of your graph.

**(2)**




In a refinement of the model of the motion of the ball, the effect of air resistance on the ball is included and this refined model is now used to find the value of *U*.

(*e*) State, with a reason, how this new value of *U* would compare with the value found in part (a), using the initial unrefined model. **(1)**

It would be lower than the initial U as air resistance would slow it down.

(*f*) Suggest one further refinement that could be made to the model, apart from including air resistance, that would make the model more realistic.

**(1)**

consider the dimensions of the ball / its mass

Heat loss when ball compresses onto the ground.

There may be other forces acting on the ball, for example, wind, which may affect speed and/or time.

**(Total for Question 5 is 12 marks)**

**6.** At time $t = 0$, a parachutist falls vertically from rest from a helicopter which is hovering at a height of 550 m above horizontal ground.

The parachutist, who is modelled as a particle, falls for 3 seconds before her parachute opens.

While she is falling, and before her parachute opens, she is modelled as falling freely under gravity.

The acceleration due to gravity is modelled as being 10 m s$^{-2}$.

(*a*) Using this model, find the speed of the parachutist at the instant her parachute opens. **(1)**

s =
u = 0
v = ?
a = 10
t = 3

$v = u + at$

$= 0 + 10(3)$

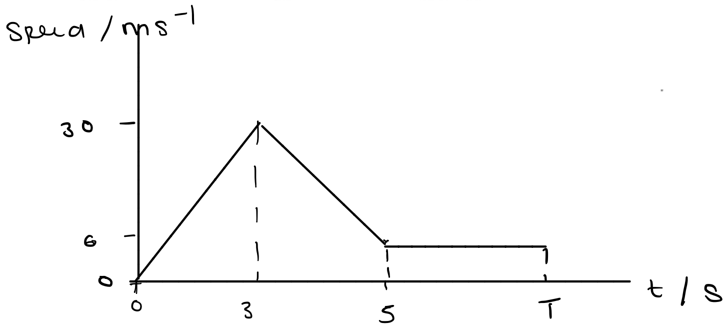
$= 30 \text{ ms}^{-1}$

When her parachute is open, the parachutist continues to fall vertically.

Immediately after her parachute opens, she decelerates at 12 m s$^{-2}$ for 2 seconds before reaching a constant speed and she reaches the ground with this speed.

The total time taken by the parachutist to fall the 550 m from the helicopter to the ground is $T$ seconds.

(*b*) Sketch a speed-time graph for the motion of the parachutist for $0 \leqslant t \leqslant T$. **(2)**




$550 = \frac{1}{2}(30 \times 3) + \left(\frac{30+6}{2} \times 2\right) + 6(T-5)$

(*c*) Find, to the nearest whole number, the value of $T$. **(5)**

$550 = \frac{1}{2}(30 \times 3) + \left(\frac{30+6}{2} \times 2\right) + 6(T-5)$

$550 = 45 + 36 + 6T - 30$

$550 = 51 + 6T$

$499 = 6T$

$83.167\ldots = T$

$83 \text{ s} = T$

In a refinement of the model of the motion of the parachutist, the effect of air resistance is included before her parachute opens and this refined model is now used to find a new value of $T$.

(*d*) How would this new value of $T$ compare with the value found, using the initial model, in part (*c*)?

The new value of T will be larger

**(1)**

(*e*) Suggest one further refinement to the model, apart from air resistance, to make the model more realistic.

**(1)**

Consider the mass of the parachutist.

• There might be other forces acting on the parachutist, eg. wind, which may affect the speed and/or time.

**(Total for Question 6 is 10 marks)**