Practice examination questions for SUVAT equations

1.Jan 2005

1 A train travels along a straight horizontal track. It is travelling at a speed of $12\,\mathrm{m\,s^{-1}}$ when it begins to accelerate uniformly. It reaches a speed of $40\,\mathrm{m\,s^{-1}}$ after accelerating for 100 seconds.

(a) (i) Show that the acceleration of the train is $0.28\,\mathrm{m\,s^{-2}}$. *(2 marks)*

(ii) Find the distance that the train travelled in the 100 seconds. *(2 marks)*

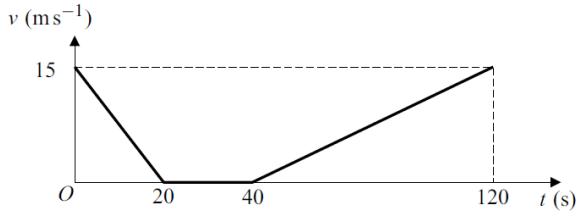
(b) The mass of the train is 200 tonnes and a resistance force of 40 000 N acts on the train. Find the magnitude of the driving force produced by the engine that acts on the train as it accelerates. *(3 marks)*

2.June 2005

2 A train travels along a straight horizontal track between two points A and B.

Initially the train is at A and moving at $15\,\mathrm{m\,s^{-1}}$. Due to a problem, the train has to slow down and stop. At time $t = 40$ seconds it begins to move again. At time $t = 120$ seconds the train is at B and moving at $15\,\mathrm{m\,s^{-1}}$ again.

The graph below shows how the velocity of the train varies as it moves from A to B.



(a) Use the graph to find the total distance between the points A and B. *(4 marks)*

(b) The train should have travelled between A and B at a constant velocity of $15\,\mathrm{m\,s^{-1}}$.

(i) Calculate the time that the train would take to travel between A and B at a speed of $15\,\mathrm{m\,s^{-1}}$. *(1 mark)*

(ii) Calculate the time by which the train was delayed. *(1 mark)*

(c) The train has mass 500 tonnes. Find the resultant force acting on the train when $40 < t < 120$. *(4 marks)*

3.Jan 2006

3 (a) A small stone is dropped from a height of 25 metres above the ground.

(i) Find the time taken for the stone to reach the ground. *(2 marks)*

(ii) Find the speed of the stone as it reaches the ground. *(2 marks)*

(b) A large package is dropped from the same height as the stone. Explain briefly why the time taken for the package to reach the ground is likely to be different from that for the stone. *(2 marks)*

4.Jan 2006

6 A van moves from rest on a straight horizontal road.

(a) In a simple model, the first 30 seconds of the motion are represented by three separate stages, each lasting 10 seconds and each with a constant acceleration.

During the first stage, the van accelerates from rest to a velocity of $4\,\mathrm{m\,s^{-1}}$.

During the second stage, the van accelerates from $4\,\mathrm{m\,s^{-1}}$ to $12\,\mathrm{m\,s^{-1}}$.

During the third stage, the van accelerates from $12\,\mathrm{m\,s^{-1}}$ to $16\,\mathrm{m\,s^{-1}}$.

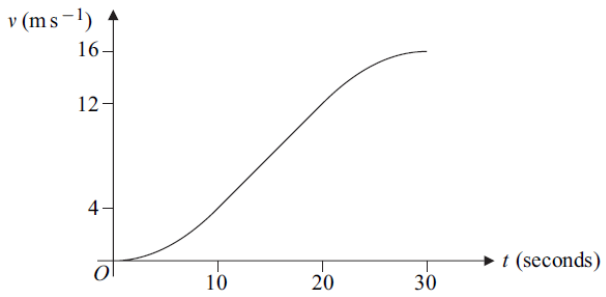
(i) Sketch a velocity–time graph to represent the motion of the van during the first 30 seconds of its motion. *(3 marks)*

(ii) Find the total distance that the van travels during the 30 seconds. *(4 marks)*

(iii) Find the average speed of the van during the 30 seconds. *(2 marks)*

(iv) Find the greatest acceleration of the van during the 30 seconds. *(2 marks)*

(b) In another model of the 30 seconds of the motion, the acceleration of the van is assumed to vary during the first and third stages of the motion, but to be constant during the second stage, as shown in the velocity–time graph below.



The velocity of the van takes the same values at the beginning and the end of each stage of the motion as in part (a).

(i) State, with a reason, whether the distance travelled by the van during the first 10 seconds of the motion in **this** model is greater or less than the distance travelled during the same time interval in the model in part (a). *(2 marks)*

(ii) Give one reason why **this** model represents the motion of the van more realistically than the model in part (a). *(1 mark)*

5.June 2006

1 A stone is dropped from a high bridge and falls vertically.

(a) Find the distance that the stone falls during the first 4 seconds of its motion. *(3 marks)*

(b) Find the average speed of the stone during the first 4 seconds of its motion. *(2 marks)*

(c) State one modelling assumption that you have made about the forces acting on the stone during the motion. *(1 mark)*

6.June 2006

3 A car travels along a straight horizontal road. The motion of the car can be modelled as three separate stages.

During the first stage, the car accelerates uniformly from rest to a velocity of $10\,\mathrm{m\,s^{-1}}$ in 6 seconds.

During the second stage, the car travels with a constant velocity of $10\,\mathrm{m\,s^{-1}}$ for a further 4 seconds.

During the third stage of the motion, the car travels with a uniform retardation of magnitude $0.8\,\mathrm{m\,s^{-2}}$ until it comes to rest.

(a) Show that the time taken for the **third** stage of the motion is 12.5 seconds. *(2 marks)*

(b) Sketch a velocity–time graph for the car during the three stages of the motion. *(4 marks)*

(c) Find the total distance travelled by the car during the motion. *(3 marks)*

(d) State one criticism of the model of the motion. *(1 mark)*

7.Jan 2007

2 A lift rises vertically from rest with a constant acceleration.

After 4 seconds, it is moving upwards with a velocity of $2\,\mathrm{m\,s^{-1}}$.

It then moves with a constant velocity for 5 seconds.

The lift then slows down uniformly, coming to rest after it has been moving for a total of 12 seconds.

(a) Sketch a velocity–time graph for the motion of the lift. *(4 marks)*

(b) Calculate the total distance travelled by the lift. *(2 marks)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 300 kg. Find the maximum tension in the cable during this motion. *(4 marks)*

8.June 2007

1 A ball is released from rest at a height h metres above ground level. The ball hits the ground 1.5 seconds after it is released. Assume that the ball is a particle that does not experience any air resistance.

(a) Show that the speed of the ball is $14.7\,\mathrm{m\,s^{-1}}$ when it hits the ground. *(2 marks)*

(b) Find h. *(2 marks)*

(c) Find the distance that the ball has fallen when its speed is $5\,\mathrm{m\,s^{-1}}$. *(3 marks)*

9.Jan 2008

1 A crane is used to lift a crate, of mass 70 kg, vertically upwards. As the crate is lifted, it accelerates uniformly from rest, rising 8 metres in 5 seconds.

(a) Show that the acceleration of the crate is $0.64\,\mathrm{m\,s^{-2}}$. *(2 marks)*

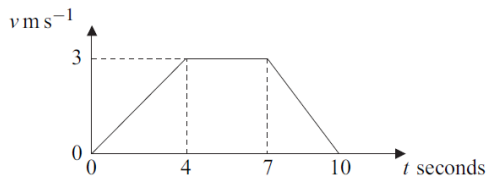
(b) The crate is attached to the crane by a single cable. Assume that there is no resistance to the motion of the crate.

Find the tension in the cable. *(3 marks)*

(c) Calculate the average speed of the crate during these 5 seconds. *(1 mark)*

10.June 2008

1 The diagram shows a velocity–time graph for a lift.



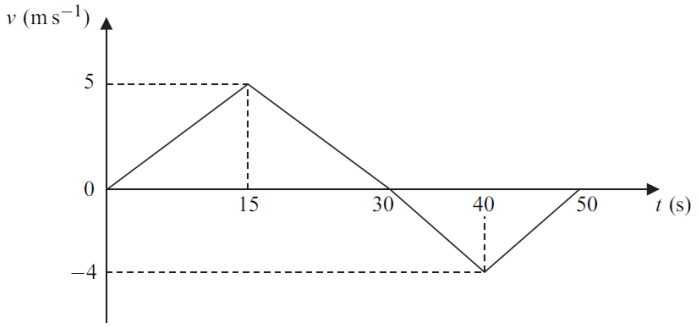
(a) Find the distance travelled by the lift. *(3 marks)*

(b) Find the acceleration of the lift during the first 4 seconds of the motion. *(1 mark)*

(c) The lift is raised by a single vertical cable. The mass of the lift is 400 kg. Find the tension in the cable during the first 4 seconds of the motion. *(3 marks)*

11.Jan 2009

2 The graph shows how the velocity of a particle varies during a 50-second period as it moves forwards and then backwards on a straight line.



(a) State the times at which the velocity of the particle is zero. *(2 marks)*

(b) Show that the particle travels a distance of 75 metres during the first 30 seconds of its motion. *(2 marks)*

(c) Find the total distance travelled by the particle during the 50 seconds. *(4 marks)*

(d) Find the distance of the particle from its initial position at the end of the 50-second period. *(2 marks)*

12.June 2009

2 A lift is travelling upwards and accelerating uniformly. During a 5 second period, it travels 16 metres and the speed of the lift increases from u m s^{-1} to 4.2 m s^{-1}.

(a) Find u. *(3 marks)*

(b) Find the acceleration of the lift. *(3 marks)*

13.Jan 2010

2 A sprinter accelerates from rest at a constant rate for the first 10 metres of a 100-metre race. He takes 2.5 seconds to run the first 10 metres.

(a) Find the acceleration of the sprinter during the first 2.5 seconds of the race. *(3 marks)*

(b) Show that the speed of the sprinter at the end of the first 2.5 seconds of the race is $8\,\mathrm{m\,s^{-1}}$. *(2 marks)*

(c) The sprinter completes the 100-metre race, travelling the remaining 90 metres at a constant speed of $8\,\mathrm{m\,s^{-1}}$. Find the total time taken for the sprinter to travel the 100 metres. *(3 marks)*

(d) Calculate the average speed of the sprinter during the 100-metre race. *(2 marks)*

14.Jan 2010

4 A ball is released from rest at a height of 15 metres above ground level.

(a) Find the speed of the ball when it hits the ground, assuming that no air resistance acts on the ball. *(3 marks)*

(b) In fact, air resistance does act on the ball. Assume that the air resistance force has a constant magnitude of 0.9 newtons. The ball has a mass of 0.5 kg.

(i) Draw a diagram to show the forces acting on the ball, including the magnitudes of the forces acting. *(1 mark)*

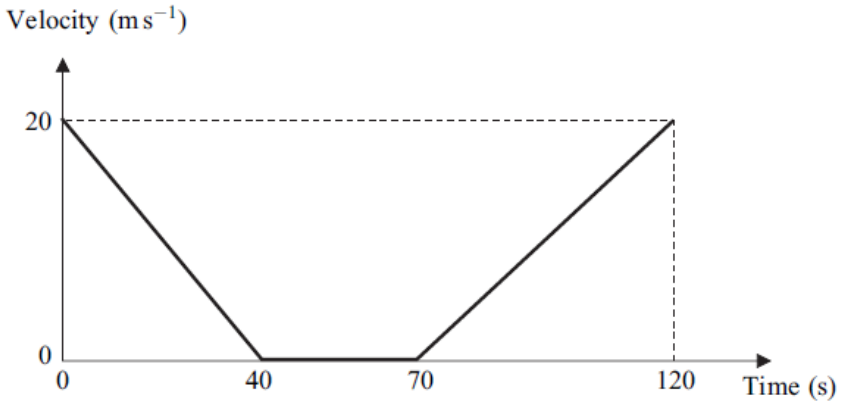
(ii) Show that the acceleration of the ball is $8\,\mathrm{m\,s^{-2}}$. *(3 marks)*

(iii) Find the speed at which the ball hits the ground. *(2 marks)*

(iv) Explain why the assumption that the air resistance force is constant may not be valid. *(1 mark)*

15.June 2010

1 A bus slows down as it approaches a bus stop. It stops at the bus stop and remains at rest for a short time as the passengers get on. It then accelerates away from the bus stop. The graph shows how the velocity of the bus varies.



Assume that the bus travels in a straight line during the motion described by the graph.

(a) State the length of time for which the bus is at rest. *(1 mark)*

(b) Find the distance travelled by the bus in the first 40 seconds. *(2 marks)*

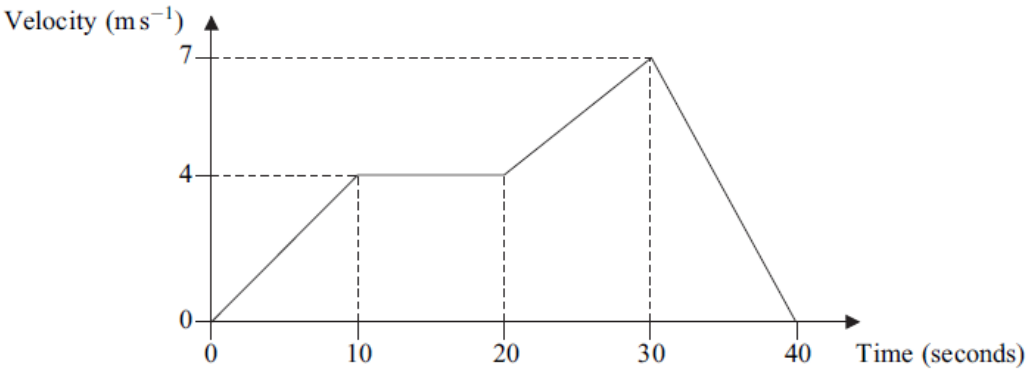
(c) Find the total distance travelled by the bus in the 120-second period. *(2 marks)*

(d) Find the average speed of the bus in the 120-second period. *(2 marks)*

(e) If the bus had not stopped but had travelled at a constant $20\,\mathrm{m\,s^{-1}}$ for the 120-second period, how much further would it have travelled? *(2 marks)*

16.Jan 2011

2 The graph shows how the velocity of a train varies as it moves along a straight railway line.



(a) Find the total distance travelled by the train. *(4 marks)*

(b) Find the average speed of the train. *(2 marks)*

(c) Find the acceleration of the train during the first 10 seconds of its motion. *(2 marks)*

(d) The mass of the train is 200 tonnes. Find the magnitude of the resultant force acting on the train during the first 10 seconds of its motion. *(2 marks)*

17.June 2011

1 A crane is used to lift a load, using a single vertical cable which is attached to the load. The load accelerates uniformly from rest. When it has risen 0.9 metres, its speed is $0.6\,\mathrm{m\,s^{-1}}$.

(a) (i) Show that the acceleration of the load is $0.2\,\mathrm{m\,s^{-2}}$. *(3 marks)*

(ii) Find the time taken for the load to rise 0.9 metres. *(2 marks)*

(b) Given that the mass of the load is 800 kg, find the tension in the cable while the load is accelerating. *(3 marks)*

18.June2011

3 A pair of cameras records the time that it takes a car on a motorway to travel a distance of 2000 metres. A car passes the first camera whilst travelling at $32\,\mathrm{m\,s^{-1}}$. The car continues at this speed for 12.5 seconds and then decelerates uniformly until it passes the second camera when its speed has decreased to $18\,\mathrm{m\,s^{-1}}$.

(a) Calculate the distance travelled by the car in the first 12.5 seconds. *(1 mark)*

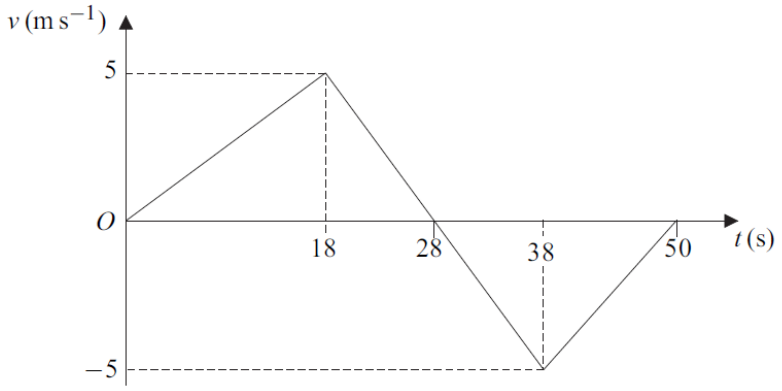
(b) Find the time for which the car is decelerating. *(3 marks)*

(c) Sketch a speed–time graph for the car on this 2000-metre stretch of motorway. *(3 marks)*

(d) Find the average speed of the car on this 2000-metre stretch of motorway. *(2 marks)*

19.Jan 2012

3 The diagram shows a velocity–time graph for a train as it moves on a straight horizontal track for 50 seconds.



(a) Find the distance that the train moves in the first 28 seconds. *(2 marks)*

(b) Calculate the total distance moved by the train during the 50 seconds. *(3 marks)*

(c) Hence calculate the average speed of the train. *(2 marks)*

(d) Find the displacement of the train from its initial position when it has been moving for 50 seconds. *(1 mark)*

(e) Hence calculate the average velocity of the train. *(2 marks)*

(f) Find the acceleration of the train in the first 18 seconds of its motion. *(1 mark)*

20.June 2012

3 A car is travelling at a speed of $20\,\mathrm{m\,s^{-1}}$ along a straight horizontal road. The driver applies the brakes and a constant braking force acts on the car until it comes to rest.

(a) Assume that no other horizontal forces act on the car.

(i) After the car has travelled 75 metres, its speed has reduced to $10\,\mathrm{m\,s^{-1}}$. Find the acceleration of the car. *(3 marks)*

(ii) Find the time taken for the speed of the car to reduce from $20\,\mathrm{m\,s^{-1}}$ to zero. *(2 marks)*

(iii) Given that the mass of the car is 1400 kg, find the magnitude of the constant braking force. *(2 marks)*

(b) Given that a constant air resistance force of magnitude 200 N acts on the car during the motion, find the magnitude of the constant braking force. *(1 mark)*

21.Jan 2013

1 A car travels on a straight horizontal race track. The car decelerates uniformly from a speed of $20\,\mathrm{m\,s^{-1}}$ to a speed of $12\,\mathrm{m\,s^{-1}}$ as it travels a distance of 640 metres. The car then accelerates uniformly, travelling a further 1820 metres in 70 seconds.

(a) (i) Find the time that it takes the car to travel the first 640 metres. *(3 marks)*

(ii) Find the deceleration of the car during the first 640 metres. *(3 marks)*

(b) (i) Find the acceleration of the car as it travels the further 1820 metres. *(3 marks)*

(ii) Find the speed of the car when it has completed the further 1820 metres. *(3 marks)*

(c) Find the average speed of the car as it travels the 2460 metres. *(2 marks)*

Answers

1.Jan 2005

1(a)(i)	$40 = 12 + 100a$ $a = \frac{40-12}{100} = 0.28\ \text{ms}^{-2}$ AG	M1 A1	 2	Use of a constant acceleration equation to form equation for a AG; correct answer from correct working
(ii)	$s = \frac{1}{2}(12+40)\times 100$ $= 2600$ m	M1 A1	 2	Expression for distance, using $t = 100$ Correct final distance
(c)	$F - 40000 = 200\times 1000\times 0.28$ $F = 40000 + 56000 = 96000$ N	M1 A1 A1	 3	Three term equation of motion Correct equation Correct force
	Total		**7**	

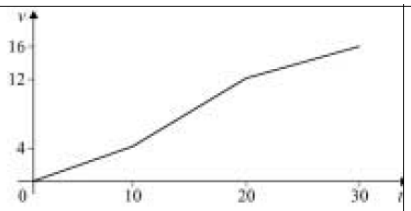
2.June 2005

2(a)	$s_1 = \frac{1}{2}\times 15\times 20 = 150$ $s_2 = \frac{1}{2}\times 15\times 80 = 600$ $s = 600 + 150 = 750$ m	M1 M1 A1 A1	 4	M1: Finding length of first stage M1: Finding length of second stage A1: Both distances correct A1: Correct total distance
(b)(i)	$t = \frac{750}{15} = 50$ s	B1ft	1	B1: Correct time or their distance correctly divided by 15
(ii)	Delay $= 120 - 50 = 70$ s	B1ft	1	B1: Correct time or their previous time correctly subtracted from 120 to give a positive answer
(c)	$a = \frac{15}{80} = \frac{3}{16} = 0.1875\ \text{ms}^{-2}$ $F = 500000\times 0.1875 = 93800$ N (to 3sf)	M1 A1 M1 A1	 4	M1: Finding acceleration A1: Correct acceleration M1: Use of $F = ma$ A1: Correct force
	Total		**10**	

3.Jan 2006

3(a)(i)	$s = ut + \frac{1}{2}at^2$ $25 = 0 + 4.9t^2$ $t = 2.26$ sec (2.236) (if g = 10) (2.259)	 M1 A1	 2	 full method
(ii)	$v^2 = u^2 + 2as$ $v^2 = 0 + 2\times 9.8\times 25$ $v = 22.1\ \text{ms}^{-1}$ (21.913) (22.14)	 M1 A1	 2	
(b)	(Time longer) air resistance slows down motion, links with motion, no contradictions	M1 A1	 2	(or Time less) package large so less distance to travel
	Total		**6**	

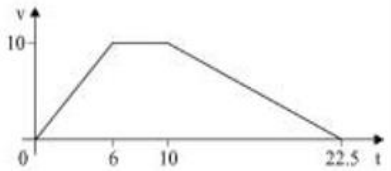
4.Jan 2006

6(a)(i)		B1 B1 B1	3	3 straight lines correct end points sensible scales + labelled v/t
(ii)	$s=\frac{1}{2}\times10\times4+\frac{1}{2}\times(4+12)\times10+$ $\frac{1}{2}(12+16)\times10$ $s=240$ metres	M1 m1 A1 A1√	4	area attempt full method equation correct √ one slip Or equation attempted full method all correct √ one slip
(iii)	Average speed $=\frac{240}{30}$ $=8\,\text{ms}^{-1}$	M1 A1√	2	√distance
(iv)	Greatest acceleration $=2^{\text{nd}}$ stage $=\frac{12-4}{10}$ $=0.8\,\text{ms}^{2}$	M1 A1	2	cao
(b)(i)	Less area below curve < area below line/velocity lower	B1 B1	2	no additional incorrect statements
(ii)	Change in velocity more gradual oe	B1	1	
	Total		**14**	

5.June 2006

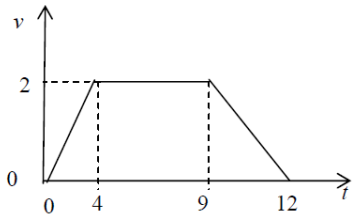
1(a)	$s=0+\frac{1}{2}\times9.8\times4^2$ $s=78.4$ metres	M1 A1 A1	3	Full method Correct subs, accept ±9.8 CAO (need positive)
(b)	Average speed $=\frac{78.4}{4}$ $=19.6\ \text{ms}^{-1}$	M1 A1F	2	Also accept full method with use of velocities at $t=0$ and 4, or at $t=2$ FT distance
(c)	Only force acting is weight	B1	1	Acc resistance forces negligible or ignored, (not friction, or air friction)
	Total		**6**	

6.June 2006

3(a)	$v=u+at$ $0=10+(-0.8)\times t$ $t=12.5$ sec	M1 A1	2	Full method with u, v used correctly Accept ±0.8 CAO (correct subs and answer)
(b)		B1 B1 B1 B1	4	each line, straight and correct end points SC: B1 for 3 lines giving correct shape but no values shown SC: first error in labelling times loses B1, repeated errors no further penalty axes labelled v, t

(c)	distance $= \frac{1}{2} \times 10 \times (4 + 22.5)$	M1		Full correct method
		A1F		Correct subs, FT graph if final $t = 12.5$
	$= 132.5$ metres	A1F	3	FT one slip, AWRT 133
(d)	Acceleration unlikely to: change so abruptly or be constant or velocity unlikely to be constant	B1	1	
	Total		**10**	

7.Jan 2007

2(a)		B1 B1 B1 B1	4	Starts and finishes at rest Correct shape Correct values on t-axis Correct values on v-axis Condone omission of the origin
(b)	$s = \frac{1}{2}(5 + 12) \times 2$	M1		Use of the area under the graph (or equivalent) to find s
	or $s = \frac{1}{2} \times 2 \times 4 + 5 \times 2 + \frac{1}{2} \times 2 \times 3 = 17$			
	$= 17$	A1	2	Correct distance **SC** When 21 used instead of 12 allow full marks for $s = 26$
(c)	$\max a = \frac{2}{4} = 0.5$	B1		Maximum acceleration
	$300 \times 0.5 = T - 300 \times 9.8$	M1		Three term equation of motion using their a
		A1		Correct equation using $a = 0.5$
	$T = 2940 + 150 = 3090$	A1	4	Correct tension
			10	

8.June 2007

1(a)	$v = 0 + 1.5 \times 9.8$	M1		Use of constant acceleration equation to find v
	$= 14.7 \text{ ms}^{-1}$	A1	2	AG Correct v from correct working $1.5 \times 9.8 = 14.7$ is not enough on its own
(b)	$h = \frac{1}{2} \times 9.8 \times 1.5^2$	M1		Use of constant acceleration equation with $a = 9.8$ to find h
	$= 11.0$ m (to 3 sf)	A1	2	Correct h Allow 11 m; ignore negative signs
(c)	$5^2 = 0^2 + 2 \times 9.8s$	M1		Use of constant acceleration equation with $u = 0$ to find s
		A1		Correct equation
	$s = \frac{25}{19.6} = 1.28$ m (to 3 sf)	A1	3	Correct s Accept 1.27

	OR $t=\frac{5}{9.8}=0.510$ $s=\frac{1}{2}(0+5)\frac{5}{9.8}=1.28$ m **OR** $s=0+\frac{1}{2}\times 9.8\times\left(\frac{5}{9.8}\right)^2=1.28$ m			
	Total		**7**	

9.Jan 2008

1. (a)	$8=\frac{1}{2}a\times 5^2$ $a=\frac{2\times 8}{25}=0.64$ ms^{-2} **AG**	M1 A1	2	Use of constant acceleration equation with $u=0$ to find a. Correct answer from correct working, showing evidence of solving for a. Allow verification / substitution.
(b)	$T-70\times 9.8=70\times 0.64$ $T=730.8=731$ N to 3 sf	M1 A1 A1	3	Three term equation of motion for crate. Correct equation Correct tension
(c)	$v=\frac{8}{5}=1.6$ ms^{-1}	B1	1	Correct average speed. Accept $\frac{8}{5}$ Allow $\frac{3.2+0}{2}=1.6$ ms^{-1}
	Total		**6**	

10.June 2008

1(a)	$s=\frac{1}{2}(3+10)\times 3$ $=19.5$ m	M1 A1 A1	3	Finding distance by summing 3 areas or using formula for the area of a trapezium Correct equation/3 correct expressions for the areas Correct total distance
(b)	$a=\frac{3}{4}=0.75$ ms^{-2}	B1	1	Correct acceleration as a decimal or as a fraction
(c)	$T-400g=400\times 0.75$ $T=3920+300=4220$ N	M1 A1F A1F	3	Three term equation of motion containing T, $400g$ and 400×0.75 or equivalent Correct equation Correct tension Only ft from $a=\frac{4}{3}$ (ft 4453 N or 4450 N from $a=\frac{4}{3}$ scores M1A1A1)
	Total		**7**	

11.Jan 2009

2 (a)	$t=0,\ \ t=30,\ \ t=50$ seconds	B1 B1	 2	B1: Any one correct time B1: The other two correct times Deduct one mark for each extra time if more than three times are given. (eg 0, 15, 30, 50 scores B1B0) (eg 0, 15, 30, 40, 50 scores B0B0) Condone 49 or 48 instead of 50
(b)	$s_1=\frac{1}{2}\times 30\times 5=75$ m **AG**	M1 A1	 2	M1: Finding distance by calculation of area. (Must see use of 0.5 or ½) A1: Correct answer from correct working. (If candidates use two constant acceleration equations, both must be seen for the M1 mark.)
(c)	$s_2=\frac{1}{2}\times 4\times 20=40$ m	M1 A1		M1: Finding distance using area of the second triangle. A1: Correct distance (ignore any negative signs). (If candidates use two constant acceleration equations, both must be seen for the M1 mark.) Accept 38/36 from use of 49/48 instead of 50
	$s=75+40=115$ m	M1 A1F	 4	M1: Addition of the 75 metres and their distance. (75 – 40 = 35 OE scores M0) A1F: Correct result using their value for second area. eg Accept 113/111 from use of 49/48 instead of 50
(d)	$s=75-40=35$ m	M1 A1F	 2	M1: Difference between 75 and their value for the second distance. (Allow their distance – 75) (75 – (– 40) = 115 OE scores M0) A1F: Correct result using their value for second area. (eg 40 – 75 = –35 M1A0) eg Accept 37/39 from use of 49/48 instead of 50
	Total		**10**	

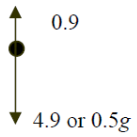
12.June 2009

2(a)	$16=\frac{1}{2}(u+4.2)\times 5$ $32=5u+21$ $5u=11$ $u=\frac{11}{5}=2.2$ ms^{-1} OR First solution from (b) to find acceleration followed by any constant acceleration equation to find u: eg. $4.2=u+0.4\times 5$ $u=2.2$	M1A1 A1 (M1) (A1) (A1)	 3	M1: Using a constant acceleration equation to find u with $v=4.2$ and $a\neq 9.8$. Could be derived from a velocity–time graph. A1: Correct equation A1: Correct value for u Eg $s=\frac{1}{2}(u+v)t$ followed by $16=(u+4.2)\times 5$ or similar scores M1A0

13.Jan 2010

2(a)	$10 = 0 \times 2.5 + \frac{1}{2}a \times 2.5^2$ $a = \frac{20}{2.5^2} = 3.2 \text{ ms}^{-2}$	M1 A1 A1	 3	M1: Use of constant acceleration equation to find a with $u = 0$. A1: Correct equation. NOTE: If v is found first, do not award any marks for part (a) until an equation to find a is produced. This could be from graphical method or from the use of $s = \frac{1}{2}(u+v)t$. A1: Correct acceleration
(b)	$10 = \frac{1}{2}(0+v) \times 2.5$ $v = 8 \text{ ms}^{-1}$ **OR** $10 = \frac{1}{2}v \times 2.5$ $v = 8 \text{ ms}^{-1}$ **OR** $v^2 = (0^2+)2 \times 3.2 \times 10$ $v = 8 \text{ ms}^{-1}$ **OR** $v = (0+)3.2 \times 2.5 = 8 \text{ ms}^{-1}$ **AG**	M1 A1	 2	M1: Use of constant acceleration equation to find v with $u = 0$. A1: Correct speed from correct working. NOTE: If v is found in part (a), with correct working award full marks. NOTE: Accept $3.2 \times 2.5 = 8$
(c)	$t = \frac{90}{8} = 11.25 \text{ s}$ Total Time $= 2.5 + 11.25$ $= 13.75$ $= 13.8 \text{ s}$	B1 M1 A1	 3	B1: Calculation of correct additional time. Could be implied by later working. M1: Addition of their time for the 90 metres and the 2.5 seconds. A1: Correct total time. Accept 13.75. NOTE: $22.5 + 2.5 = 25$ scores B0M1A0
(d)	$\frac{100}{13.75} = 7.27 \text{ ms}^{-1}$	M1 A1F	 2	M1: Finding average speed. Must see 100 and their answer from part (c). A1F: Follow through candidate's time from part (c), regardless of working in part (c). Allow 7.25 ms^{-1} from 13.8 seconds.
	Total		**10**	

14.Jan 2010

4(a)	$v^2 = 0^2 + 2 \times 9.8 \times 15$ $v^2 = 294$ $v = 17.1 \text{ ms}^{-1}$	M1 A1 A1	 3	M1: Use of constant acceleration equation to find v with $u = 0$ and $a = \pm 9.8$. A1: Correct equation A1: Correct speed from correct working. Accept AWRT 17.1. Accept 17.15. Accept $7\sqrt{6}$ Note: If $g = 9.81$ is used for the first time deduct one mark. Should get 17.2 ms^{-1} from $g = 9.81$.
(b)(i)		B1	1	B1: Correct diagram, with arrows and labels. Must see 0.9 and 4.9 or 0.5g (or 4.905 if working with $g = 9.81$).
(b)(ii)	$4.9 - 0.9 = 0.5a$	M1B1		M1: Uses $0.5a$. B1: Explicit statement of "4.9 – 0.9" or "mg – 0.9" or "0.5g – 0.9".

	$(a=)\frac{4}{0.5}=8\ \text{ms}^{-2}$ **AG**	A1	3	A1: Correct acceleration from correct working. Can be awarded without the B1 mark. Must see $\frac{4.9(\text{or } 0.5g)-0.9}{0.5}$ or $\frac{4}{0.5}$ or $4=0.5a$ Note: If $g=9.81$ is used candidates will get 8.01 ms^{-2}. Deduct 1 mark if 8.01 is seen. Examples: $4.9=0.5a+0.9$ $a=8$ M1B0A0 $4=0.5a$ $a=8$ M1B0A1 If candidates only write $a=\frac{4}{0.5}=8$ award M0B0A0.
(b)(iii)	$v^2=0^2+2\times8\times15$ $v=15.5\ \text{ms}^{-1}$	M1 A1	2	M1: Use of constant acceleration equation to find v with $u=0$ and $a=\pm8$. A1: Correct speed from correct working. Accept AWRT 15.5 or truncated to 15.4. Accept $4\sqrt{15}$.
(b)(iv)	The air resistance force will not be constant, but changes **as the speed of the ball changes** (or **changes as the ball accelerates**).	B1	1	B1: Correct explanation, key words in bold. Do not award mark for statements that imply that the acceleration causes the air resistance to change.
	Total		**10**	

15.June 2010

1(a)	30 seconds	B1	1	B1: Correct statement of time.
(b)	$s_1=\frac{1}{2}\times40\times20=400\ \text{m}$ **OR** $s_1=\frac{1}{2}\times(20+0)\times40=400\text{m}$ **OR** $a=-\frac{20}{40}=-\frac{1}{2}$ $0^2=20^2+2\left(-\frac{1}{2}\right)s$ $s=20^2=400\ \text{m}$	M1 A1 (M1) (A1) (M1) (A1)	2	M1: A method for calculating the first distance. Must see 40 and $\frac{1}{2}$. A1: Correct distance. Note on third method: Must see $-\frac{1}{2}$ or $-\frac{20}{40}$ plus attempt to find distance for M1.
(c)	$s_2=\frac{1}{2}\times50\times20=500\text{m}$ **OR** $s_2=\frac{1}{2}\times(0+20)\times50=500\text{m}$ **OR** $a=\frac{20}{50}=\frac{2}{5}$	M1 (M1)		M1: Method for finding the second distance and calculating the total distance.

	$20^2 = 0^2 + 2\left(\frac{2}{5}\right)s$ $s = 20^2 \times \frac{5}{4} = 500$ m Total = 400 + 500 = 900 m	(M1) A1F	 2	Note on third method: Must see $\frac{2}{5}$ or $\frac{20}{50}$ plus attempt to find distance. A1F: Correct total distance. Award the follow through mark for correct addition of 500 and their answer to (b).
(d)	$v_{AVERAGE} = \frac{900}{120} = 7.5$ ms^{-1}	M1 A1F	 2	M1: Their total distance divided by 120 A1F: Correct average speed based on their answer to (c).
(e)	$120 \times 20 - 900 = 1500$ m	M1A1F	2	M1: Multiplication of 20 and 120 to find distance. Note: Award M1 if 2400 seen in this part. A1F: Correct difference based on their answer to (c) provided final answer is positive.
	Total		**9**	

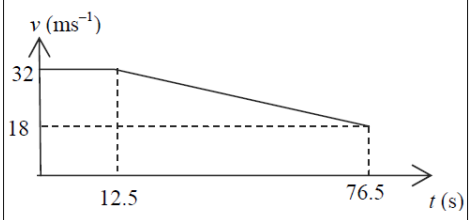
16.Jan 2011

2(a)	$s = \frac{1}{2} \times 10 \times 4 + 10 \times 4 + \frac{1}{2} \times (4+7) \times 10 + \frac{1}{2} \times 7 \times 10$ $(= 20 + 40 + 55 + 35)$ $= 150$ m **OR** $s = \frac{1}{2} \times (10+20) \times 4 + \frac{1}{2} \times (4+7) \times 10 + \frac{1}{2} \times 7 \times 10$ $(= 60 + 55 + 35)$ $= 150$ m **OR** $s = \frac{1}{2} \times 10 \times 4 + 10 \times 4 + 10 \times 4 + \frac{1}{2} \times 10 \times 3 + \frac{1}{2} \times 7 \times 10$ $(= 20 + 40 + 40 + 15 + 35)$ $= 150$ m	M1M1A1 A1 (M1M1A1) (A1) (M1M1A1) (A1)	 4	M1: Any one term correct. M1: A second term correct. A1: Correct expression for total distance. A1: Total distance correct.
(b)	Average Speed $= \frac{150}{40} = 3.75$ ms^{-1}	M1 A1F	 2	M1: Their total distance divided by 40. A1F: Correct average speed based on their distance from part (a). Must be correct to three or more significant figures.
(c)	$a = \frac{4}{10} = 0.4$ ms^{-2}	M1 A1	 2	M1: Any division involving the numbers 10 and 4. A1: Correct acceleration. CAO
(d)	$F = 200000 \times 0.4 = 80000$ N	M1A1F	2	**Note on use of constant acceleration equations:** award M1 for correct equation with correct values and A1 for correct final answer. M1: Multiplication of , 2×10^n , for any integer n, by candidate's acceleration from part (c). A1F: Correct force based on their answer to part (c) multiplied by 200000. Note: use of $a = 2.5$ gives 500000 N Accept 80kN
	Total		**10**	

17.June 2011

1(a)(i)	$0.6^2 = 0^2 + 2a \times 0.9$ $a = \frac{0.6^2}{1.8} = 0.2 \text{ ms}^{-2}$ **AG**	M1A1 A1	3	M1: Correct use of constant acceleration equation with $u = 0$ to find a. A1: Correct equation. A1: Correct a but some intermediate working must be seen. Note that $0^2 = 0.6^2 + 2a \times 0.9$ Scores M0A0A0 Verification methods require a conclusion for full marks to be awarded. Condone seeing just the second line of working.
(a)(ii)	$0.9 = \frac{1}{2}(0 + 0.6)t$ $t = \frac{0.9}{0.3} = 3$ seconds **OR** $0.6 = 0 + 0.2t$ $t = \frac{0.6}{0.2} = 3$ seconds **OR** $0.9 = \frac{1}{2}0.2t^2$ $t = 3$ seconds	M1 A1 (M1) (A1) (M1) (A1)	2	M1: Correct use of constant acceleration equation with $u = 0$ (and $a = 0.2$ if needed) to find t. A1: Correct time. Note: Do not penalise $0.9 = \frac{1}{2}(0.6 + 0)t$ in the first method. Note: $0 = 0.6 + 0.2t$ scores M0A0 in the second method.
(b)	$T - 800 \times 9.8 = 800 \times 0.2$ $T = 7840 + 160 = 8000$ N	M1A1 A1	3	M1: Three term equation of motion. Must have these three terms but can have incorrect signs. Must use $a = 0.2$ A1: Correct equation with correct signs. (Allow 800g) A1: Correct tension. Accept 8008 or 8010 from use of $g = 9.81$.
	Total		**8**	

18.June 2011

3(a)	$s = 32 \times 12.5 = 400$ m	B1	1	B1: Correct distance.
(b)	$1600 = \frac{1}{2}(32 + 18)t$ $t = \frac{1600}{25} = 64$ seconds	M1dM1 A1	3	M1: Seeing 2000 – candidate's answer to part (a) calculated dM1: Use of constant acceleration equation(s) to find t, with $u = 32$ and $v = 18$ A1: Correct time. Accept only 64
(c)		B1 B1 B1F	3	B1: Shape of the graph. B1: Correct velocities (ie 18 and 32) on vertical axis. B1F: Correct times (ie 12.5 and 76.5) on the horizontal axis. (Follow through incorrect answers to part (b)). Award marks for graph if seen in earlier parts.

(d)	Average Speed $= \dfrac{2000}{12.5+64} = 26.1\ \text{ms}^{-1}$	M1 A1F	2	M1: Use of 2000 over candidate's total time (not 64 or 12.5). A1F: Correct speed. AWRT 26.1. FT candidate's answer to part (b) or (c).
	Total		**9**	

19.Jan 2012

3(a)	$s_1 = \frac{1}{2} \times 5 \times 28 = 70\ \text{m}$	M1A1	2	M1: For $\frac{1}{2} \times 5 \times 28$ or equivalent. A1: Correct distance.
(b)	$s = 70 + \frac{1}{2} \times 5 \times 22$ $= 70 + 55$ $= 125\ \text{m}$	B1M1 A1F	3	B1: For $\pm\frac{1}{2} \times 5 \times 22$ or equivalent. M1: For adding the distances. A1F: Correct distance. Follow through their answer from part (a) only.
(c)	Average speed $= \dfrac{125}{50} = 2.5\ \text{ms}^{-1}$	M1 A1F	2	M1: For their answer to (b) divided by 50. A1F: Correct average speed. Follow through answers from part (b).
(d)	Displacement from $O = 70 - 55$ $= 15\ \text{m}$	B1	1	B1: Correct displacement.
(e)	Average velocity $= \dfrac{15}{50} = 0.3\ \text{ms}^{-1}$	M1 A1F	2	M1: For their answer to (d) divided by 50, provided they have subtracted in (d). A1F: Correct average velocity. Follow through answers from part (d) Award no marks if the final answer is 0.
(f)	$a = \dfrac{5}{18} = 0.278\ \text{ms}^{-2}$	B1	1	B1: Correct acceleration. Accept $\frac{5}{18}$ or equivalent fraction or 0.277 or AWRT 0.278. Condone 0.28
	Total		**11**	

20.June 2012

3(a)(i)	$10^2 = 20^2 + 2 \times a \times 75$ $a = \dfrac{100-400}{150} = -2\ \text{ms}^{-2}$	M1A1 A1	3	M1: Use of a constant acceleration equation to find a, with $v = 10$ and $u = 20$. $20^2 = 10^2 + 2 \times a \times 75$ scores M0 A1: Correct equation. A1: Correct acceleration. For two equation methods award no marks until an equation for a is obtained.
(ii)	$0 = 20 - 2t$ $t = 10$ seconds	M1 A1	2	M1: Using a constant acceleration equation, with $u = 20$ and $v = 0$, to find t using their acceleration from (a) even if positive. Using $s = 75$ scores M0 A1: Correct time from correct working CSO.

(iii)	$F = 1400 \times 2$ $= 2800$ N	M1 A1F	2	M1: Use of $F = ma$ with ± their acceleration and mass of 1400. A1F: Correct force. Follow through the magnitude of their acceleration. Answer must be positive. Sign changes do not need to be justified.
(b)	$F = 2800 - 200 = 2600$ N	B1F	1	B1F: The magnitude of their force minus 200. Do not award if M1 not awarded in (a)(iii). Final answer must be positive. Follow through only if their answer to (a)(iii) is greater than 200.
	Total		**8**	

21.Jan 2013

1(a)(i)	$640 = \frac{1}{2}(12+20)t$ $t = \frac{640 \times 2}{32} = 40$ s	M1A1 A1	3	M1: Use of constant acceleration equation to find t with s = 640, 20 and 12. A1: Correct equation. A1: Correct time. For two equation methods, award no marks until an equation for t is obtained. Using a = 0.2 to find t = –40 scores M1A0A0
(a)(ii)	$12^2 = 20^2 + 2 \times a \times 640$ $a = \frac{12^2 - 20^2}{2 \times 640} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	M1A1 A1	3	M1: Use of constant acceleration equation to find a with u = 20 and v = 12. A1F: Correct equation. A1F: Correct deceleration. Do not award for a = 0.2
	OR $12 = 20 + 40a$ $a = \frac{-8}{40} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2}) OR $640 = 20 \times 40 + \frac{1}{2}a \times 40^2$ $a = \frac{-160}{800} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	(M1A1F) (A1F) (M1A1F) (A1F)	(3) (3)	Accept –0.2 or $\pm\frac{1}{5}$ m s^{-2} for deceleration Follow through incorrect times from part (a). For two equation methods, award no marks until an equation for a is obtained. Accept $\frac{8}{40} = 0.2$ provided that the equations 20 = 12 +40a or $20^2 = 12^2 + 1280a$ are not seen $a = \frac{8}{40} = 0.2$ scores M1A1A0 unless a is defined as deceleration
1(b)(i)	$1820 = 12 \times 70 + \frac{1}{2} \times a \times 70^2$ $a = \frac{1820 - 12 \times 70}{2450} = 0.4$ m s^{-2}	M1A1 A1	3	M1: Constant acceleration equation to find a with u = 12 (or 20), s = 1820 and t = 70. A1F: Correct equation. A1F: Correct acceleration. Accept $\frac{2}{5}$ m s^{-2} oe.

(b)(ii)	$1820 = \frac{1}{2}(12+v)\times 70$ $v = \frac{1820}{35} - 12 = 40 \text{ m s}^{-1}$ OR $v = 12 + 0.4\times 70$ $= 40 \text{ m s}^{-1}$ OR $v^2 = 12^2 + 2\times 0.4\times 1820$ $v = \sqrt{1600} = 40 \text{ m s}^{-1}$ OR $1820 = 70v - \frac{1}{2}\times 0.4\times 70^2$ $v = 40 \text{ m s}^{-1}$	M1A1 A1 (M1A1F) (A1F) (M1A1F) (A1F) (M1A1F) (A1F)	 3 (3) (3) (3)	M1: Constant acceleration equation to find v with s = 1820 and t = 70. A1F: Correct equation. A1F: Correct velocity. For two equation methods, award no marks until an equation for v is obtained.
(c)	Average Speed $= \frac{640+1820}{40+70}$ $= \frac{2460}{110} = 22.4 \text{ m s}^{-1}$	M1 A1F	 2	M1: Division of 2460 by their total time (70 + their answer to (a)). A1F: Correct time. Accept 22.3 or AWRT 22.4
	Total		**14**	