



**Topic Test: OxfordAQA AS
Mathematics**
Mechanics

Name: _____

Class: _____

Date: _____

Time: **72 minutes**

Marks: **59 marks**

Comments:

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 m s^{-1} .

(a) (i) Show that the acceleration of the load is 0.2 m s^{-2} . (3)

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

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

(Total 8 marks)

2 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 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 m s^{-1} .

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

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

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

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

(Total 9 marks)

3 A particle, of mass 3 kg, moves along a straight line. At time t seconds, the displacement, s metres, of the particle from the origin is given by

$$s = 8t^3 + 15$$

(a) Find the velocity of the particle at time t . (2)

(b) Find the magnitude of the resultant force acting on the particle when $t = 2$. (4)

(Total 6 marks)

4 A car is travelling at a speed of 20 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. Assume that no other horizontal forces act on the car.

(a) After the car has travelled 75 metres, its speed has reduced to 10 m s^{-1} . Find the acceleration of the car. (3)

- (b) Find the time taken for the speed of the car to reduce from 20 m s^{-1} to zero. (2)
- (c) Given that the mass of the car is 1400 kg , find the magnitude of the constant braking force. (2)
- (Total 7 marks)**

- 5** A tractor, of mass 3500 kg , is used to tow a trailer, of mass 2400 kg , across a horizontal field. The trailer is connected to the tractor by a horizontal tow bar. As they move, a constant resistance force of 800 newtons acts on the trailer and a constant resistance force of $R \text{ newtons}$ acts on the tractor. A forward driving force of 2500 newtons acts on the tractor. The trailer and tractor accelerate at 0.2 m s^{-2} .
- (a) Find R . (3)
- (b) Find the magnitude of the force that the tow bar exerts on the trailer. (3)
- (c) State the magnitude of the force that the tow bar exerts on the tractor. (1)
- (Total 7 marks)**

- 6** A block, of mass 4 kg , is made to move in a straight line on a rough horizontal surface by a horizontal force of 50 newtons , as shown in the diagram.



Assume that there is no air resistance acting on the block.

- (a) Draw a diagram to show all the forces acting on the block. (1)
- (b) Find the magnitude of the normal reaction force acting on the block. (1)
- (c) The acceleration of the block is 3 m s^{-2} . Find the magnitude of the friction force acting on the block. (3)
- (d) Find the coefficient of friction between the block and the surface. (2)
- (e) Explain how and why your answer to part (d) would change if you assumed that air resistance did act on the block. (2)
- (Total 9 marks)**

- 7** A toy train of mass 300 grams is moving along a straight horizontal track at a speed of 2.8 m s^{-1} . This toy train collides with another toy train, of mass 200 grams, which is at rest on the same track. During the collision, the two trains lock together and then move together.

Find the speed of the trains immediately after the collision.

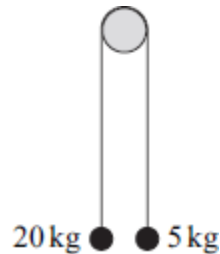
(Total 3 marks)

- 8** Two particles, A and B , are moving towards each other along the same straight horizontal line when they collide. Particle A has mass 5 kg and particle B has mass 4 kg. Just before the collision, the speed of A is 4 m s^{-1} and the speed of B is 3 m s^{-1} . After the collision, the speed of A is 0.6 m s^{-1} and both particles move on the same straight horizontal line.

Find the two possible speeds of B after the collision.

(Total 6 marks)

- 9** Two particles have masses of 20 kg and 5 kg. They are connected by a light inextensible string that passes over a smooth fixed peg, as shown in the diagram.



The particles are released from rest.

By forming two equations of motion, find the magnitude of the acceleration of the particles.

(Total 4 marks)

Mark schemes

1

(a) (i) $0.6^2 = 0^2 + 2a \times 0.9$

M1: Correct use of constant acceleration equation with $u = 0$ to find a .

A1: Correct equation.

M1A1

$$a = \frac{0.6^2}{1.8} = 0.2 \text{ ms}^{-2} \quad \mathbf{AG}$$

A1: Correct a but some intermediate working must be seen.

A1

Note that $0^2 = 0.6^2 + 2a \times 0.9$

Scores MOA0A0

Verification methods require a conclusion for full marks to be awarded.

Condone seeing just the second line of working.

3

(ii) $0.9 = \frac{1}{2} (0 + 0.6)t$

M1: Correct use of constant acceleration equation with $u = 0$ (and $a = 0.2$ if needed) to find t .

M1

$$t = \frac{0.9}{0.3} = 3 \text{ seconds}$$

A1: Correct time.

A1

Note: Do not penalise $0.9 = \frac{1}{2} (0.6 + 0)t$ in the first method.

OR

$$0.6 = 0 + 0.2t$$

(M1)

$$t = \frac{0.6}{0.2} = 3 \text{ seconds}$$

(A1)

Note: $0 = 0.6 + 0.2t$ scores MOA0 in the second method.

OR

$$0.9 = \frac{1}{2} 0.2t^2$$

(M1)

$$t = 3 \text{ seconds}$$

(A1)

2

(b) $T - 800 \times 9.8 = 800 \times 0.2$

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)

M1A1

$$T = 7840 + 160 = 8000 \text{ N}$$

A1: Correct tension.

A1

Accept 8008 or 8010 from use of $g = 9.81$.

3

[8]

2

(a) $s = 32 \times 12.5 = 400 \text{ m}$

B1: Correct distance.

B1

1

(b) $1600 = \frac{1}{2} (32 + 18)t$

M1: Seeing 2000 – candidate's answer to part (a) calculated

dM1: Use of constant acceleration equation(s) to find t , with $u = 32$ and $v = 18$

M1dM1

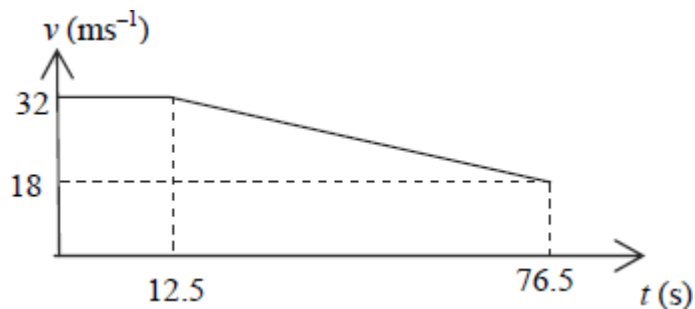
$$t = \frac{1600}{25} = 64 \text{ seconds}$$

A1: Correct time. Accept only 64

A1

3

(c)



B1: Shape of the graph.

B1

B1: Correct velocities (ie 18 and 32) on vertical axis.

B1

B1F: Correct times (ie 12.5 and 76.5) on the horizontal axis.

B1F

*(Follow through incorrect answers to part (b)).
Award marks for graph if seen in earlier parts.*

3

(d) Average Speed = $\frac{2000}{12.5 + 64} = 26.1 \text{ ms}^{-1}$

M1: Use of 2000 over candidate's total time (not 64 or 12.5).

M1

*A1F: Correct speed. AWRT 26.1.
FT candidate's answer to part (b) or (c).*

A1F

2

[9]

3 (a) $v = \frac{ds}{dt}$

M1

$= 24t^2$

A1

2

(b) $a = \frac{dv}{dt}$

$= 48t$

B1

When $t = 2$, $a = 96$

B1

Using $F = ma$

$$F = 3 \times 96$$

M1

$$= 288 \text{ N}$$

A1

4

[6]

4

(a) $10^2 = 20^2 + 2 \times a \times 75$

M1: Use of a constant acceleration equation to find a , with $v = 10$ and $u = 20$.

$$20^2 = 10^2 + 2 \times a \times 75 \text{ scores M0}$$

A1: Correct equation.

M1A1

$$a = \frac{100 - 400}{150} = -2 \text{ ms}^{-2}$$

A1: Correct acceleration.

For two equation methods award no marks until an equation for a is obtained.

A1

3

(b) $0 = 20 - 2t$

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

M1

$$t = 10 \text{ seconds}$$

A1: Correct time from correct working CSO.

A1

2

(c) $F = 1400 \times 2 = 2800 \text{ N}$

M1: Use of $F = ma$ with \pm 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.

M1A1F

2

[7]

5

(a) $5900 \times 0.2 = 2500 - 800 - R$

M1: Equation of motion for tractor and trailer as a single particle, with 2500, 800, R (which might be implied by seeing 1180 and 1700 or 1180 and 3300) and 5900×0.2 OE, with any signs.

A1: Correct equation.

M1A1

$(R =)2500 - 1180 - 800 = 520 \text{ N}$

A1: Correct R.

A1

If tension found first, do not award any marks until an equation for R is obtained. Award M1 for $3500 \times 0.2 = \pm 2500 \pm R \pm 1280$.

3

(b) $T - 800 = 2400 \times 0.2$

M1: Equation for trailer with 2400 and 800.

A1: Correct equation.

M1A1

$(T =)800 + 480 = 1280 \text{ N}$

A1: Correct tension.

A1

3

OR

$$3500 \times 0.2 = 2500 - 520 - T$$

M1: Equation for tractor with 3500, 2500 and 520.

A1F: Correct equation.

(M1A1F)

$$(T =) 2500 - 700 - 520 = 1280 \text{ N}$$

A1F: Correct tension.

(A1F)

(3)

Follow through incorrect R from part (a).

If the tension has been found in part (a) it only needs to be stated here.

(c) 1280 N

B1F: Same answer as part (b).

Do not accept - 1280.

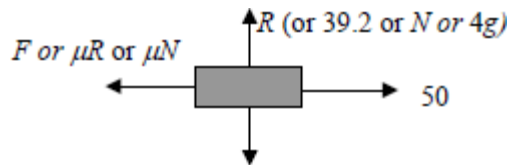
B1F

1

[7]

6

(a)



mg or W or 4g or 39.2

B1: Correct force diagram with four forces with arrows and labels. Accept words eg friction instead of letters.

Ignore negative signs in labels.

Do not accept 4 kg for the weight.

Award marks if forces are drawn on the diagram in the question.

B1

1

(b) 39.2 N

B1: Correct reaction force.

Accept 4g. Do not accept 39.

B1

1

(c) $50 - F = 4 \times 3$

M1: Three term equation of motion with the correct terms.

A1: Correct equation with correct signs.

M1A1

$$F = 38$$

A1: Correct friction.

A1

3

(d) $38 = \mu \times 39.2$

M1: Use of $F = \mu R$ with their answers to (b) and (c).

M1

$$\mu = \frac{38}{39.2} = 0.969$$

*A1F: Correct μ based on their answers to (b) and (c).
Accept AWRT 0.969.*

A1F

Note: $F = 12$ leads to 0.306 and award M1 A1F

Condone 0.97 or FT to 2sf

Condone use of inequalities.

2

(e) Less friction, so a smaller coefficient of friction.

B1: Less friction.

B1

B1: Smaller μ .

B1

Note:

More friction anywhere scores B0 B0

Less friction, greater μ scores B1 B0

Smaller μ with no / inexact reason B0 B1

2

[9]

7

$$0.3 \times 2.8 = (0.3 + 0.2) v$$

M1: Use of 2 or 3 term equation for conservation of momentum with 0.5 or equivalent on the RHS. Condone missing brackets if recovered.

A1: Correct equation.

M1A1

$$v = \frac{0.3 \times 2.8}{0.5} = 1.68 \text{ m s}^{-1}$$

A1: Correct speed. CAO.

A1

Condone use of 300, 200 and 500 grams or use of correct ratios, eg 3, 2 and 5.

Note for consistent use of weight instead of mass penalise by one mark.

[3]

8

Case 1: where 0.6 is taken as positive

$$5 \times 4 - 4 \times 3 = 5 \times 0.6 + 4v$$

$$8 = 3 + 4v$$

M1: Conservation of momentum, with left hand side as $5 \times 4 \pm 4 \times 3$.

A1: Correct equation ($8 = 3 + 4v$ OE).

M1A1

$$v = 1.25 \text{ m s}^{-1}$$

A1: Correct speed (1.25).

A1

Case 2: where 0.6 is taken as negative

$$5 \times 4 - 4 \times 3 = 5 \times (-0.6) + 4v$$

$$8 = -3 + 4v$$

M1: Seeing one of $8 = 3 - \pm 4v$ or

$-8 = 3 \pm 4v$ or $32 = -3 \pm 4v$ or

$-32 = 3 \pm 4v$ OE

A1: Seeing ± 2.75 or $\frac{11}{4}$

M1A1

$$v = 2.75 \text{ m s}^{-1}$$

A1: Correct speed. Accept $\frac{11}{4}$

A1

If mg used consistently instead of m deduct one mark, to give a maximum of 5 marks.

[6]

9

$$20g - T = 20a$$

M1: Three term equation of motion for one particle.

M1

$$T - 5g = 5a$$

$$15g = 25a$$

M1: Three term equation of motion for the other particle.

A1: Both equations correct.

M1A1

$$a = \frac{15g}{25} = 5.88 \text{ ms}^{-2}$$

A1: Correct acceleration from correct working.

A1

[4]