AS Mechanics Practice Paper B
45 Marks

45 Minutes

1. A car of mass 1.25 tonnes tows a caravan of mass 0.75 tonnes along a straight, level road. The total resistance to motion experienced by the car and the caravan is 1200 N.

The car and caravan accelerate uniformly from rest to 25 m s-1 in 20 seconds.

Calculate the driving force produced by the car's engine. **(3)**

(Total marks: 3)

2. A cyclist and her bicycle have a combined mass of 78 kg. While riding on level ground and using her greatest driving force, she is able to accelerate uniformly from rest to 10 ms^{-1} in 15 seconds against constant resistive forces that total 60 N.

a. Show that her maximum driving force is 112 N. **(4)**

The cyclist begins to ascend a hill, inclined at an angle α to the horizontal, riding with her maximum driving force and against the same resistive forces. In this case, she is able to maintain a steady speed.

b. Find the angle α, giving your answer to the nearest degree. **(4)**

c. Comment on the assumption that the resistive force remains constant

i. in the case when the cyclist is accelerating,

ii. in the case when she is maintaining a steady speed. **(2)**

(Total marks: 10)

3. Anila is practising catching tennis balls. She uses a mobile computer-controlled machine which fires tennis balls vertically upwards from a height of 2.5 metres above the ground. Once it has fired a ball, the machine is programmed to move position rapidly to allow Anila time to get into a suitable position to catch the ball.

The machine fires a ball at 24 ms -1 vertically upwards and Anila catches the ball just before it touches the ground.

a. Draw a speed-time graph for the motion of the ball from the time it is fired by the machine to the instant before Anila catches it.

(3)

b. Find, to the nearest centimetre, the maximum height which the ball reaches above the ground. **(4)**

c. Calculate the speed at which the ball is travelling when Anila catches it **(4)**

d. Calculate the length of time that the ball is in the air. **(3)**

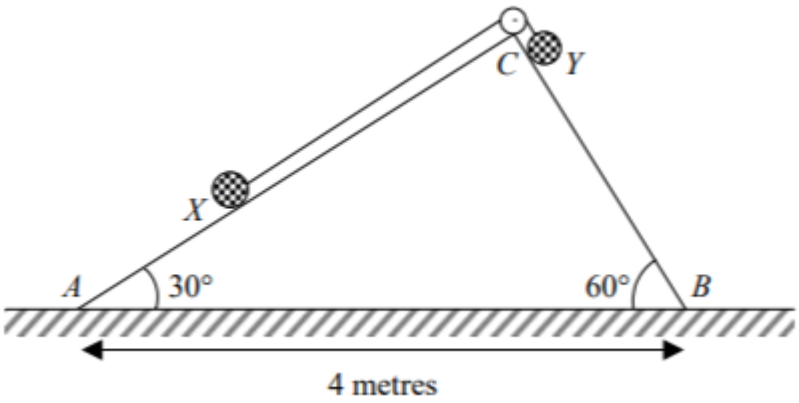
(Total marks: 14)

4. The figure shows a particle X of mass 3 kg on a smooth plane inclined at an angle 30° to the horizontal, and a particle Y of mass 2 kg on a smooth plane inclined at an angle 60° to the horizontal.

The two particles are connected by a light, inextensible string of length 2.5 metres passing over a smooth pulley at C which is the highest point of the two planes.

Initially, Y is at a point just below C touching the pulley with the string taut. When the particles are released from rest they travel along the lines of greatest slope, AC in the case of X and BC in the case of Y, of their respective planes.

A and B are the points where the planes meet the horizontal ground and AB = 4 metres.



a. Show that the initial acceleration of the system is given by $\frac{g}{10}\left(2\sqrt{3}-3\right) ms^{-2}$ **(7)**

b. By finding the tension in the string, or otherwise, find the magnitude of the force exerted on the pulley and the angle that this force makes with the vertical.

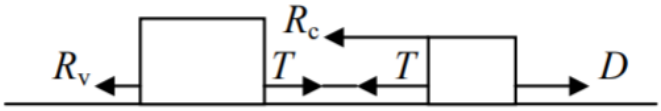
(7)

c. Find, correct to 2 decimal places, the speed with which Y hits the ground. **(4)**

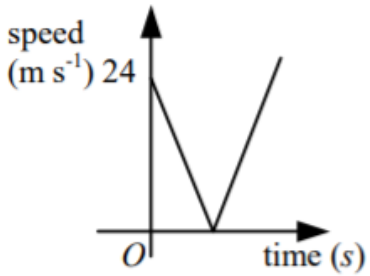
(Total marks: 18)

Total Marks for Paper: 45

Mark Scheme

1		
	$acceleration = \frac{25-0}{20} = \frac{5}{4}$	**M1**
	For car and van, equation of motion is, $D - 1200 = 2000 \times \frac{5}{4}$	**M1**
	$D = 3700\ N$	**A1**

2a	Acceleration = $\frac{10-0}{15}$	**M1**
	$= \frac{2}{3} ms^{-2}$	**A1**
	Equation of motion is $D - 60 = 78 \times \frac{2}{3}$	**M1**
	$D = 112N$	**A1**
2b	Equation of motion is $112 - 60 - 78g \sin\alpha = 0$	**M1** **A1**
	$\sin\alpha = \frac{52}{78g} = \frac{2}{3g}$	**M1**
	$\alpha = 3.901$ $\alpha = 4$	**A1**

3a		**B3**
3b	At max heigh, $v = 0; use\ of\ v^2 = u^2 + 2as$ $a = -9.8$ $u = 24$	**M1**
	$0 = 576 - 19.6s$ $s = 29.387 \ldots$	**M1** **A1**
	Start value $2.5m$, so max height = 31.89m	**A1**
3c	Use $v^2 = u^2 + 2as$ $a = -9.8$ $u = 24$ $s = -2.5$ Up = positive	**M1**
	$v^2 = 576 + 49$	**M1** **A1**
	$v = \pm 25$ I.e, speed = 25 ms^{-1} downwards	**A1**
3d	Use of $v = u + at$ with $v = 25,\ u = -24\ and\ a = 9.8$ (Down in +ve)	**M1**
	$25 = -24 + 9.8t$ $t = 5$	**M1** **A1**

4a	For X: $T - 3gsin30 = 3a$ $T - \frac{3}{2}g = 3a$	**M1** **A1**
	For Y: $2g\cos 30 - T = 2a$ $g\sqrt{3} - T = 2a$	**M1** **A1**
	(1) + (2) $g\sqrt{3} - T = 2a$	**M1** **A1**
	$a = \frac{g\sqrt{3}}{5} - \frac{3g}{10}$ $a = \frac{g}{10}(2\sqrt{3} - 3)$	**A1**
4b	Sub a. into (1) to get $T = 3a + \frac{3g}{2} = \frac{3g}{10}(2\sqrt{3} - 3) + \frac{3g}{2}$	**M1** **A1**
	$T = 16.0645$	**A1**
	Force on pulley = $\sqrt{T^2 + T^2} = T\sqrt{2}$	**M1**
	Force on pulley = 22.7 N	**A1**
	Force acts at an angle 45° to each plane, i.e, 15° to the vertical	**M1** **A1**
4c	Initially, Y is at C and $CB = 4\sin 30 = 2$m	**M1**
	$v^2 = u^2 + 2as$ $u = 0$ $s = 2$ $a = \frac{g}{10}(2\sqrt{3} - 3)$	**M1**
	$v^2 = 0 + \frac{4g}{10}(2\sqrt{3} - 3)$ $v = 1.35$ ms^{-1}	**M1** **A1**