AS Mechanics Practice Paper E
45 Marks

45 Minutes

1. The figure shows a toy lorry being pulled by a piece of string, up a ramp inclined at an angle of 25° to the horizontal. When the string is pulled with a force of 20 N parallel to the line of greatest slope of the ramp, the lorry is on the point of moving up the ramp.

In a simple model of the situation, the ramp is considered to be smooth.

a. Draw a diagram showing all the forces acting on the lorry. **(2)**

b. Find the weight of the lorry and the magnitude of the reaction between the lorry and the ramp, giving your answers to an appropriate degree of accuracy.

(4)

c. Write down any modelling assumptions that you have made about

i. The lorry

ii. The string. **(2)**

In a more refined model, the ramp is assumed to be rough.

d. State the effect that this would have on your answers to part (b) **(2)**

(Total marks: 8)

2. A car on a straight test track starts from rest and accelerates to a speed of V ms^{-1} in 6 seconds. The car maintains this speed for a further 50 seconds before decelerating to rest. In a simple model of this motion, the acceleration and deceleration are assumed to be uniform and the magnitude of the deceleration to be 1.5 times that of the acceleration.

a. Show that the total time for which the car is moving is 60 seconds. **(3)**

b. Sketch a velocity-time graph for this journey. **(3)**

Given that the total distance travelled is 1320 metres,

c. Find V. **(3)**

In a more sophisticated model, the acceleration is assumed to be inversely proportional to the velocity of the car.

d. Explain how the acceleration would vary during the first six seconds under this model. **(2)**

(Total marks: 11)

3. A car of mass 1250 kg tows a caravan of mass 850 kg up a hill inclined at an angle α to the horizontal where $\sin \alpha = \frac{1}{14}$. The total resistance to motion experienced by the car is 400 N, and by the caravan is 500 N.

Given that the driving force of the engine is 3 kN,

a. Show that the acceleration of the system is 0.3 ms $^{-2}$, **(5)**

b. Find the tension in the towbar linking the car and the caravan. **(3)**

Starting from rest, the car accelerates uniformly for 540 m until it reaches a speed of v m s^{-1} at the top of the hill.

c. Find v. **(3)**

At the top of the hill the road becomes level and the driver maintains the speed at which the car and caravan reached the top of the hill.

d. Assuming that the resistance to motion on each part of the system is unchanged, find the percentage reduction in the driving force of the engine required to achieve this. **(4)**

(Total marks: 15)

4. Two flies P and Q, are crawling vertically up a wall. At time t = 0, the flies are at the same height above the ground, with P crawling at a steady speed of 4 cm s $^{-1}$.

Q starts from rest at time t = 0 and accelerates uniformly to a speed of 6 cm s^{-1} in 6 seconds. Fly Q then maintains this speed.

a. Find the value of t when the two flies are moving at the same speed. **(3)**

b. Sketch on the same diagram, speed-time graphs to illustrate the motion of the two flies. **(3)**

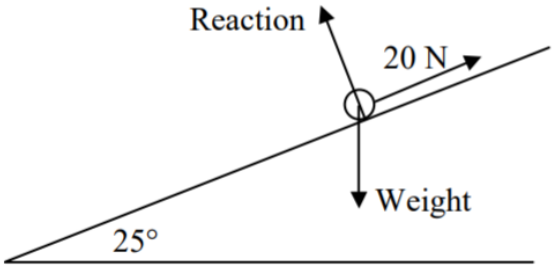
Given that the distance of the two flies from the top of the wall at time t = 0 is x cm and that Q reaches the top of the wall first,

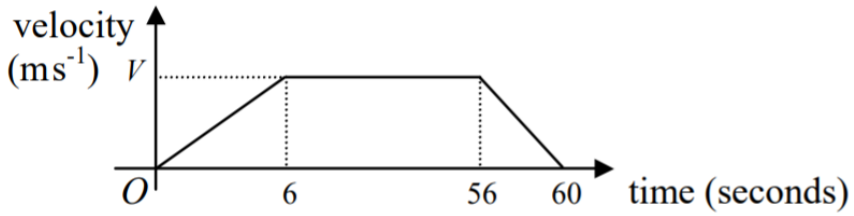
c. Show that $x > 36$. **(5)**

(Total marks: 11)

Total Marks for Paper: 45

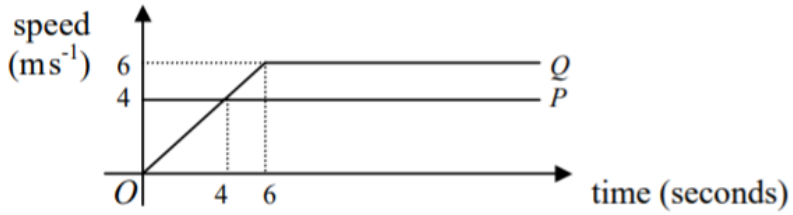
Mark Scheme

1a		**B1** **B1**
1b	Resolve parallel to the plane: $20 - W \sin 25 = 0$	**M1**
	$W = \frac{20}{\sin 25}$ $W = 47.3\ N$	**A1**
	Resolving perpendicular to the plane: $R - W \cos 25 = 0$	**M1**
1c i	$R = 47.324$ x cos 25 $R = 42.9$N	**A1**
1 cii	Inextensible	**B1**
1d	W and R will both be lower	**B2**

2a	e.g. since acceleration and deceleration are uniform, time for deceleration = $\frac{1}{1.5}$ time for acceleration	**M1**
	Deceleration = 4 seconds, therefore total time = 6 + 50 + 4 = 60 seconds	**M1** **A1**
2b		**B1** **B1** **B1**
2c	Area under graph = $\frac{1}{2}(6)(V) + 50V + \frac{1}{2}(4)(V) = 1320$	**M1**
	$55V = 1320$	**M1**
	$V = 24$ms^{-1}	**A1**
2d	Car accelerates more quickly at first, but acceleration decreases throughout the six seconds	**B1** **B1**

3a	For car + caravan, equation of motion is 3000 – 900 – 2100g sin $\propto$ = 2100a	**M1** **M1** **A1**
	2100 – 1470 = 2100a	**M1**
	$a = 0.3\ ms^{-2}$	**A1**
3b	For caravan, T – 500 – 850 g sin $\propto$ = 850 x 0.3	**M1**
	T – 500 – 595 = 255	**M1**
	T = 1350 N	**A1**
3c	$u = 0$ $a = 0.3$ $s = 540$ $v^2 = 0 + 2(0.3)(540)$	**M1**

	$v^2 = 0 + 2(0.3)(540) = 324$	**M1**
	$v = 18ms^{-1}$	**A1**
3d	$D - 900 = 0$	**M1**
	$D = 900$ N	**A1**
	% Reduction = $\frac{3000-900}{3000} \times 100$	**M1**
	= 70%	**A1**

4a	For $Q = a = \frac{\Delta v}{t} = \frac{6-0}{6} = 1$	**M1**
	$u = 0, v = 4$ $v = u + at$	**M1**
	$4 = 0 + 1t$ $t = 4\ seconds$	**A1**
4b		**B3**
4c	Q will catch P when area under Q graph = area under P graph $\frac{1}{2}(6)(6) + 6(t-6) = 4t$	**M1**
	i.e, $18 + 6t - 36 = 4t$ $2t = 18$	**M1**
	$t = 9$	**A1**
	After 9 seconds, P has travelled $4 \times 9 = 36\ cm$	**M1**
	Therefore, Q reaches the top first is $x > 36$	**A1**