AS Mechanics Practice Paper D
45 Marks

45 Minutes

1. A lorry accelerates uniformly from 5 ms^{-1} to 20 ms^{-1} in 30 seconds.

Find how far it travels while accelerating. **(3)**

(Total marks: 3)

2. Three forces $(-5\mathbf{i} + 4p\mathbf{j})$ N, $(2q\mathbf{i} + 3\mathbf{j})$ N and $(\mathbf{i} + \mathbf{j})$ N act on a particle A of mass 2 kg. Given that A is in equilibrium, find the values of p and q.

(4)

(Total marks: 4)

3. An underground train accelerates uniformly from rest at station A to a velocity of 24 ms^{-1}. It maintains this speed for 84 seconds, until it decelerates uniformly to rest at station B. The total journey time is 116 seconds and the magnitudes of the acceleration and deceleration are equal.

a. Find the time it takes the train to accelerate from rest to 24 ms^{-1} **(2)**

b. Illustrate this information on a velocity-time graph. **(2)**

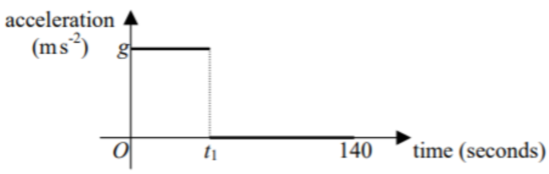
c. Using your graph, or otherwise, find the distance between the two stations **(3)**

(Total marks: 7)

4. A student attempts to sketch the acceleration-time graph of a parachutist who jumps from a plane at a height of 2200 m above the ground.

The student assumes that the parachutist falls freely from rest under gravity until she is 240 m from the ground at which point she opens her parachute.

The student makes the assumption that, at this point, the velocity of the parachutist is immediately reduced to a value which remains constant until she reaches the ground 140 seconds after she left the plane.



The student decides to ignore air resistance and his sketch is shown in the figure. The value t_1 is used by the student to denote the time at which the parachute is opened.

Using the model proposed by the student, calculate

a. The speed of the parachutist immediately before she opens her parachute **(4)**

b. The value of t_1 **(3)**

c. The speed of the parachutist after the parachute is opened **(2)**

d. Comment on two features of the student's model which are unrealistic and say what effect taking account of these would have had on the values which you calculated in parts (a) and (b).

(4)

(Total marks: 13)

5. A ball of mass 2 kg moves on a smooth horizontal surface under the action of a constant force, F. The initial velocity of the ball is $(2\mathbf{i} - 3\mathbf{j})$ ms^{-1} and 4 seconds later it has velocity $(10\mathbf{i} + 9\mathbf{j})$ ms^{-1} where **i** and **j** are perpendicular, horizontal unit vectors.

a. Referring to the mass of the ball and the force it experiences, explain why it is reasonable to assume that the acceleration is constant.

(2)

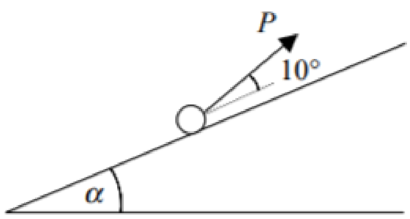
b. Find, giving your answers correct to 3 significant figures,

i. the magnitude of the acceleration experienced by the ball,

ii the angle which F makes with the vector **i**. **(7)**

(Total marks: 9)

6. The figure below shows a ball of mass 3 kg lying on a smooth plane inclined at an angle α to the horizontal where $\sin \alpha = \frac{5}{3}$. The ball is held in equilibrium by a force of magnitude P newtons, which acts at an angle of 10° to the line of greatest slope of the plane.



a. Suggest a suitable model for the ball. **(1)**

Giving your answers correct to 1 decimal place

b. Find the value of P **(4)**

c. find the magnitude of the reaction between the ball and the plane. **(4)**

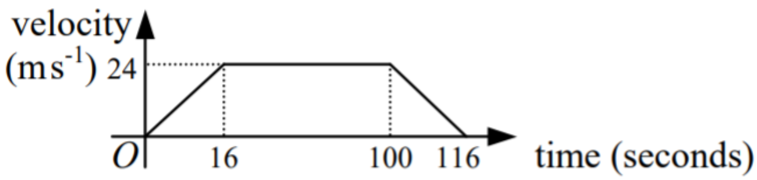
(Total marks: 9)

Total Marks for Paper: 45

Mark Scheme

1	$s = \left(\frac{u+v}{2}\right)t$ $u = 5, v = 20, t - 30$	**M1**
	$s = \frac{25}{2} \times 30$	**M1**
	$s = 375\ m$	**A1**

2	$-5 + 2q + 1 = 0$ $q = 2$	**M1** **A1**
	$4p + 2 + 1 = 0$ $p = -1$	**M1** **A1**

3a	$t = \frac{116-84}{2}$	**M1**
	$t = 16\ s$	**A1**
3b		**B2**
3c	$distance = area\ under\ graph$	**M1**
	$= \frac{1}{2}(116 + 84)(24)$	**M1**
	$= 2400\ m$	**A1**

4a	$u = 0$ $s = 2200 - 240 = 1960$	**M1**
	$a = 9.8$ $v^2 = u^2 + 2as$	**M1**
	$v^2 = 0 + 2(9.8)(1960)$ $v = 196$ ms^{-1}	**M1** **A1**
4b	$s = ut + \frac{1}{2}at^2$	**M1**
	$1960 = 0 + 4.9t^2$	**M1**
	$t = 20\ seconds$	**A1**
4c	$140 - 20 = 120\ seconds$ to travel 240m	**M1**
	Speed = 2ms^{-1}	**A1**
4d	No air resistance; velocity on opening parachute will not immediately reduce	**B1**
	if air resistance included, value in (a) would be much lower and consequently value in (b) much higher	**B1**

5a	Mass of ball remains constant	**B1**
	Force is constant F = ma so a constant	**B1**
5bi	$a = \frac{\Delta v}{t} = \frac{1}{4}[(10\boldsymbol{i} + 9\boldsymbol{j}) - (2\boldsymbol{i} - 3\boldsymbol{j})]$	**M1**
	$a = 2\boldsymbol{i} + 3\boldsymbol{j}$	**A1**
	Magnitude of $a = \sqrt{2^2 + 3^2} = \sqrt{13}$	**M1**
	= 3.61 ms^{-2}	**A1**
5bii	F = ma = 2(2**i** + 3**j**)	**M1**

	$= 4\mathbf{i} + 6\mathbf{j}$	
	Required angle = $\tan^{-1}\left(\frac{3}{2}\right) = 56.3^o$	**M1** **A1**

6a	Particle	**B1**
6b	Resolving parallel to the plane: $P\cos 10 - 3g\sin\alpha = 0$	**M1** **A1**
	$P\cos 10 = 3g\left(\frac{3}{5}\right)$	**M1**
	$P = 17.9\ N$	**A1**
6c	Resolving perpendicular to the plane:	**M1**
	$R + P\ sin10 - 3g\cos\alpha$	**A1**
	$R = 3g\left(\frac{4}{5}\right) - P\sin 10$	**M1**
	$R = 20.4\ N$	**A1**