A-Level Mathematics

Edexcel

2024 Predicted Paper

Paper 3

Statistics and Mechanics

Primrose Kitten
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Name:.....

Date:.....

2 hours allowed

You may use a calculator

Rough Grade Boundaries

These do not guarantee you the same mark in the exam.

A* - 75%
A - 55%
B - 45%
C - 35%
D - 25%
E - 15%

Question	Possible Marks	Marks Gained
Section A: Statistics	50	
Section B: Mechanics	50	
Total	**100**	

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SECTION A:
Statistics

01 C and D are two independent events.

It is known that:

$$P(C') = 0.60 \text{ and } P(C \cap D) = 0.11$$

a) Find $P(D)$

[3 marks]

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b) Find $P(C \cup D)$

[2 marks]

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c) Find $P(C'|D)$

[3 marks]

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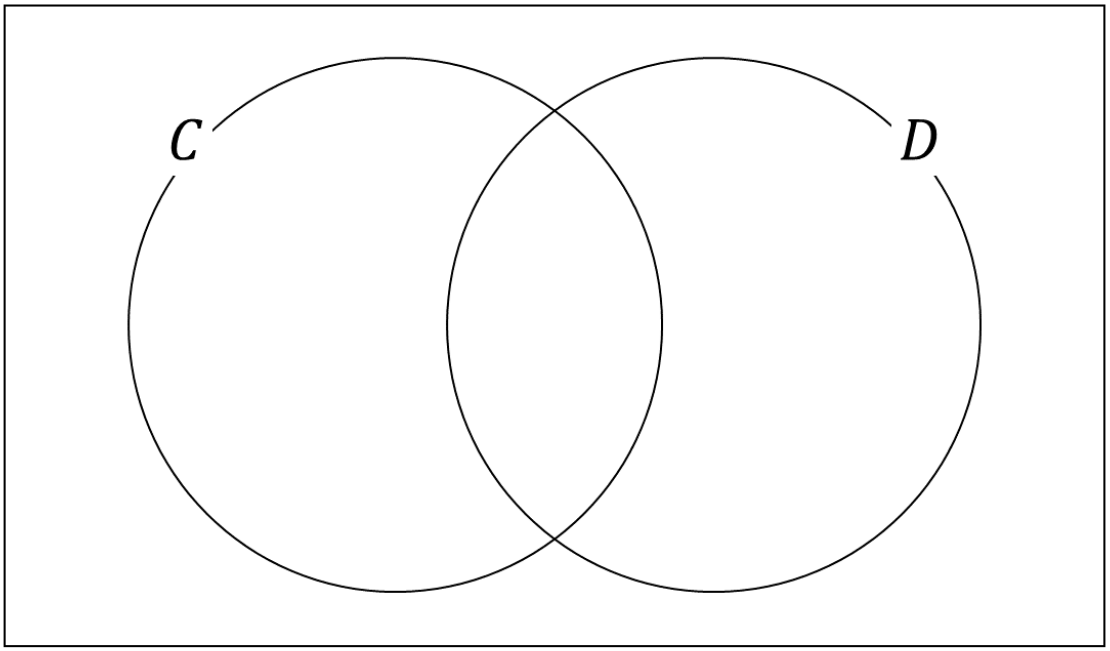
d) Complete the Venn diagram.

[2 marks]



02 The time taken to complete a race is considered to follow a normal distribution.

15% of runners took more than 22 minutes to complete the race.
18% of runners took less than 12 minutes to complete the race.

a) Use this information to find the values for the mean, μ, and the standard deviation, σ.

[7 marks]

b) Write down the median time taken to complete the race.

[1 mark]

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c) Find the probability that a runner took more than 25 minutes to complete the race.
Include the distribution used in your answer.

[3 marks]

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03 A runner has run 20 races. They won 6 of these races.
They are going to run another 50 races in the next year.

If we assume that they have a fixed probability of winning the races we can model this as a binomial distribution.

a) State **two** other conditions that must be met to model the probability of the runner winning races as a binomial distribution.

[2 marks]

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b) Write down the binomial distribution to model the probability of winning their next 50 races.
Include the test statistic in your answer.

[2 marks]

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c) Work out the probability of the runner winning exactly 25 races.

[1 mark]

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d) Work out the probability of the runner winning more than 10 races but less than 20.

[3 marks]

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The runner employed a new coach who promised to increase the proportion of races they won.

After employing the coach, the runner wins 24 out of 50 races.

e) Evaluate if, at the 5% level of significance, the new coach has increased the proportion of races won.
State your hypotheses clearly.

[6 marks]

04 A shop owner has an ice-cream shop at a holiday resort in Camborne.

They were interested to see what effect the amount of rainfall had on the sales of ice-cream.

The data below shows the amount of rainfall and the sales of ice-cream on different days of the week during a week in June.

Day	Rainfall (mm)	Ice-cream sales (£)
Monday	4.4	1500.65
Tuesday	0.8	3001.58
Wednesday	0	3200.50
Thursday	0.4	3512.44
Friday	2.6	2105.65
Saturday	1.6	2987.58
Sunday	0.2	3407.98

a) Calculate the product moment correlation coefficient.

[1 mark]

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b) State the explanatory (independent) variable and the response (dependent) variable.

[2 marks]

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The shop owner wanted to investigate the correlation between rainfall and ice-cream sales.

To do this they need to use the table of critical values for correlation coefficients.

Product moment correlation coefficient Significance level				Sample size, n
0.10	**0.05**	**0.025**	**0.01**	
0.6870	0.8054	0.8783	0.9343	5
0.6084	0.7293	0.8114	0.8822	6
0.5509	0.6694	0.7545	0.8329	7
0.5067	0.6215	0.7067	0.7887	8

c) Test, at the 5% level of significance, whether or not there is a negative correlation between the rainfall and the ice-cream sales. State your hypothesis clearly.

[3 marks]

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d) Suggest a reason for the observed correlation.

[1 mark]

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05 A teacher wanted to analyse their year groups mock exam results.

The results of the 130 students in the year group was summarised in the table below.

Test score, t	Frequency
1-20	15
21-40	23
41-60	34
61-80	26
81-100	19
101-120	13

Where $\sum ft = 7565$ and $\sum ft^2 = 553332.5$

a) Use linear interpolation to find an estimate for the interquartile range of the results.
Give your answer to 2 decimal places.

[3 marks]

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b) Estimate the mean test score.

[1 mark]

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c) Estimate the variance of the test score.

[2 marks]

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The highest score in the test was 115 and the lowest score was 2.

Outliers can be found using the equations:

$$outliers < Q_1 - 1.5 \times IQR$$

$$outliers > Q_3 + 1.5 \times IQR$$

d) Show that there are no outliers in these results.

[2 marks]

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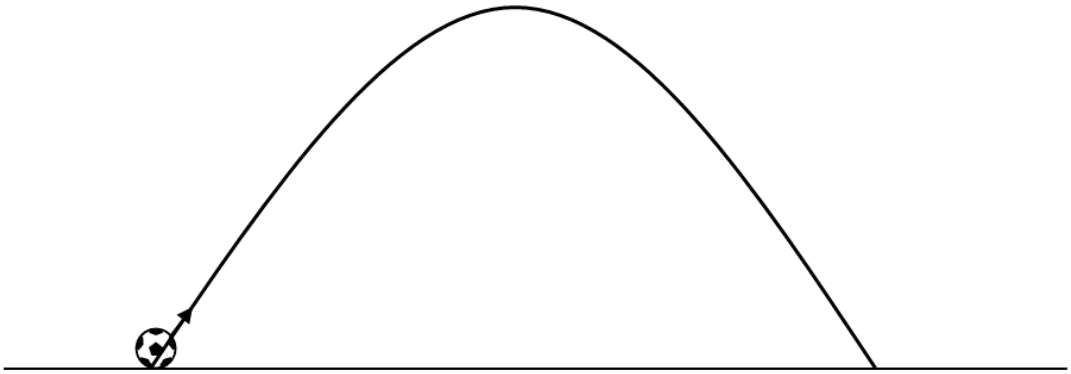
SECTION B:
Mechanics

06 A ball is kicked into the air from the ground by a footballer.



The moment the ball leaved the footballers foot it moves with a speed of U at an angle α to the horizontal.

The football lands on the ground 20 m away from the footballer.

The football is modelled as a particle moving freely under gravity, g.

a) Show that:

$$20\tan\alpha - \frac{200g}{U^2}\sec^2\alpha = 0$$

[6 marks]

It is given that $\cos\alpha = \frac{3}{5}$.

b) Find the initial speed of the ball when it is kicked by the footballer.

[3 marks]

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c) Calculate the maximum height reached by the football.

[3 marks]

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d) State **one** assumption made in this model.

[1 mark]

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07 A particle, A, moves with a velocity $\boldsymbol{v}$ ms^{-1} at time t.

$$\boldsymbol{v} = (t^2 + 2t)\mathbf{i} + (-8t + 5)\mathbf{j}$$

Where $\boldsymbol{i}$ and $\boldsymbol{j}$ are unit vectors due east and north respectively.

a) Find the magnitude of the acceleration of the particle when $t = 5\,s$.

[4 marks]

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b) Find the displacement between $t = 1\,s$ and $t = 4\,s$.

[4 marks]

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c) Find the times the particle is moving in the north-west direction.

[3 marks]

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08 Two balls, A and B, are connected by a light, inextensible string.

Ball A has a mass of 2.3 kg and ball B has a mass of 2.7 kg.

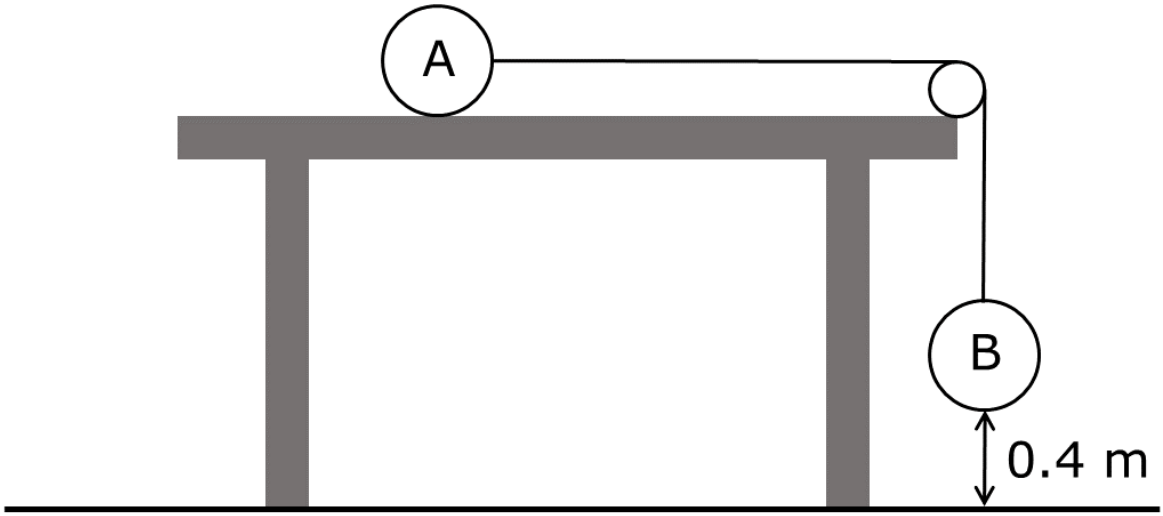
Ball A is held at rest on the surface of a rough, horizontal table.

The string connecting A and B is passed over a smooth, light pulley.

Ball B hangs freely at rest, vertically below the pulley.

At $t = 0$, ball A is released and moves with an acceleration of a.

Ball B hits the ground in 0.7 seconds.



a) Calculate the acceleration of ball A.

[3 marks]

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b) Calculate the tension, T, in the string.

[3 marks]

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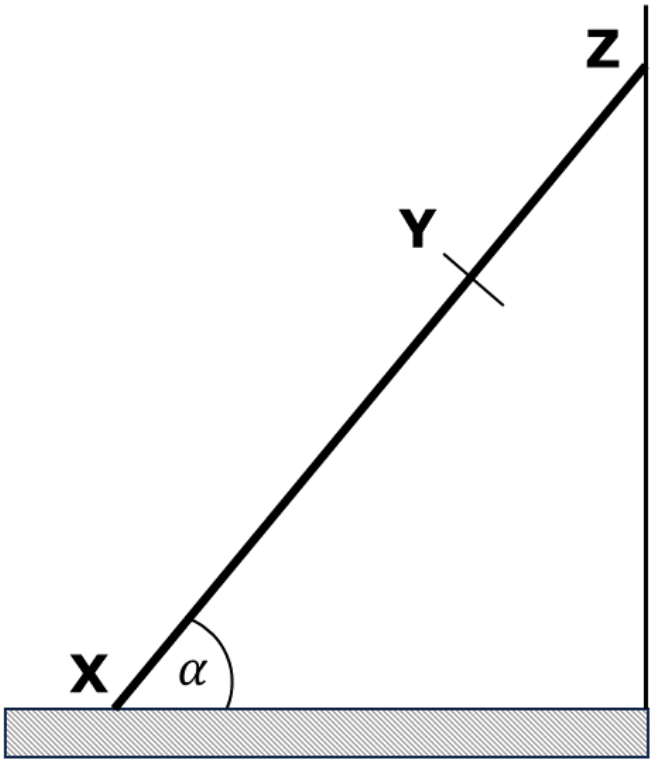
c) Calculate the coefficient of friction, μ, between the table and ball A.

[6 marks]

09 A ladder of mass 5 kg and length 10a is placed against a smooth vertical wall onto rough horizontal ground.



The coefficient of friction between the ladder and the ground is 0.4.

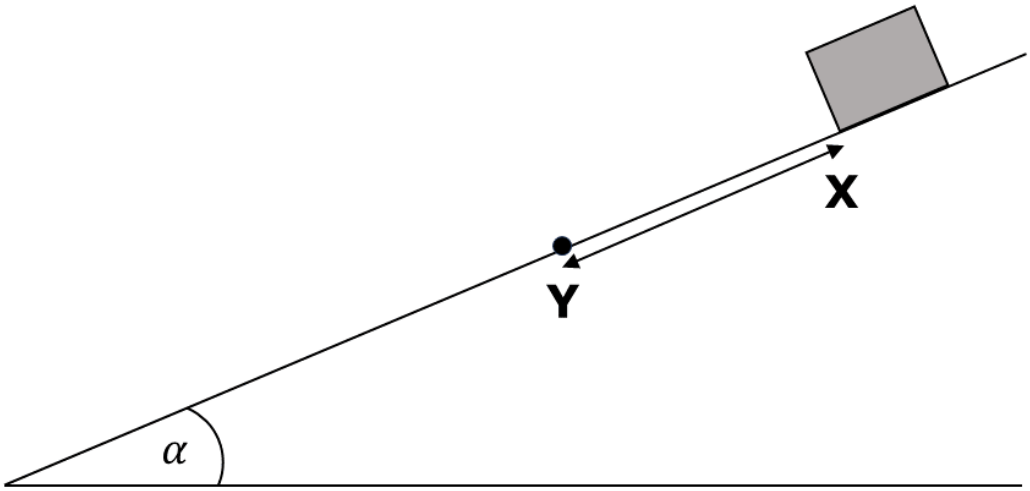
The angle between the ladder and the ground is α.

A person of weight 70 kg stands on the ladder at the point Y where XY:YZ = 3:1.

Given that the ladder is modelled as a uniform rod and is under limiting equilibrium, find the angle α.

[7 marks]

10 A box of mass 2 kg is placed on a rough plane at point X.



The coefficient of friction between the plane and the box is 0.7.

The incline of the plane is α, such that $\cos\alpha = \frac{3}{10}$

The box is released from rest, and it slides down the plane.
After 0.5 seconds the box reaches point Y.

Find the velocity of the box at Y.

[7 marks]

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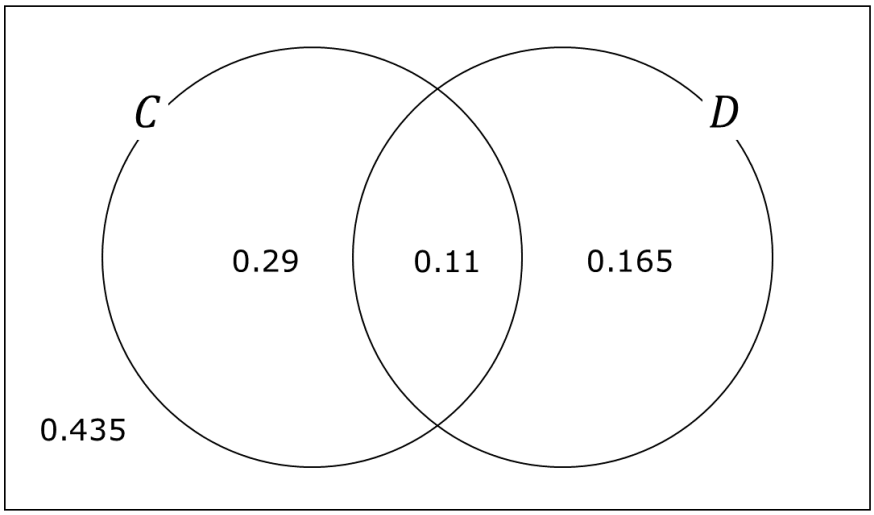
END OF QUESTIONS

MARKING GUIDANCE

Question	Solution
1 (a)	A1M for P(C) = 1 – P(C') = 0.4 A1M for use of P(C) x P(D) = P(C ∩ D) P(D) = 0.11/0.4 A1M for 0.275
1 (b)	A1M for use of P(C ∪ D) = P(C) + P(D) - P(C ∩ D) P(C ∪ D) = 0.4 + 0.275 – 0.11 A1M for 0.565
1 (c)	A1M for P(C' ∩ D) = 0.165 A1M for use of $P(C'\|D) = \frac{P(C' \cap D)}{P(D)} = \frac{0.165}{0.275}$ A1M for 0.6
1 (d)	 A2M for correct Venn diagram Allow A1M for 3 correct values
2 (a)	A1M for P(X<12) = 0.18 A1M for $\frac{12-\mu}{\sigma} = -0.91537$ A1M for P(X>22) = 0.15 A1M for $\frac{22-\mu}{\sigma} = 1.03643$ A1M for correct method to solve e.g. simultaneous equations A1M for $\mu = 16.6899\ldots$ A1M for $\sigma = 5.1235\ldots$

2 (b)	A1M for $16.6899\ldots$
2 (c)	A1M for $X \sim N(16.6899, 5.1235^2)$ A1M for P(X>25) A1M for 0.05241
3 (a)	A2M for any **two** from: The is a fixed number of trials Each trial has only two outcomes – winning the race or not winning The trials are independent of each other
3 (b)	A1M for $X \sim B(50, 0.3)$ A1M for X = number of races won
3 (c)	A1M for $P(X = 25) = 0.00144$
3 (d)	A1M for $P(X \leq 10) = 0.07885$ A1M for $P(X < 20) = P(X \leq 19) = 0.9152$ A1M for $P(10 < X < 20) = 0.9152 - 0.07885 = 0.83635$
3 (e)	A1M for H_0=0.3 and H_1>0.3 A1M for $P(X \geq 24) = 1 - P(X \leq 23)$ or alternative method to find $P(X \geq 24)$ A1M for $P(X \geq 24) = 0.00559$ (implies previous mark – award both for correct value) A1M for 0.00559<0.05 A1M for reject null hypothesis A1M for there is sufficient evidence that the new coach increased the likelihood of winning races.
4 (a)	A1M for -0.9646
4 (b)	A1M for Explanatory – rainfall A1M for Response – ice-cream sales
4 (c)	A1M for $H_0: \rho = 0$ and $H_1: \rho < 0$ A1M for 0.6694<0.9646 A1M for There is enough evidence to reject H_0, there is a negative correlation between rainfall and ice-cream sales.
4 (d)	A1M for any reasonable explanation, e.g. People are more likely to stay home when it rains and therefore not buy ice-cream.
5 (a)	A1M for $Q_1 = \frac{20}{23} \times 17.5 + 20.5$ or alternative method to find Q_1 OR Q_3 A1M for Q_1= 35.71739… AND Q_3=80.11538… A1M for IQR = 44.40
5 (b)	A1M for $\mu = \frac{7565}{130} = 58.1923076\ldots$ Accept correctly rounded answer e.g. 58.2

5 (c)	A1M for $\sigma^2 = \frac{553332.5}{130} - \left(\frac{7565}{130}\right)^2$ A1M for = 870.05917… Accept correctly round answer e.g. 870.1
5 (d)	A1M for 35.71739 – 1.5 x 44.40 = -30.88261 AND 80.11538 + 1.5 x 44.40 = 146.71538 A1M for No outliers, as the biggest result is smaller than 146.7 and smallest result is bigger than -30.88.
6 (a)	A2M for $x = U\cos\alpha\, t = 20$ A2M for $y = U\sin\alpha\, t - \frac{1}{2}gt^2 = 0$ A1M for correct substitution $$U\sin\alpha \times \frac{20}{U\cos\alpha} - \frac{1}{2}g \times \frac{400}{U^2\cos^2\alpha} = 0$$ A1M for correct use of identities to get: $$20\tan\alpha - \frac{200g}{U^2}\sec^2\alpha = 0$$
6 (b)	A1M for correctly identifying: $$\tan\alpha = \frac{4}{3}$$ $$\sec\alpha = \frac{5}{3}$$ A1M for correct substitution: $$20 \times \frac{4}{3} - \frac{200g}{U^2} \times \left(\frac{5}{3}\right)^2 = 0$$ A1M for U = 14.29 ms^{-1}
6 (c)	A1M Use of $v^2 = u^2 + 2as$ A1M correct substitution: $$0^2 = \left(14.29 \times \frac{4}{5}\right)^2 + 2 \times -9.8 \times s$$ A1M for s = 6.67 m
6 (d)	A1M for No air resistance/wind.
7 (a)	A1M for $\mathbf{a} = \frac{d\mathbf{v}}{dt} = (2t+2)\mathbf{i} - 8\mathbf{j}$ A1M for $(2\times 5+2)\mathbf{i} - 8\mathbf{j} = 12\mathbf{i} - 8\mathbf{j}$ A1M for $\sqrt{\mathbf{12^2} + (\mathbf{-8})^2}$ A1M for 14.42 ms^{-2}

7 (b)	A2M for $s = \int_1^4 v dt = \left[\left(\frac{t^3}{3} + \frac{2t^2}{2}\right)i + \left(-\frac{8t^2}{2} + 5t\right)j\right]_1^4$ A1M for $\left[\left(\frac{4^3}{3} + \frac{2\times4^2}{2}\right)i + \left(-\frac{8\times4^2}{2} + 5\times4\right)j\right] - \left[\left(\frac{1^3}{3} + \frac{2\times1^2}{2}\right)i + \left(-\frac{8\times1^2}{2} + 5\times1\right)j\right]$ A1M for 36i-45j
7 (c)	A1M for $-(t^2 + 2t) = (-8t + 5)$ A1M for $(t-5)(t-1) = 0$ A1M for $t = 1s$ and $t = 5s$
8 (a)	A1M for Use of $s = ut + \frac{1}{2}at^2$ A1M for Correct substitution $0.4 = 0 \times 0.7 + \frac{1}{2} \times a \times 0.7^2$ A1M for 1.63 ms^{-2}
8 (b)	A2M for 2.7g – T = 2.7 x 1.63 A1M for T = 22.059N
8 (c)	A1M for R = 2.3g A1M for $F_r = \mu \times 2.3g$ A2M for $T - \mu \times 2.3g = 2.3a$ A1M for $22.059 - \mu \times 2.3g = 2.3 \times 1.63$ A1M for $\mu = 0.81$
9	A1M for resolving vertically R = 5g +70g = 75g A1M for resolving horizontally Fr =μR= N A2M for moments around X $5a\cos\alpha \times 5g + 7.5a\cos\alpha \times 70g = N \times 10a\sin\alpha$ A1M for correct substitution: $5a\cos\alpha \times 5g + 7.5a\cos\alpha \times 70g = 0.4 \times 75g \times 10a\sin\alpha$ A1M for correct simplification $\tan\alpha = \frac{55}{30}$ A1M for $\alpha = 61.4°$

10	A1M for resolving perpendicular to the plane: $$R = 2g\cos\alpha = 2g \times \frac{3}{10}$$ A2M for resolving perpendicular to the plane: $$2g\sin\alpha - 0.7 \times 2g\cos\alpha = 2a$$ A1M for correct substitution: $$2g \times \frac{\sqrt{91}}{10} - 0.7 \times 2g \times \frac{3}{10} = 2a$$ A1M for a = 7.29 ms^{-2} A1M for correct use of suvat: $$v = 0 + 7.29 \times 0.5$$ A1M for v = 3.645 ms^{-1}
Total	**100**