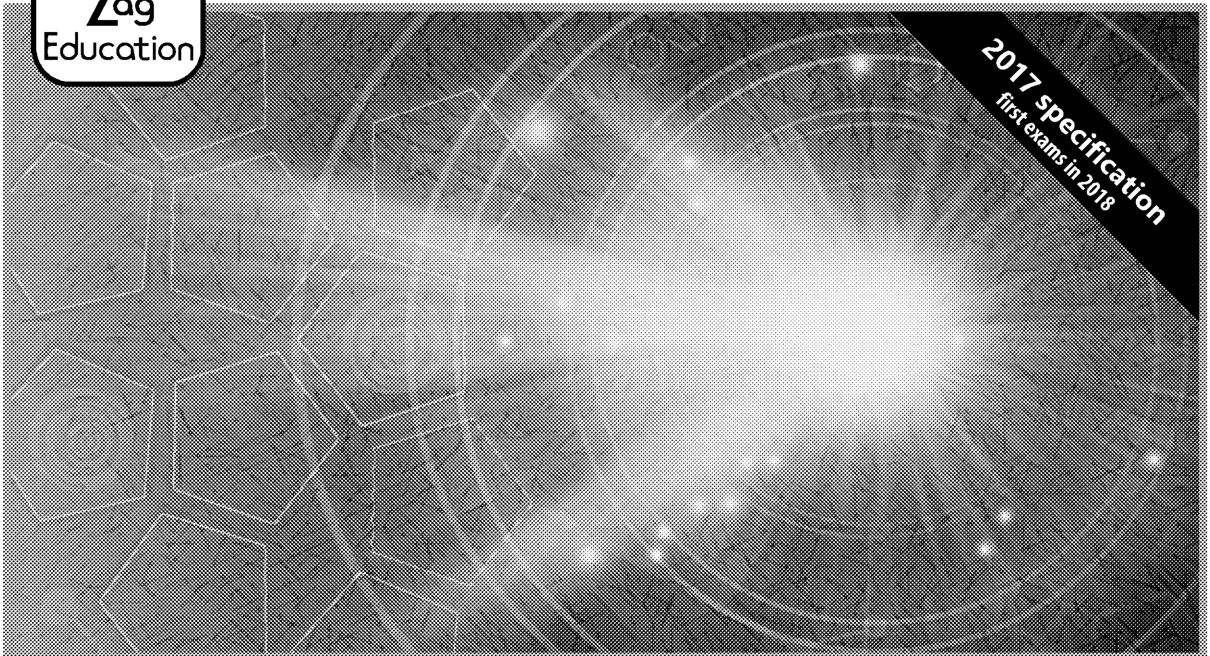
Zig Zag Education

Maths **A Level | Edexcel | 9MA0**



Practice Exams

for A Level Edexcel Paper 3 Statistics and Mechanics

zigzageducation.co.uk **POD 9712**

Contents

Teacher's Introduction

This pack contains five examination-style question papers and solutions (Sets A–E) for the applied part of the Edexcel A Level Maths 2017 specification.

Written for the 2017 A Level specification, these papers are designed to be used by your students in preparation for their examinations. In line with the real examinations, every paper examines a large part of the specification, including taking into account the following particular changes:

- there is now a greater emphasis on **harder problem-solving and modelling** questions
- **three new assessment objectives** replace the old five
- the use of a **calculator** is now required and expected in every paper

Remember!
Always check the exam board website for new information, including changes to the specification and sample assessment material.

Non-write-on question papers
The papers have been provided individually in a condensed **A4 non-write-on format** to keep photocopying costs to a minimum.

Mark schemes
The mark schemes have been provided as A4 masters. They include fully worked solutions and common alternative solutions, making them helpful and easy for students to follow. Where the final answer is numerical, this has been provided in a separate answer column to speed up the marking process. Questions that ask the student to establish a given result have been labelled as either a 'Show that' question or as a 'Prove that' question in this column, indicating that it is the student's working that is of interest here, not their final answer.
Each solution starts with any relevant information from the question or any relevant formulae – this is useful to see how the solution starts and is a good habit for students to follow.

Formula book
The Edexcel formula book is not provided with this resource, but a copy of it should be provided to students as they will need to become familiar with its contents.

Suggested use of this resource
With five papers at your disposal, there is a variety of flexible ways to use this resource:

- Set papers A and B as open-book tests, so that students can get used to examination-style questions, then take the plunge and use papers C–E in exam-style conditions.
- Space out the five papers over the whole revision period so students can build their confidence and see their hard work paying off in the form of ever-improving marks.

Also available from ZigZag Education
This pack contains five 'Paper 3' exams – to prepare fully, a pack of five 'Paper 1' exams and a pack of five 'Paper 2' exams are also available. Each of sets A–E can then be used to mimic an entire A Level Maths examination consisting of the three papers – the sets have the correct overall weighting of assessment objectives.

A Level Edexcel Exam Set C Practice Paper 3	Ti
Do **not** write on this paper. Give your answers to **3 significant figures**	

Section A: Statistics

1. Gerald runs a website that allows people to register UFO sightings. H sightings each week, S, and the total rainfall each week, R mm, for 7 autumn. He calculates the product moment correlation coefficient fo
   (a) Test at the 1 % level of significance whether the correlation bet rainfall is negative. State your hypotheses clearly.
   (b) Suggest a possible reason for any such correlation.

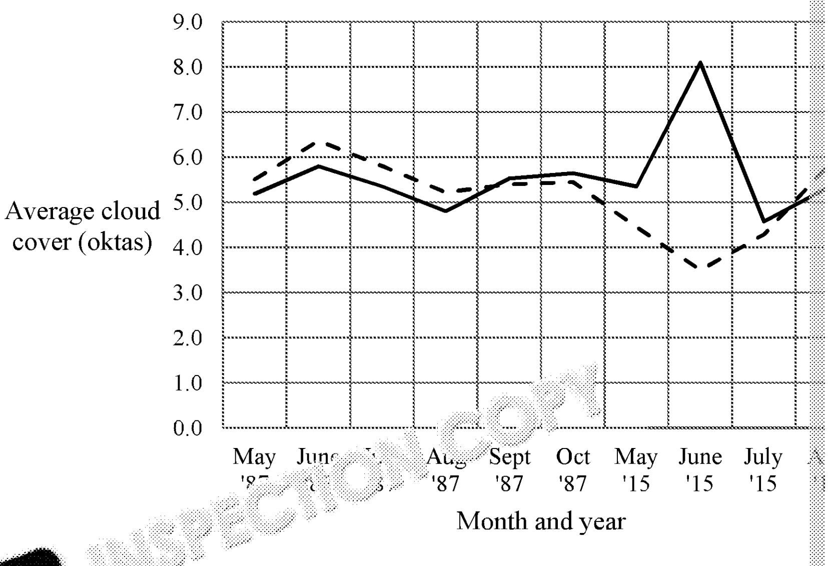
   Gerald plans to model the data using a linear regression model.
   (c) State, giving a reason, whether the value of the product momen is consistent with Gerald's choice of model.
   (d) State, giving a reason, which variable would be the response va

   Gerald then finds the linear regression equation of S on R to be $S = 6$
   (e) Interpret the gradient of Gerald's regression line in context.

2. Jermaine copies some data on daily mean total cloud cover in oktas f for various months in 1987 and 2015 from the large data set. He calc month and records the results in the following table:

	1987						
	May	**June**	**July**	**August**	**September**	**October**	**May**
Hurn	5.2	5.8	5.4	4.8	5.5	5.6	5.4
Heathrow	5.5	6.4	5.8	5.2	5.4	5.5	4.5

Using the table, he produces the following line graph:



   (a) Identify by month, year and location which entry in the table is

   An outlier is defined to be a value that is more than 1.5 times the inte or more than 1.5 times the interquartile range above Q_3
   (b) By finding any necessary statistics from the table, show that th identified in part (a) is indeed an outlier.
   (c) Explain why the mean is an inappropriate measure of the avera with the identified outlier.
   (d) Using your knowledge of the large data set, explain why the ou an error.

3. A biased four-sided dice can land on any of the numbers 1, 2, 3 or 4.
represents the number that the dice lands on after being rolled once.

Given that $\mathrm{P}(X=d)=2\times\mathrm{P}(X=5-d)$ for d = 1, 2, and that $\mathrm{P}(X$

(a) find the complete probability distribution of X

Océane rolls the dice 40 times.

(b) Find the probability that more than half of the dice rolls land on

The random variable Y is given by $Y=\dfrac{1}{X+1}$

(c) Find $\mathrm{P}(X-4Y\le 2)$

4. Thara is studying the daily maximum relative humidity (%), h, in the
May and October. She takes an opportunity sample from the large da

11 days of May 2015 in Leuchars. She then codes the data using the

Thara calculates that $\sum x=105$ and $\sum x^2=1006.12$.

(a) Find the mean and standard deviation of the original data that T
your working clearly.

The maximum relative humidity on 12th May 2015 was 75%.

(b) State how adding this data point would affect the mean.

(c) Give two suggestions for how Thara could make better use of th
for her study.

5. The events A, B and C satisfy P(A) = 0.2, P(B) = 0.65 and P(C) = 0.1
The events A and C are mutually exclusive, while A and B are statisti

Given that $\mathrm{P}(B\cap C)=0.02$:

(a) draw a Venn diagram to illustrate the probabilities associated w

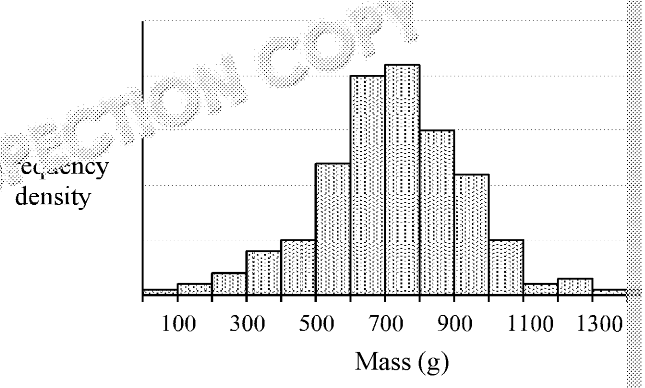
(b) show that the events B and C are not statistically independent

(c) find $\mathrm{P}(B\mid C')$

(d) find $\mathrm{P}((A\cup C)\mid B')$

6. Alan is a greengrocer investigating his stock of swedes. He classifies
with a mass between 500 g and 750 g.

Alan calculates that his swedes have a mean mass of 801 g with stand
produces the following histogram showing the distribution of masses



(a) Explain why the masses of the swedes can be modelled by a no

(b) Assuming that the masses of the swedes are normally distribute
swedes that are not baby swedes according to Alan's classificat

A crate containing a large number of vegetables is delivered to Alan's
are supposed to be swedes, but Alan's colleague Ellie thinks they are
She weighs 25 of the vegetables in the crate and finds that their mean

(c) Assuming a population standard deviation of 224 g, test at the
whether the mean mass of vegetables in the crate is less than 80
hypotheses clearly.

It turns out that the vegetables in the crate are actually turnips. The m
normally distributed with a mean mass of 741 g. Alan's records indi
of turnips with a mass of at least 700 g is 60%.

(d) Find the standard deviation of the masses of turnips.

Section B: Mechanics

Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}.

7. A block of mass m kg is projected down a line of greatest slope on a
makes an angle of θ to the horizontal, where $\tan\theta = \frac{7}{24}$.

The block moves down the plane with a constant acceleration of $\frac{1}{5}g$.

By modelling the block as a particle, find the coefficient of friction b
and the plane.

8. A ladder AB of mass M and length $2a$ rests on smooth horizontal groun
propped against a smooth vertical wall. The ladder is held in place by
horizontal rope connected to the ladder at A and to the wall at C, as ske
the right. The acute angle between the ladder and the wall is θ, where
Model the ladder as a uniform rod and the rope as a light inextensible

(a) Show that the tension in the rope has magnitude $\frac{1}{4}Mg$

A decorator of mass $5M$ climbs the ladder until the rope is on the poi
moment the tension in the rope has magnitude $\frac{3}{4}Mg$, the normal reac
has magnitude R, and the normal reaction on the ladder at B has mag

(b) Find the value of $\frac{R}{S}$

(c) Calculate the distance from A to the decorator in terms of a

9. A boat is moving on a large lake. At time $t = 0$ the boat is at the fixe
velocity $(\mathbf{i} + 2\mathbf{j})$ m s^{-1}, where $\mathbf{i}$ and $\mathbf{j}$ are the unit vectors due east and
After 10 seconds the boat is at the point A, which has position vector (
Model the boat as a particle moving with constant acceleration.

(a) Show that the magnitude of the boat's acceleration is 1.3 m s^{-2}

At the moment the boat leaves A its acceleration changes so that it no
acceleration of $(4\mathbf{i} + 5\mathbf{j})$ m s^{-2}.

When the boat reaches the point B, it is travelling on a bearing of 045
(b) Find the time taken for the boat to travel from point A to point B

10. Two particles, P and Q, are connected by a light, inextensible string that passes over a smooth pulley. Particle P has mass 4 kg and lies on a rough horizontal surface. Particle Q has mass 3 kg and hangs freely below the pulley. The string is taut and is horizontal between P and the pulley, as sketched to the right.

The coefficient of friction between P and the surface is μ. When the particles are released from rest, P accelerates towards the pulley at 2.8 m s^{-2}.

(a) Find the tension in the string immediately after the particles are

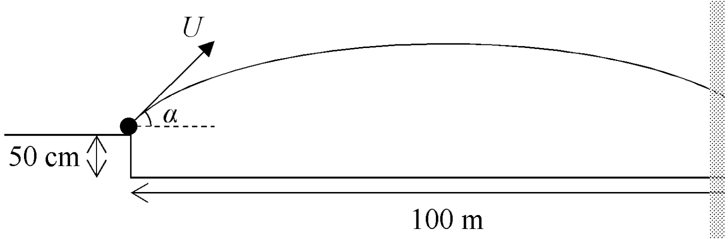
(b) Show that $\mu = 0.25$

Three seconds after the particles are released from rest, the string bre the ground.

(c) Assuming that P stays on the surface, find the time taken for P

(d) State how you have used the fact that the pulley is smooth in yo

11. A golfer hits a ball from an elevated platform that is 50 cm above the ball has initial velocity of U m s^{-1} at an angle of α above the horizo returns to the height from which the golfer hit it, the ball has travelled 100 m, as sketched in the diagram below.



Model the ball as a particle moving freely in a vertical plane under gr

(a) Show that $U^2 = \dfrac{50g}{\sin\alpha\cos\alpha}$

When the ball hits the ground, it has travelled a horizontal distance of

(b) Find the angle α

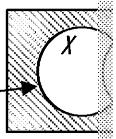
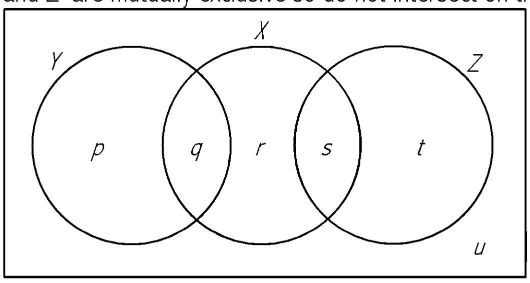
(c) State one limitation of the model

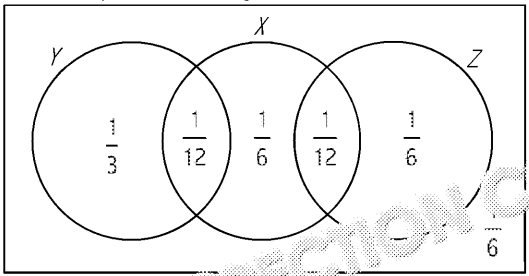
Preview of Questions Ends Here

Qu №	Answer	Solutions
1a	'Show that' question – Answer given in question	Interquartile range, IQR $= Q_3 - Q_1$ $= 9 - 4 = 5$ So outliers are $< Q_1 - 1.5\times \text{IQR} = 4 - 1.5\times 5 = -3.5$ or $> Q_3 + 1.5\times \text{IQR} = 9 + 1.5\times 5 = 16.5$ $22 > 16.5$, so 22 is an outlier
b	Any suitable reason for including the outlier, e.g. • It is a real data point and all the data should be considered Any suitable reason for excluding the outlier, e.g. • It could be an error in the data set or in Michael's copying • As an outlier it will unduly affect Michael's study (by distorting the mean and stand	
c	Any suitable interpretation of positive correlation in context, e.g. • Days with a higher mean temperature tend to have a higher mean wind speed	
d	Any suitable description of the rate, e.g. • A 1 °C increase in mean temperature leads to a 0.74 kn increase in wind speed	
ei	Any comment on Michael's method being unsuitable, e.g. • Michael only used 12 days from one month and one location, which is not represe	
eii	Any valid suggestion for arriving at a more representative sample, e.g. • He should use data from more UK locations • He should use data from other months of the year	
2ai	0.230 (3 s.f.)	Let T be the number of packs containing the card Toby wants Toby buys 18 packs, and each pack has a $\frac{1}{5}$ chance of conta $\therefore T \sim \text{B}\left(18, \frac{1}{5}\right)$ **Either:** From a calculator, $\text{P}(T=3) = 0.229683\ldots$ $= 0.230$ (3 s.f.) **Or:** $\text{P}(T=3) = \binom{18}{3}$ $= 0.229683\ldots$ $= 0.230$ (3 s.f.)
aii	0.133 (3 s.f.)	$\text{P}(T>5) = 1 - \text{P}(T\le 5)$ From a calculator, $\text{P}(T\le 5) = 0.867083\ldots$ $\therefore \text{P}(T>5) = 1 - 0.867083\ldots = 0.132916\ldots$ $= 0.133$ (3 s.f.)

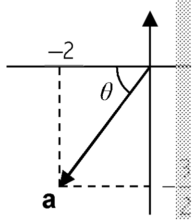
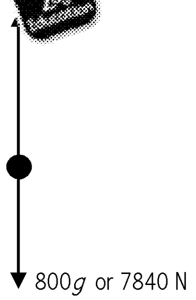
Qu №	Answer	Solutions
b	Reject H_0 **(must see working)**	We are testing whether the probability, p, of a pack containing greater than $\frac{1}{5}$, so: $H_0: p = \frac{1}{5} \qquad H_1: p > \frac{1}{5}$ Test is one-tailed Level of significance = 1% = 0.01 Let U be the number of packs containing the card Toby wants Toby buys 40 packs, so assuming H_0 is true, $U \sim B\left(40, \frac{1}{5}\right)$ The card Toby wants is in 15 of the packs $P(U \geq 15) = 1 - P(U \leq 14)$ From a calculator, $P(U \leq 14) = 0.992084\ldots$ $\therefore P(U \geq 15) = 1 - 0.992084\ldots$ $= 0.00791585\ldots$ $0.00791585\ldots < 0.01$, so there is sufficient evidence to reje and accept Alex's claim
3a	Height = 18 cm Width = 2 cm	On the histogram, $85 < h \leq 91$ group has width 4 cm So $1 \text{ cm} = \frac{91-85}{4} = 1.5\%$ on the horizontal axis So $95 < h \leq 98$ group has width $\frac{98-95}{1.5} = 2$ cm Area of $85 < h \leq 91$ group on the histogram is $4 \text{ cm} \times 6 \text{ cm} = 24 \text{ cm}^2$ Frequency of $85 < h \leq 91$ group is 4 So $1 \text{ cm}^2 = \frac{4}{24} = \frac{1}{6}\%$ humidity Frequency of $95 < h \leq 98$ group is 6 So area of $95 < h \leq 98$ group on histogram is $\frac{6}{1/6} = 36 \text{ cm}^2$ $\therefore \text{height} = \frac{36}{2} = 18$ cm

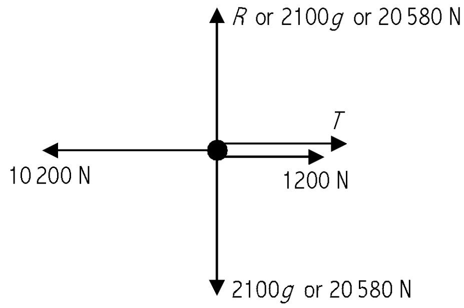
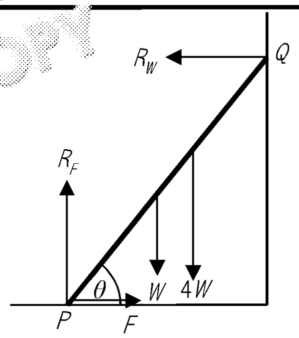
Qu №	Answer	Solutions
b	$\bar{h} = 93.8\ \%$ (3 s.f.) $\sigma_h = 5.20\ \%$ (3 s.f.) (allow $s_h = 5.28\%$)	Using the midpoints of the humidity ranges: 82.5, 88, 93, 96.5 Then, from a calculator, for the mean: **Either:** $\bar{h} = 93.7833\ldots = 93.8\%$ (3 s.f.) **Or:** $\bar{h} = \frac{\sum h}{n}$ $\sum h = 2813.5$ $\therefore \bar{h} = \frac{2813.5}{30}$ $= 93.8\ \%$ (3 s. For the standard deviation: **Either:** $\sigma_h = 5.19564\ldots = 5.20\%$ (3 s.f.) **Or:** $\sigma_h = \sqrt{\frac{\sum h^2}{n}}$ $\sum h^2 = 2646$ $\bar{h} = 93.7833\ldots$ $\therefore \sigma_h = \sqrt{264}$ $= \sqrt{26.9947\ldots}$ $= 5.19564\ldots$ **Also allow:** $s_h = \sqrt{\frac{\sum h^2 - n\bar{h}^2}{n-1}}$ $= \sqrt{\frac{264669.25 - 30 \times 93.7833\ldots^2}{29}} = 5.28446\ldots = 5.28\%$
c	The standard deviation at Heathrow is 6.34 %, which is greater than the 5.20 % standard Leuchars, so the humidity is more variable at Heathrow. But Heathrow is south of Leuchars, so this does not support Zachariah's belief.	
d	5 days (or 5.4 days)	From part (b), $\bar{h} - \sigma_h = 93.8 - 5.20 = 88.6$ 88.6 lies in the $85 < h \leq 91$ group So number of days with $h \leq 88.6$ is estimated as: $3 + \frac{88.6 - 85}{91 - 85} \times 4$ $= 5.4$ $\therefore$ 5.4 days or 5 days (1 s.f.)
e	5 days (or 4.76 days)	Let H be the daily maximum relative humidity in % Aaliyah's model: $H \sim \mathrm{N}(94.1, 5.5^2)$ From calculator, $\mathrm{P}(H \leq 88.6) = 0.158655\ldots$ There are 30 days in June, so number with $H \leq 88.6$ is predi $0.158655\ldots \times 30 = 4.75965\ldots$ $\therefore$ 4.76 days (3 s.f.) or 5 days (1 s.f.)
f	Any valid comment, e.g. • The 4.76 days predicted by Aaliyah's model is an underestimate of the 5.4 days g model is unsuitable • The 5 days predicted by Aaliyah's model is equal to the 5 days estimated from the suitable	

Qu №	Answer	Solutions
4a	$\frac{4}{7}$	$\text{P}(X'\mid Y')=\frac{\text{P}(X'\cap Y')}{\text{P}(Y')}$  $\text{P}(X'\cap Y')=1-\text{P}(X\cup Y)$ $\text{P}(X\cup Y)=\text{P}(X)+\text{P}(Y)-\text{P}(X\cap Y)=\frac{1}{3}+\frac{5}{12}-\frac{1}{12}=\frac{2}{3}$ $\therefore \text{P}(X'\cap Y')=1-\frac{2}{3}=\frac{1}{3}$ $\text{P}(Y')=1-\text{P}(Y)=1-\frac{5}{12}=\frac{7}{12}$ $\therefore \text{P}(X'\mid Y')=\frac{1/3}{7/12}$ $=\frac{4}{7}$
b	'Show that' question – Answer given in question	**Either:** X and Y are independent if: $\text{P}(X)\times\text{P}(Y)=\text{P}(X\cap Y)$ But: $\text{P}(X)\times\text{P}(Y)=\frac{1}{3}\times\frac{5}{12}=\frac{5}{36}$ $\neq\frac{1}{12}=\text{P}(X\cap Y)$ So X and Y are not independent **Or:** X and Y are in $\text{P}(X\mid Y)=\text{P}($ $\text{P}(X'\mid Y')=\text{P}($ But: $\text{P}(X'\mid Y')=\frac{4}{7}$ $\text{P}(X')=1-\text{P}($ So X and Y are
c		Y and Z are mutually exclusive so do not intersect on the Venn diagram. So it looks like  where: $p=\text{P}(Y)-\text{P}(X\cap Y)=\frac{5}{12}-\frac{1}{12}=\frac{1}{3}$ $q=\text{P}(X\cap Y)=\frac{1}{12}$ $s=\text{P}(X\cap Z)=\text{P}(X)\times\text{P}(Z)$ since X and Z are independent $=\frac{1}{3}\times\frac{1}{4}$ $=\frac{1}{12}$ $t=\text{P}(Z)-\text{P}(X\cap Z)=\frac{1}{4}-\frac{1}{12}=\frac{1}{6}$

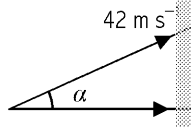
Qu №	Answer	Solutions
		$r = \mathrm{P}(X) - \mathrm{P}(X \cap Y) - \mathrm{P}(X \cap Z) = \frac{1}{3} - \frac{1}{12} - \frac{1}{12} = \frac{1}{6}$ $u = 1 - (p+q+r+s+t) = 1 - \left(\frac{1}{3} + \frac{1}{12} + \frac{1}{6} + \frac{1}{12} + \frac{1}{6}\right) = \frac{1}{6}$ So the complete Venn diagram is: 
d	$\frac{1}{2}$	**Either:** From the Venn diagram, $\mathrm{P}\left(\left[X \cup Z\right]'\right)$ is the sum of probabilities not in X or Z, i.e. $\mathrm{P}\left(\left[X \cup Z\right]'\right) = \frac{1}{3} + \frac{1}{6}$ $= \frac{1}{2}$ **Or:** From the Venn $\mathrm{P}\left(\left[X \cup Z\right]'\right)$ where $\mathrm{P}(X \cup$ probabilities in $P\left(\left[X \cup Z\right]'\right)$ $= 1 - \left(\frac{1}{12} + \frac{1}{6}\right.$ $= \frac{1}{2}$
5a	Reject H_0	We are testing whether the mean is different from 191 minutes $H_0: \mu = 191 \qquad H_1: \mu \neq 191$ Sample size is 600, level of significance is 1% = 0.01 Test is two-tailed, so the significance level in each tail is 0.005 Let S be the time in hours spent sunbathing in 2009 Then, assuming H_0 is true, the sample mean $\bar{S}$ is normally dis $\bar{S} \sim \mathrm{N}\left(191, \left(\frac{89}{\sqrt{600}}\right)^2\right)$ In 2009, the sample of 600 people had mean 212 From a calculator, $\mathrm{P}(\bar{S} \geq 212) = 3.74181\ldots \times 10$ $3.74181\ldots \times 10 < 0.005$, so there is sufficient evidence to re the mean time spent sunbathing changed from 1999 to 2
b		$\bar{S} \sim \mathrm{N}\left(191, \left(\frac{89}{\sqrt{600}}\right)^2\right)$ **Either:** We need to find α and β so that $\mathrm{P}(\bar{S} \leq \alpha) = 0.005$ and $\mathrm{P}($ Using a calculator gives $\alpha = 181.640\ldots = 182$ minutes (nea and $\beta = 200.359\ldots = 200$ minutes (nearest minute)

Qu №	Answer	Solutions
	Minimum = 182 minutes Maximum = 200 minutes	**Or:** Let $Z = \frac{\bar{S} - 191}{89/\sqrt{600}}$, so $Z \sim \mathrm{N}\left(0, 1^2\right)$ From the 'Percentage Points of the Normal Distribution' table, $\mathrm{P}\left(Z < z\right) = 0.005 \;\Rightarrow\; z = -2.5758$ So minimum value $\bar{s}_{\min}$ satisfies $-2.5758 = \frac{\bar{s}_{\min} - 191}{89/\sqrt{600}}$ $\therefore \bar{s}_{\min} = 191 - 2.5758 \times \frac{89}{\sqrt{600}} = 181.641\ldots = 182$ minutes Similarly the maximum value $\bar{s}_{\max}$ satisfies $2.5758 = \frac{\bar{s}_{\max} - 1}{89/\sqrt{60}}$ $\therefore \bar{s}_{\max} = 191 + 2.5758 \times \frac{89}{\sqrt{600}} = 200.358\ldots = 200$ minutes
ci	Not supported With valid reason, e.g. • The test implies only that the mean amount spent has increased, but it does not sa	
cii	Not supported With valid reason, e.g. • The test implies that the mean amount spent has increased, but that could be beca more expensive, not necessarily because people ate more	
6	$t = 0$ and $t = 3$	$x = \frac{1}{6}t^2\left(3t^2 - 10t - 9\right)$ Particle is at rest when $v = \dot{x} = 0$ $\frac{\mathrm{d}}{\mathrm{d}t}\left(t^n\right) = nt^{n-1}$ $x = \frac{1}{2}t^4 - \frac{5}{3}t^3 - \frac{3}{2}t^2$ $\therefore \dot{x} = 2t^3 - 5t^2 - 3t$ $\dot{x} = 0 \;\Rightarrow\; 2t^3 - 5t^2 - 3t = 0$ $\therefore t\left(2t^2 - 5t - 3\right) = 0$ $\therefore t\left(2t + 1\right)\left(t - 3\right) = 0$ $\therefore t = 0,\ t = -\frac{1}{2},\ t = 3$ But $t \geq 0$, so $t = 0$ and $t = 3$

Qu №	Answer	Solutions
7a	$p = 3$, $q = 10$	The particle is in equilibrium, so $\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 = 0$ $\therefore (2p\mathbf{i} - q\mathbf{j}) + (-q\mathbf{i} + 7\mathbf{j}) + (4\mathbf{i} + p\mathbf{j}) = 0$ $\therefore (2p - q + 4)\mathbf{i} + (-q + 7 + p)\mathbf{j} = 0$ $\therefore\ 2p - q + 4 = 0 \quad \mathbf{(1)}$ $\quad -q + 7 + p = 0 \quad \mathbf{(2)}$ **(1)** – **(2)** gives: $p - 3 = 0$, so $p = 3$ Substituting $p = 3$ into **(1)** gives: $6 - q + 4 = 0$, so $q = 10$
b	Magnitude = 2.5 m s^{-2} Bearing = 233° (3 s.f.)	When $\mathbf{F}_3$ is removed, resultant force is: $\mathbf{F}_1 + \mathbf{F}_2 = (6\mathbf{i} - 10\mathbf{j}) + (-10\mathbf{i} + 7\mathbf{j}) = -4\mathbf{i} - 3\mathbf{j}$ Newton's second law says: $\mathbf{F} = m\mathbf{a}$ $\therefore \mathbf{a} = \frac{1}{m}\mathbf{F}$ We are told that $m = 2$ kg, and from above $\mathbf{F} = -4\mathbf{i} - 3\mathbf{j}$ $\therefore \mathbf{a} = \frac{1}{2}(-4\mathbf{i} - 3\mathbf{j})$ $= -2\mathbf{i} - \frac{3}{2}\mathbf{j}$ Magnitude of acceleration is $\lvert\mathbf{a}\rvert$ $\lvert x\mathbf{i} + y\mathbf{j}\rvert = \sqrt{x^2 + y^2}$ $\therefore \lvert\mathbf{a}\rvert = \sqrt{(-2)^2 + \left(-\frac{3}{2}\right)^2} = \sqrt{\frac{25}{4}} = 2.5 \text{ m s}^{-2}$ For the bearing consider the diagram:  So $\theta = \arctan\left(\frac{3/2}{2}\right) = 36.8698\ldots$ The bearing is measured clockwise from north, so is: $270 - \theta$ $= 270 - 36.8698\ldots$ $= 233.130\ldots$ $= 233°$ (3 s.f.)
8ai		

Qu №	Answer	Solutions
aii		
b	'Show that' question – Answer given in question	Newton's second law says: $F = \ldots$ For the horse: Resultant force acting upwards = $T - 800g$ Mass = 800 kg $\therefore T - 800g = 800a$ **(1)** For the tractor: Resultant force acting to the left = $10\,200 - T - 1200$ Mass = 2100 kg $\therefore 10\,200 - T - 1200 = 2100a$ **(2)** **(1)** + **(2)** gives: $T - 800g + 10\,200 - T - 1200 = 800a + 2$ $\therefore 9000 - 800g = 2900a$ $\therefore 9000 - 800 \times 9.8 = 2900a$ $\therefore 1160 = 2900a$ $\therefore a = \dfrac{1160}{2900} = 0.4 \text{ m s}^{-2}$
c	8160 N	From **(1)** above, $T = 800g + 800a$ $= 800 \times 9.8 + 800 \times 0.4$ $= 8160$ N
d	Any valid suggestion that would improve the model, e.g. • Make the rope extensible • Give the rope mass • Make the pulley rough • Vary the resistance that the tractor experiences, e.g. with air resistance	
9a		Consider the force diagram:  Ladder is in equilibrium, so resultant moment about any point Take moments about P with clockwise positive: $\dfrac{l}{2} \times W\cos\theta + xl \times 4W\cos\theta - l \times R_W \sin\theta = 0$

<table>
<tr><th>Qu №</th><th>Answer</th><th>Solutions</th></tr>
<tr><td></td><td>'Show that' question – Answer given in question</td><td>Divide through by $l\cos\theta$:
$\frac{W}{2} + 4Wx - R_W\tan\theta = 0$
Use $\tan\theta = 2$:
$\frac{W}{2} + 4Wx - 2R_W = 0$
$\therefore R_W = 2Wx + \frac{W}{4} = \frac{W}{4}(8x+1)$ N</td></tr>
<tr><td>b</td><td>$0 \le x \le \frac{3}{8}$</td><td>For equilibrium we need total vertical force equal to zero and force equal to zero
Resolving forces vertically:
$R_F = W + 4W = 5W$
Resolving forces horizontally:
$F = R_W$
We also need frictional force less than the limiting value F_{max} =
So $F \le \mu R_F = \frac{1}{5} \times 5W = W$
Combining the two conditions on F:
$R_W \le W$
Substituting in the value of R_W from part (a) gives:
$\frac{W}{4}(8x+1) \le W$
$\therefore \frac{1}{4}(8x+1) \le 1$
$\therefore 8x+1 \le 4$
$\therefore 8x \le 3$
$\therefore x \le \frac{3}{8}$
We are given that $0 \le x \le 1$, so $0 \le x \le \frac{3}{8}$</td></tr>
<tr><td>c</td><td colspan="2">If the paint cans are placed at P, then the only new force is a vertical force at P, so takin
gives the same result, i.e. we still have $R_W = \frac{W}{4}(8x+1)$ and resolving horizontally F =
But resolving forces vertically, $R_F = 5W$ + weight of the paint cans, so R_F increases
Since $F \le \mu R_F$, this means $F = R_W$ can be greater before the ladder slips, and so x ca
ladder slips</td></tr>
</table>

Qu №	Answer	Solutions
10ai		Initial velocity decomposes as shown:  So vertical component of initial velocity = $42\sin\alpha$ We are told that $\tan\alpha = \frac{1}{7}$, so $\sin\alpha = \frac{1}{\sqrt{1^2+7^2}} = \frac{1}{\sqrt{50}}$ So vertical component of initial velocity is $\frac{42}{\sqrt{50}}$ m s^{-1} (or 5.9 The bolt reaches its greatest height when its vertical velocity is
		Either: Use $v = u + at$ with $v = 0$, $u = \frac{42}{\sqrt{50}}$, $a = -9.8$: $0 = \frac{42}{\sqrt{50}} - 9.8t$ So bolt reaches its maximum height when $t = \frac{42}{9.8\sqrt{50}}$ s (or 0.606091… s) To find the height, use $s = ut + \frac{1}{2}at^2$ with $u = \frac{42}{\sqrt{50}}$, $t = \frac{42}{9.8\sqrt{50}}$, $a = -9.8$: $s = \frac{42}{\sqrt{50}} \times \frac{42}{9.8\sqrt{50}} - \frac{1}{2} \times 9.8 \times \left(\frac{42}{9.8\sqrt{50}}\right)^2$ = 1.8 m **Or:** Use $v^2 = u^2 +$ $u = \frac{42}{\sqrt{50}}$, $a =$ $0^2 = \left(\frac{42}{\sqrt{50}}\right)^2$ $\therefore 0 = \frac{1764}{50} -$ $\therefore 19.6s = \frac{176}{50}$ $\therefore s = \frac{1764}{50 \times 19.}$ = 1.8 m
	3.3 m	So the maximum height of the bolt is 1.5 + 1.8 = 3.3 m or 3.
aii		As in part (a), the horizontal component of the initial velocity is We are told that $\tan\alpha = \frac{1}{7}$, so $\cos\alpha = \frac{7}{\sqrt{1^2+7^2}} = \frac{7}{\sqrt{50}}$ So horizontal component of initial velocity is $42 \times \frac{7}{\sqrt{50}} = \frac{29}{\sqrt{5}}$ The bolt is directly above the apple when it has travelled 48 m time = $\frac{\text{distance}}{\text{speed}}$, distance = 48 m and speed = $\frac{294}{\sqrt{50}}$ m time = $\frac{48}{294/\sqrt{50}}$ $= \frac{8\sqrt{50}}{49}$ s (or 1.15446… s) To find its vertical height at this time use $s = ut + \frac{1}{2}at^2$ with $u = \frac{42}{\sqrt{50}}$, $t = \frac{8\sqrt{50}}{49}$, $a = -9.8$:

Qu №	Answer	Solutions
	0.827 m (allow $\frac{81}{98}$ m)	$s=\frac{42}{\sqrt{50}}\times\frac{8\sqrt{50}}{49}-\frac{1}{2}\times 9.8\times\left(\frac{8\sqrt{50}}{49}\right)^2$ $=\frac{16}{49}$ m (or 0.326530… m) So the bolt's height at this moment is $1.5+\frac{16}{49}=1.82653\ldots$ So its height above the apple is $1.82653\ldots-1=0.826530\ldots$
b	$\frac{59}{8}$ and $\frac{1}{8}$ (al[illegible] a[illegible]25)	As above, the bolt's initial velocity has vertical component 42 s horizontal component $42\cos\alpha$ m s^{-1} [illegible]orizontal distance between the starting point of the bolt a Using $s=ut+\frac{1}{2}at^2$ where $a=0$, $48=42\cos\alpha\times t+\frac{1}{2}\times$ So the time taken for the bolt to reach the apple is $t=\frac{48}{42\cos}$ At which time the bolt has height: $1.5+42\sin\alpha\times\frac{8}{7\cos\alpha}-\frac{1}{2}\times 9.8\times\left(\frac{8}{7\cos\alpha}\right)^2$ $=1.5+48\tan\alpha-\frac{32}{5}\sec^2\alpha$ Using the identity $\sec^2\alpha=1+\tan^2\alpha$ gives the height as: $-4.9+48\tan\alpha-6.4\tan^2\alpha$ For the bolt to hit the apple, this height must equal the height $-4.9+48\tan\alpha-6.4\tan^2\alpha=1$ $\therefore 6.4\tan^2\alpha-48\tan\alpha+5.9=0$ So, by the quadratic formula: $\tan\alpha=\frac{48\pm\sqrt{(-48)^2-4\times 6.4\times 5.9}}{2\times 6.4}$ $=\frac{48\pm\sqrt{2152.96}}{12.8}$ $=\frac{48\pm 46.4}{[illegible]}$ $=\frac{[illegible]}{8}$ and $\frac{1}{8}$
c	Any [illegible]mment on the unsuitability of the model, e.g. • The model relies on the bolt leaving the crossbow at a very precise speed and angl • The model ignores air resistance • The apple is not a point, so there is some leeway in hitting the target	
d	Any valid suggestion for improving the model, e.g. • Include air resistance • Model the apple as an area rather than a point	

Preview of Answers Ends Here