Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS/A LEVEL

S25-2300U20-1

2300U20-1

FRIDAY, 23 MAY 2025 – AFTERNOON

MATHEMATICS – AS unit 2
APPLIED MATHEMATICS A

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	6	
2	4	
3	11	
4	8	
5	11	
6	6	
7	6	
8	8	
9	4	
10	11	
Total	75	

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01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a Formula Booklet;
- a calculator;
- statistical tables (RND/WJEC Publications).

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Take g as $9{\cdot}8\,\text{ms}^{-2}$.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The maximum mark for this paper is 75.

The number of marks is given in brackets at the end of each question or part-question.

Sufficient working must be shown to demonstrate the **mathematical** method employed.

Answers without working may not gain full credit.

Unless the degree of accuracy is stated in the question, answers should be rounded appropriately.

You are reminded of the necessity for good English and orderly presentation in your answers.

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Reminder: Sufficient working must be shown to demonstrate the **mathematical** method employed.

Section A: Statistics

1. Financial transactions on a network occur at an average rate of one every 10 minutes. Transactions occur singly, randomly and independently.

(a) Stating an appropriate model, calculate the probability that there will be exactly 5 transactions in a randomly selected one-hour period. [3]

Let X = number of transactions in a one-hour period.

Mean rate = $60 \div 10 = 6$ per hour, $X \sim Po(6)$

$P(X = 5) = \frac{6^5 \times e^{-6}}{5!}$

$P(X = 5) = 0.160623...$

$P(X = 5) = 0.161$ (3 s.f.)

During a busy period, the average rate of transactions is 10 per hour. The cost per transaction is \$30.

(b) For this busy period, calculate the probability that the total cost of the transactions will be at least \$360 in a randomly selected hour. [3]

Let Y = number of transactions in a one-hour period, $Y \sim Po(10)$

Total cost $\geq$ \$360 $\Rightarrow$ $30Y \geq 360$ $\Rightarrow$ $Y \geq 12$

$P(Y \geq 12) = 1 - P(Y \leq 11)$

$= 1 - 0.6968$

$= 0.3032$ (= 0.303 to 3 s.f.)

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2. The probability distribution of a discrete random variable X is given below.

x	2	3	4	5
P($X = x$)	0·1	0·4	0·3	0·2

Given that X_1 and X_2 are two independent observations of X, calculate the probability that $X_1 + X_2 = 6$. [4]

$X_1 + X_2 = 6$ for the pairs (2, 4), (3, 3), (4, 2)

$P(X_1 + X_2 = 6) = P(2)P(4) + P(3)P(3) + P(4)P(2)$

$= 0.1 \times 0.3 + 0.4 \times 0.4 + 0.3 \times 0.1$

$= 0.03 + 0.16 + 0.03$

$= 0.22$

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3. Martin is designing a new question for a multiple-choice quiz. The question has three options, only one of which is correct. Martin designs the question to be misleading and difficult to answer correctly. He claims that people would do better if they select their answer to the question at random rather than trying to work out the correct answer.

(a) Write suitable hypotheses to test Martin's claim. [1]

Let p = probability that a person answers the question correctly.

H_0: $p = \frac{1}{3}$ H_1: $p < \frac{1}{3}$

Martin decides to carry out a hypothesis test at the 5% level of significance to investigate his claim. He takes a random sample of 63 people and asks them to try to work out the correct answer to the new question, instead of just guessing randomly. He finds that 15 people answer the new question correctly and 48 people answer incorrectly.

(b) (i) Calculate the *p*-value for Martin's data.

(ii) Complete the hypothesis test at the 5% level of significance and make a conclusion in context. [5]

(i) Let X = number of people who answer correctly.

Under H_0, $X \sim B(63, \frac{1}{3})$

p-value $= P(X \leq 15)$

$= 0.06794... = 0.0679$

(ii) $0.0679 > 0.05$, so there is insufficient evidence to reject H_0 at the 5% level of significance.

There is insufficient evidence at the 5% level to suggest that people do worse by trying to work out the correct answer than by selecting an answer at random, so Martin's claim is not supported.

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(c) Now suppose that Martin's new question is such that the true probability that the question is answered correctly is 0·2. Calculate the probability of a Type II error in a random sample of size 63. Interpret your answer in context. [5]

Under H_0, $X \sim B(63, \frac{1}{3})$

$P(X \leq 14) = 0.0379 < 0.05$, $P(X \leq 15) = 0.0679 > 0.05$

$\therefore$ critical region is $X \leq 14$

Type II error: H_0 is not rejected when H_0 is false, i.e. $X \geq 15$

$P(\text{Type II error}) = P(X \geq 15 \mid X \sim B(63, 0.2))$

$= 1 - P(X \leq 14)$

$= 1 - 0.7318$

$= 0.2682$ (0.268 to 3 s.f.)

Interpretation: if $p = 0.2$, people really are worse at answering the new question than if they had guessed at random, but there is about a 27% chance that Martin's test fails to reject H_0, so he would wrongly fail to conclude that his claim is true.

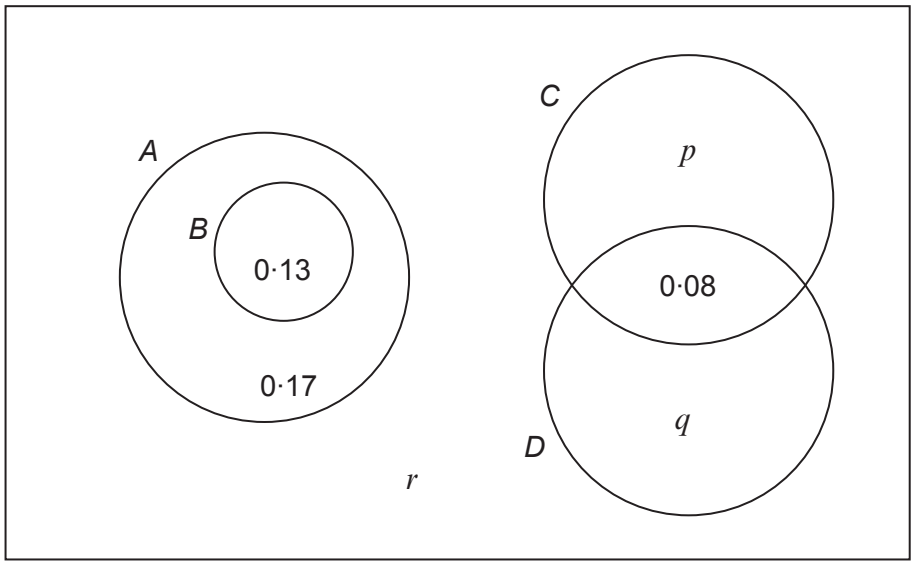
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4. The following Venn diagram shows the events A, B, C, D together with some probabilities.



(a) Find:

(i) P(A)

(ii) P($A \cap B$). [2]

(i) $P(A) = 0.13 + 0.17 = 0.3$

(ii) B is inside A, so $P(A \cap B) = P(B) = 0.13$

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(b) Given that P(C') = 0·6 and that the events C and D are independent, calculate p, q and r. [6]

$P(C) = 1 - P(C') = 1 - 0.6 = 0.4$

$p + 0.08 = 0.4 \Rightarrow p = 0.32$

C and D independent: $P(C \cap D) = P(C) \times P(D)$

$0.08 = 0.4 \times (0.08 + q)$

$0.08 = 0.032 + 0.4q$

$0.4q = 0.048 \Rightarrow q = 0.12$

Total probability = 1:

$0.13 + 0.17 + 0.32 + 0.08 + 0.12 + r = 1$

$0.82 + r = 1 \Rightarrow r = 0.18$

$p = 0.32, \quad q = 0.12, \quad r = 0.18$

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5. The World Health Organisation (WHO) compiles data on life expectancy and other factors.

A hobbyist statistician is exploring the data he collects from the WHO. The following screenshot shows part of his work.

Country	Life expectancy	Adult mortality	Hepatitis B	Polio	GDP	Population	Years of schooling	Life expectancy
Benin	60	249	82	78	784	13958086	10·7	60
Botswana	65·7	256	95	96	6533	2705113	12·6	65·7
Comoros	63·5	227	91	92	728	777424	11·1	63·5
Costa Rica	79·6	AB	92	92	1146	5235470	14·2	79·6
Saudi Arabia	74·5	88	98	97	2733		16·1	74·5
Seychelles	73·2	168	98	97	1539	93419	14·1	73·2

(a) Give **two** ways in which the data could be cleaned. [2]

1. The population figure for Saudi Arabia is missing: it could be found and added to the table.

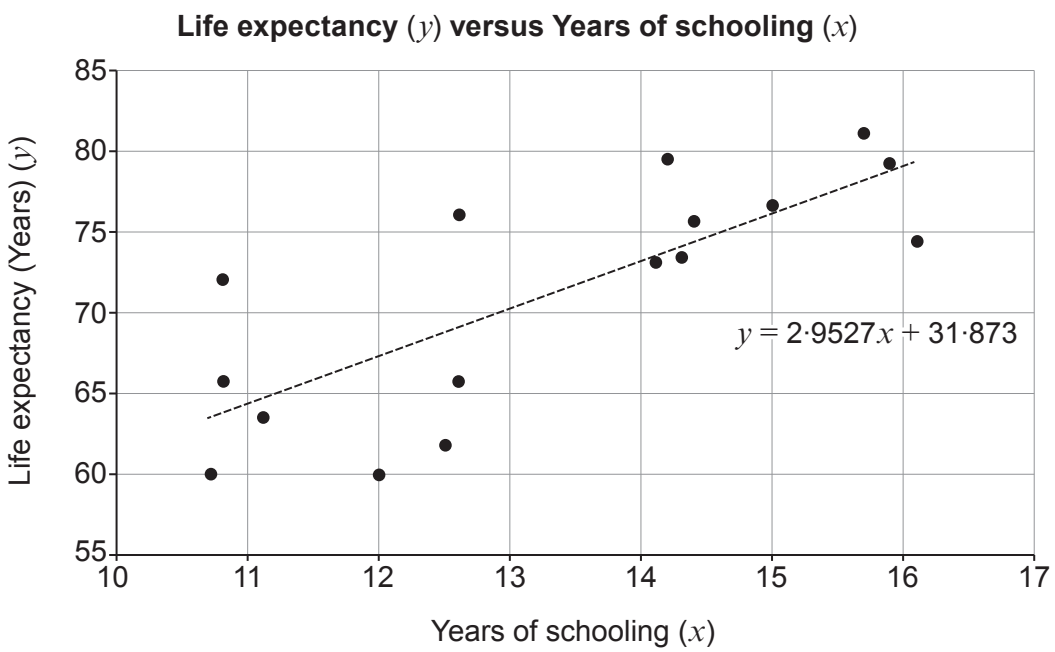
2. "AB" in the adult mortality column for Costa Rica is clearly incorrect: the correct figure could be found, or the value ignored.

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The graph below shows the life expectancy and years of schooling for 16 randomly selected countries.



(b) Interpret the gradient of the regression line in context. [1]

For each additional year of schooling, the life expectancy goes up by about 2.95 years on average.

(c) Comment on the causal nature or otherwise of the correlation. [1]

It could be causal: more education is likely to lead to better life choices and so a longer life. However, correlation alone does not prove causation, as a third factor such as wealth could lead to both more schooling and better health care.

TURN OVER FOR QUESTIONS 5(d)–5(f)

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(d) (i) Calculate an estimate of the life expectancy for a country that has 14·6 years of schooling. [1]

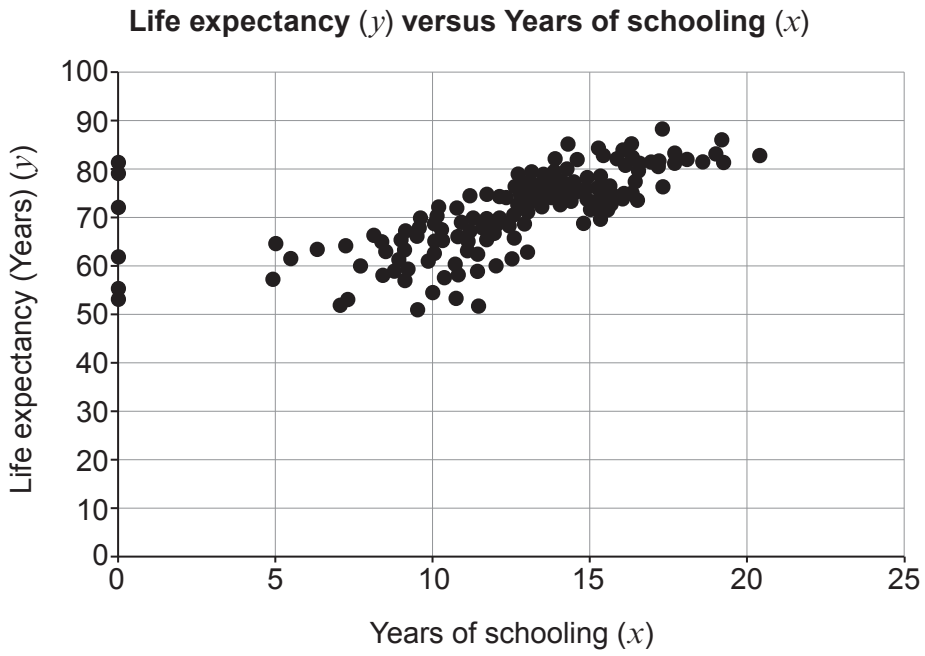
(ii) Comment on the reliability of your answer. [1]

(i) $y = 2.9527 \times 14.6 + 31.873$

$= 74.98242 = 74.98$ years (about 75 years)

(ii) Reasonably reliable, because 14.6 years is within the range of the data (interpolation) and the pattern of the data is roughly linear.

The entire data set was used to produce the following scatter diagram.



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(e) State the curious feature of the graph and what might be done about it. [1]

There seem to be several countries with 0 years of schooling, which is unlikely to be accurate. These points could be ignored in the analysis, or further research done to find the missing years of schooling.

(f) The summary data for life expectancy, y, in years, for the entire data set are given as follows.

$$\sum y = 13\,105\cdot 9 \qquad \sum y^2 = 950\,615\cdot 47 \qquad n = 183$$

(i) Show that the mean is 71·6 years, correct to 3 significant figures, and calculate the standard deviation. [3]

(ii) The hobbyist statistician claims that 71·6 years represents average global life expectancy. Comment on this claim. [1]

(i) $\bar{y} = \frac{\Sigma y}{n} = \frac{13105.9}{183} = 71.6169\ldots = 71.6$ years (3 s.f.)

$\sigma^2 = \frac{\Sigma y^2}{n} - \bar{y}^2 = \frac{950615.47}{183} - \left(\frac{13105.9}{183}\right)^2$

$\sigma^2 = 5194.620\ldots - 5128.986\ldots = 65.634\ldots$

$\sigma = \sqrt{65.634\ldots} = 8.1014\ldots = 8.10$ years

(ii) The claim is not valid: each country counts equally in this mean, whatever its size. The mean should be weighted by country population size to represent average global life expectancy.

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11

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Section B: Mechanics

6. Two forces $\mathbf{G}$ and $\mathbf{H}$ are given by

$$\mathbf{G} = (-4\mathbf{i} + 6\mathbf{j})\,\text{N},$$

$$\mathbf{H} = (k\mathbf{i} - 9\mathbf{j})\,\text{N},$$

where k is a constant. A particle has a mass of 0·5 kg.

(a) Given that the particle is in equilibrium under the action of the force $3\mathbf{G} + 2\mathbf{H}$, show that $k = 6$. [3]

In equilibrium: $3G + 2H = 0$

$3(-4i + 6j) + 2(ki - 9j) = 0$

$-12i + 18j + 2ki - 18j = 0$

$(2k - 12)i + 0j = 0$

$2k - 12 = 0$

$k = 6$ (as required)

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(b) The force $\mathbf{G} + \mathbf{H}$ acts on the particle. Determine the acceleration vector of the particle. [3]

$G + H = (-4i + 6j) + (6i - 9j) = 2i - 3j$

Newton's second law: $G + H = ma$

$2i - 3j = 0.5a$

$a = (4i - 6j)\ ms^{-2}$

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7. (a) Using the equations $v = u + at$ and $s = \frac{1}{2}(u + v)t$, show that

$$s = ut + \frac{1}{2}at^2.$$ [2]

Substitute $v = u + at$ into $s = \frac{1}{2}(u + v)t$:

$s = \frac{1}{2}(u + u + at)t$

$s = \frac{1}{2}(2u + at)t$

$s = \frac{1}{2}(2ut + at^2)$

$s = ut + \frac{1}{2}at^2$ (as required)

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(b) A small object, of mass 0·07 kg, is projected vertically upwards from the ground with a speed of 29·4 ms^{-1}.

(i) Find the time taken for the object to return to its point of projection. [3]

(ii) State **one** assumption that you have made in your solution. [1]

(i) Taking upwards as positive: $u = 29.4$, $a = -9.8$, $s = 0$

$s = ut + \frac{1}{2}at^2$

$0 = 29.4t + \frac{1}{2}(-9.8)t^2$

$0 = 29.4t - 4.9t^2 = 4.9t(6 - t)$

$t = 0$ (the start, so reject) or $t = 6$

Time taken = 6 s

(ii) Air resistance is ignored.

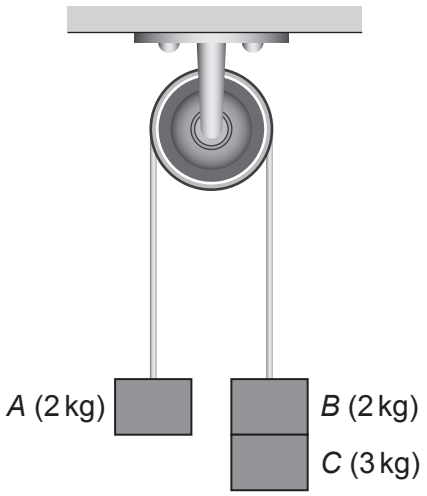
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8. Two objects *A* and *B* are connected by a light inextensible string passing over a smooth fixed pulley. Object *A* has mass 2 kg and object *B* has mass 2 kg. Another object *C*, of mass 3 kg, is attached to object *B* as shown in the diagram below.

Initially, the system is held at rest with the string just taut and the hanging parts of the string vertical.



The system is then released from rest.

(a) (i) Find the magnitude of the acceleration of *A* and the tension in the string. [6]

(ii) Hence, find the force exerted by the string on the pulley. [1]

(i) Let a = acceleration, T = tension.

A (upwards): $T - 2g = 2a$

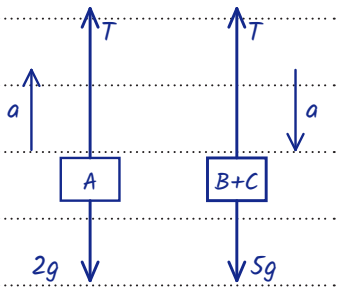
B and C (downwards): $5g - T = 5a$

Adding: $3g = 7a$

$a = \frac{3g}{7} = 4.2\ ms^{-2}$

$T = 2g + 2a = 19.6 + 8.4$

$T = 28\ N$



(ii) Force on pulley = $2T = 2 \times 28 = 56$ N (vertically downwards)

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(b) Object *C* separates from *B* and falls away. Without carrying out any further calculations, write down the acceleration of *A* after the separation. [1]

Acceleration of A = 0 ms^{-2}

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9. A small toy car, which may be modelled as a particle, is moving along a straight horizontal track as shown below. Two points *A* and *B* are positioned along the track.



The velocity of the car, v cms^{-1}, at time t seconds, is given by

$$v = 50t - 2t^3 \qquad \text{for} \qquad 0 \leqslant t \leqslant 5.$$

When $t = 1$, the car passes the point *A*.

(a) Find an expression for the displacement of the car from *A* at time t s. [3]

$x = \int (50t - 2t^3)\, dt$

$x = 25t^2 - \frac{1}{2}t^4 + C$

Displacement from A, so $x = 0$ when $t = 1$:

$0 = 25 - \frac{1}{2} + C \quad \Rightarrow \quad C = -24.5$

$x = 25t^2 - \frac{1}{2}t^4 - 24.5 \quad (cm)$

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(b) When $t = 4$, the car passes the point *B*. Determine the length of the track between *A* and *B*. [1]

When $t = 4$: $x = 25(4)^2 - \frac{1}{2}(4)^4 - 24.5$

$= 400 - 128 - 24.5$

$AB = 247.5$ cm

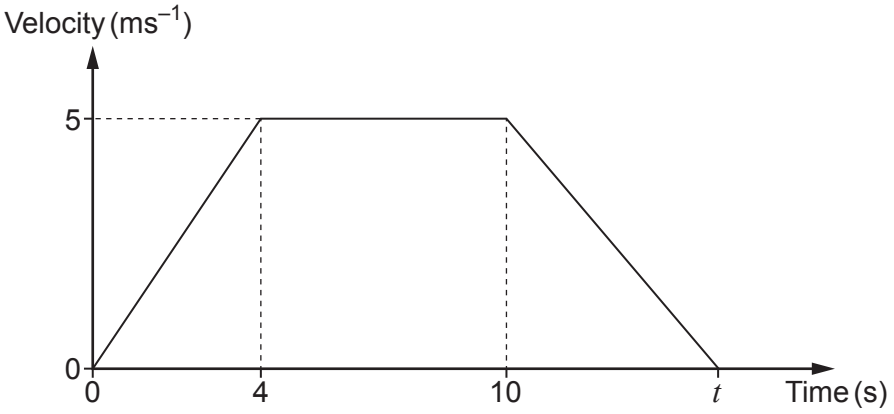
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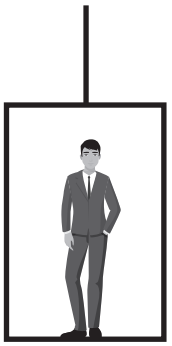
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10. A lift is pulled upwards by means of a single cable, as shown in the diagram on the right. A person of mass 80 kg is standing in the lift. The mass of the lift is 420 kg.

The diagram on the left shows a sketch of the velocity-time graph for the journey of the lift for a period of t seconds.





(a) Find the tension in the cable while the lift is accelerating. [4]

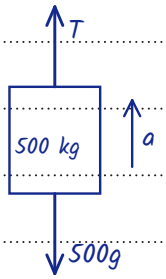
Acceleration = gradient = $\frac{5}{4}$ = 1.25 ms^{-2}

N2L on lift and person (mass 500 kg), up +ve:

$T - 500g = 500a$

$T - 4900 = 500 \times 1.25 = 625$

$T = 5525$ N



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(b) While the lift is decelerating, the magnitude of the reaction of the floor of the lift on the person is 704 N. Determine the deceleration of the lift and hence show that $t = 15$. [5]

N2L on the person only, upwards positive:

$R - 80g = 80a$

$704 - 784 = 80a$

$a = -1 \Rightarrow$ deceleration of lift = 1 ms^{-2}

From t = 10 to t, acceleration = gradient = −1:

$\frac{0 - 5}{t - 10} = -1$

$t - 10 = 5$

$t = 15$ (as required)

TURN OVER FOR QUESTION 10(c)

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(c) Calculate the distance travelled by the lift during the entire 15 s journey. [2]

Distance = area under the velocity-time graph

$= \frac{1}{2}(4)(5) + (10 - 4)(5) + \frac{1}{2}(15 - 10)(5)$

$= 10 + 30 + 12.5$

$= 52.5$ m

END OF PAPER

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