

- 20 source of sound of constant power  $P$  is situated in an open space. The intensity  $I$  of sound at distance  $r$  from this source is given by

(a)  $X$  and  $Y$  are connected in series to a cell.

parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV .

.....  
 .....  
 .....  
 .....

[8]

(b) student wishes to measure a distance of about 10 cm to a precision of 0.01 cm .

.....  
 .....  
 .....  
 .....

[6]

- 14 velocity-time graph shown models the motion of a parachutist falling vertically. There are four stages in the motion:

curve  $C$  with equation

(c) a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.

.....  
 .....  
 .....  
 .....

[6]

(a)  $I_n = \int_0^1 x^n(1-x)^{\frac{1}{2}} dx$ , for  $n \geq 0$ . Show that, for  $n \geq 1$ ,

.....  
 .....  
 .....  
 .....

[3]

- (b) is an approximate value for the speed of sound in air?

.....

.....

.....

.....

[3]

- 10 Find the value of  $a$ .

the surface area generated when  $C$  is rotated through  $2\pi$  radians about the  $x$ -axis.

.....

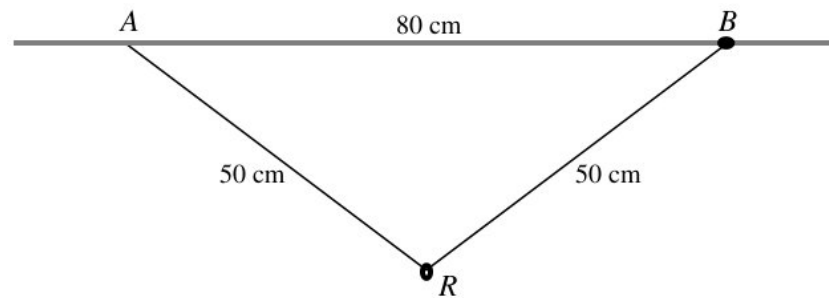
.....

.....

.....

[6]

- 20 (a) potential difference across a resistor is  $12\text{ V}$ . The current in the resistor is  $2.0\text{ A}$ .  
thermistor is connected to a cell with negligible internal resistance.



- (iv) radius of the circle in which  $P$  moves and the radius of the circle in which  $Q$  moves,

.....

.....

.....

.....

[12]

team of 4 is to be randomly chosen from 3 boys and 5 girls. The random variable  $X$  is the number of girls in the team.

- (iii) is the magnitude of  $F$  when the child stands at X and when the child stands at Y ?

object is fully submerged in a liquid.

$$n = 150 \quad \Sigma x = 27.0 \quad \Sigma x^2 = 5.01$$

.....  
 .....  
 .....  
 .....

[6]

- (c) what can be deduced from this about the rotation of Mars on its axis.

- (iii) curve  $C$  has equation

.....  
 .....  
 .....  
 .....

[6]

the point  $(2, \frac{1}{2}\pi)$ .

- (i) any assumption that you make, test at the 10% significance level whether the greengrocer's claim is supported by this evidence.

.....  
 .....  
 .....  
 .....

[10]

the exact value of  $a$ .

- (ii) continuous random variable  $X$  has probability density function  $f$  given by

$A$  contains 4 balls numbered 2, 4, 5, 8. Bag  $B$  contains 5 balls numbered 1, 3, 6, 8, 8. Bag  $C$  contains 7 balls numbered 2, 7, 8, 8, 8, 8, 9. One ball is selected at random from each bag.

.....  
 .....  
 .....  
 .....

[10]

- (d) The total momentum is conserved only in elastic collisions.

- (ii) force is caused only by a pressure difference?

Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

.....  
 .....  
 .....  
 .....

[1]

is given that

- (vi) is the relationship between the amplitude of a wave and its intensity?

.....  
 .....  
 .....  
 .....

[6]

solid plastic cylinder floats in water. It is used to support one end of a horizontal uniform beam  $AB$  as shown in Fig. 2.1.

- (iv) Given that there is no term in  $x^3$  in the expansion of  $(k + 2x) \left(1 - \frac{3}{2}x\right)^6$ , find the value of the constant  $k$ .

.....  
 .....  
 .....  
 .....

[6]

- (b) has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.
- (v) time  $T$ , the particle strikes a smooth horizontal plane at a point which is a horizontal distance  $D$  from  $O$  and a vertical distance  $H$  below  $O$ .

.....  
 .....  
 .....  
 .....

[15]

on the graph would the elastic limit be found?

- (ii) solid cubes, A and B, are measured to determine the density of their materials.

.....  
 .....  
 .....  
 .....

[3]

a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.

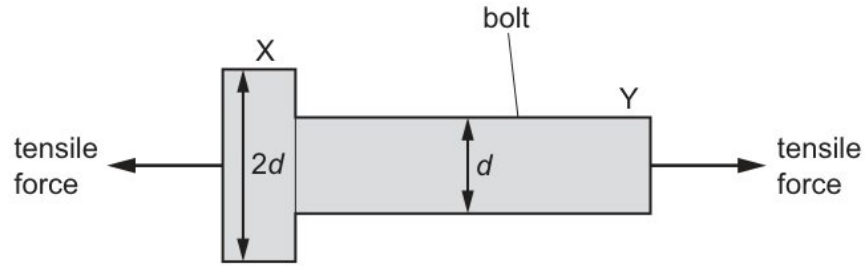
- (i) Solve the inequality  $|2x - 5| < |x + 3|$ .

.....  
 .....  
 .....  
 .....

[5]

the tension in the string and the acceleration of the particles.

- (iii) statement about light waves and sound waves is correct?



.....  
 .....  
 .....  
 .....

[8]

- 7 (e) Hence show that the differential equation  
 transmitted light has intensity  $I$ .

$$\frac{d^n}{dx^n} (x^n \ln x) = n! \left( \ln x + 1 + \frac{1}{2} + \dots + \frac{1}{n} \right).$$

- (iii) diagram, showing these three forces to scale, is correct?

.....  
 .....  
 .....  
 .....

[4]

the differential equation, obtaining a relation between  $x$  and  $y$ .

- (ii) a transformation from  $\mathbb{R}^4$  to  $\mathbb{R}^4$ .

.....  
 .....  
 .....  
 .....

[4]

the speed of the combined particle after this collision.

- (i) sample of an ideal gas at thermodynamic temperature  $T$  has internal energy  $U$ .  
 many different colour arrangements are there of the 10 books with exactly 4 books  
 between the 2 yellow books?

.....  
 .....  
 .....  
 .....

[8]

- (b) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution  
 with mean 61.4 and standard deviation 12.3.

car is travelling along a road that has a uniform downhill gradient, as shown in Fig.  
 2.1.

variables  $x$  and  $y$  are related by the differential equation

- (iv) the expected value and variance of  $Y$ .

.....  
 .....  
 .....  
 .....

where = .....  $ej$  [6]

the identity  $\cot^2 \theta - \tan^2 \theta \equiv 4 \cot 2\theta \operatorname{cosec} 2\theta$ .

- (i) some of the oil evaporates, the droplet loses mass and starts to accelerate. Its  
 charge remains constant.

.....  
 .....  
 .....  
 .....

[5]

the term interference.

- (vi) is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

.....  
 .....  
 .....  
 .....

[4]

7 height of the liquid in the beaker is  $0.20 \text{ m} \pm 2\%$ .

- (b) Find the probability that the total number of cars sold in the two showrooms during 3 days is exactly 2 .

that  $rp^3 = q^3$ .

Using a 5% significance level, test whether there is non-zero correlation between the variables.

.....  
 .....  
 .....  
 .....

applies = ..... un [6]

- (c) (iv) the probability that the mass of pasta in a randomly chosen large bag is less than 2.65 kg .

$$n = 150 \quad \Sigma x = 27.0 \quad \Sigma x^2 = 5.01$$

particle of mass  $m$  and charge  $+Q$  moves at speed  $v$  into a region where there is a uniform magnetic field, as shown in Fig. 7.1.

.....  
 .....  
 .....  
 .....

[4]



only one of the following two alternatives.

(iii)

	$v_1/\text{ms}^{-1}$	$v_2/\text{ms}^{-1}$
A	4.0	4.0
B	9.2	9.2
C	14	14
D	16	16

$I_n = \int_0^1 (1-x)^n \sinh x \, dx$ , where  $n$  is a non-negative integer.

Calculate the distance the car travels from when the brakes are applied until the car comes to rest.

.....  
 .....  
 .....  
 .....

[12]

gas is compressed so that its temperature increases to  $3T$ .

(ii) the curve with equation  $y = \left| \frac{2x^2-5x}{2x^2-7x-4} \right|$ .

Use a different liquid that has twice the density and the same volume as the original liquid.

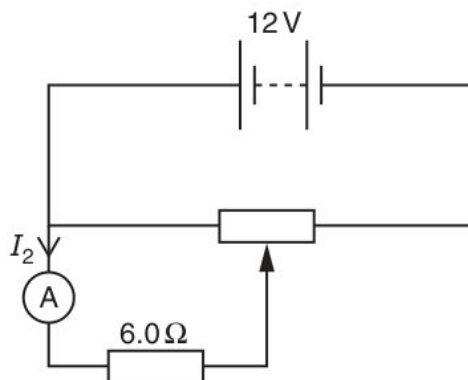
matrix  $\mathbf{M}$  represents a sequence of two geometrical transformations in the  $x-y$  plane.

.....  
 .....  
 .....  
 .....

[5]

the probability that at least 1 of these students studies Drama.

- (i) particle is projected with speed  $15 \text{ m s}^{-1}$  at an angle of  $40^\circ$  above the horizontal from a point on horizontal ground. Calculate the time taken for the particle to hit the ground.



.....  
 .....  
 .....  
 .....

[4]

- (a) Find the power output of the tractor's engine.

The power to  $X$  will decrease and the powers to  $Y$  and  $Z$  will increase.

.....  
 .....  
 .....  
 .....

[8]

- (d) mass of peaches sold per day in a supermarket is normally distributed with mean 65.8 kg and standard deviation 9.6 kg

.....  
 .....  
 .....  
 .....

State = .....  $zf$  [6]

- 15 random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.

roots of the cubic equation  $x^3 + 2x^2 - 3 = 0$  are  $\alpha, \beta$  and  $\gamma$ .

$$y = 0.46x + 1.62 \quad \text{and} \quad x = 0.93y + 8.24$$

adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

the exact value of  $a$ .

- (v) (a)  $\lambda$  is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

Show that  $\frac{dy}{dx} = 2t^{\frac{1}{2}} \frac{dy}{dt}$  and  $\frac{d^2y}{dx^2} = 2 \frac{dy}{dt} + 4t \frac{d^2y}{dt^2}$ .

.....  
 .....  
 .....  
 .....

[4]

Find also the exact value of the surface area generated when  $C$  is rotated through  $2\pi$  radians about the  $x$ -axis.

- (e) Find the cartesian equation of  $\Pi_1$ .

the arc length of  $C$ ,

.....  
 .....  
 .....  
 .....

[5]

object is fired upwards from horizontal ground. The object has an initial velocity of  $20 \text{ ms}^{-1}$  at an angle of  $45^\circ$  to the horizontal. Air resistance is negligible.

- (b) the period of small oscillations,

Show that  $b = 1 - a$ .

$x$	1	2	3	6
$P(X = x)$	0.15	$p$	0.4	$q$

.....  
 .....  
 .....  
 .....

[3]

- (i) 8 Let  $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, dx$  for  $n > 0$ .

.....  
 .....  
 .....  
 .....

spheres = ..... *og* [4]

- (ii) (a) Use the iterative formula  $x_{n+1} = \tan^{-1}(x_n + \pi)$  to determine  $x$  correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

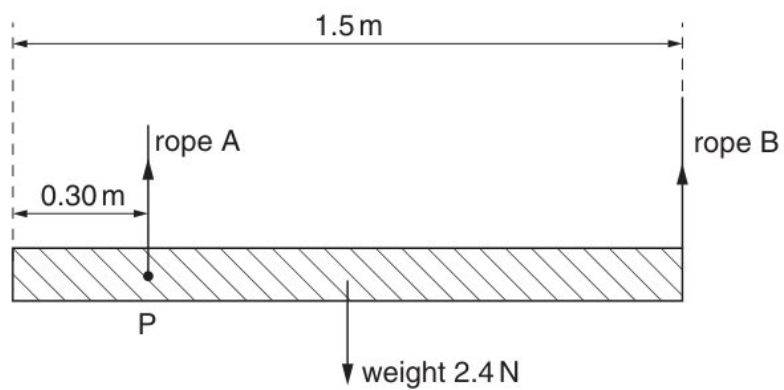
on the graph would the elastic limit be found?

.....  
 .....  
 .....  
 .....

[8]

The weight of the plank can be considered to be acting at its midpoint.

(c) random variable  $X$  has the distribution  $\text{Po}(1.5)$ .



.....  
.....  
.....  
.....

[2]

$A$  contains 6 red marbles, 5 blue marbles and 1 green marble.

- (e) Show that  $\cos \theta = \frac{2}{3}$ .

flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in Fig. 4.1.

.....  
 .....  
 .....  
 .....

[5]

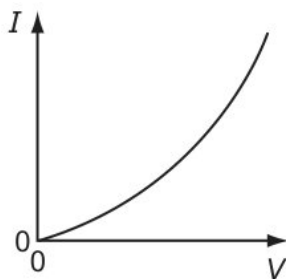
- 12 Given also that  $C$  has a turning point when  $x = 2$ , find the value of  $c$ .

.....  
 .....  
 .....  
 .....

[6]

- 12 The wavelength of maximum intensity of emission is used to determine a value for the surface temperature of the star.

- (d) (ii)



$B$  has speed  $38 \text{ m s}^{-1}$  immediately before it strikes the plane.

.....  
 .....  
 .....  
 .....

[4]

a normal distribution, calculate a 95% confidence interval for the population mean.

- (i) Find  $\sum_{r=n+1}^{2n} u_r$ .  
is the angle  $\theta$  ?

$$f(t) = \begin{cases} 0 & t < 0 \\ \lambda e^{-\lambda t} & t \geq 0 \end{cases}$$

.....  
 .....  
 .....  
 .....

[12]

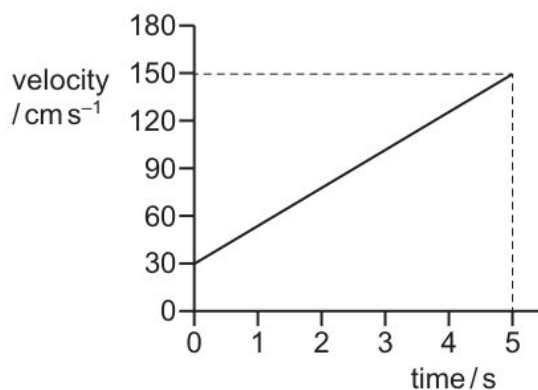
- (c) Write down matrices  $\mathbf{P}$  and  $\mathbf{D}$  such that  $\mathbf{P}^{-1}\mathbf{A}\mathbf{P} = \mathbf{D}$ , where  $\mathbf{D}$  is a diagonal matrix, and hence find the matrix  $\mathbf{A}^n$  in terms of  $n$ , where  $n$  is a positive integer.

a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.

.....  
 .....  
 .....  
 .....

[10]

9 (c)



random variable  $Y$  is defined by  $Y = \sqrt[3]{X}$

respect to the origin  $O$ , the points  $A$  and  $B$  have position vectors  $2\mathbf{i} + 4\mathbf{k}$  and  $5\mathbf{i} + \mathbf{j} + 6\mathbf{k}$  respectively. The line  $l_1$  passes through the points  $A$  and  $B$ .

marks of the pupils in a certain class in a History examination are as follows.

.....  
 .....  
 .....  
 .....

[4]

(b)  $V$  remains the same because the sum of the p.d.s across  $r$  and  $R$  is still equal to  $E$ .

(iii) random variable  $Z$  is the sum of the number of red balls and the number of different colours present in Kieran's selection. Kieran claims that the probability generating function of  $Z$  is equal to  $G_X(t) \times G_Y(t)$ .

Show that  $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$ .

Explain why two gamma-ray photons are produced, rather than just one.

.....  
 .....  
 .....  
 .....

[3]



Find the solution of the equation  $\mathbf{Ax} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}$  of the form  $\mathbf{x} = \begin{pmatrix} 4 \\ 9 \\ \alpha \\ \beta \end{pmatrix}$ , where  $\alpha$  and  $\beta$  are positive integers to be found.

- (ii) the rank of the matrix  
stationary nucleus has nucleon number  $A$ .

.....  
 .....  
 .....  
 .....  
 [2]

that for  $n \geq 2$ ,  $I_n = -1 + n(n-1)I_{n-2}$

- (i) On Fig. 9.1, sketch the variation of the activity  $A$  of the sample with  $t$  for values of  $t$  between  $t = 0$  and  $t = 24$  min.

.....  
 .....  
 .....  
 .....  
 [6]

17 moment of a force.

- (c) (iii) the method of differences to find  $\sum_{r=1}^n \frac{1}{(2-3r)(5-3r)}$  in terms of  $n$ .

Find the greatest height that  $P$  reaches above the level of  $O$ .

that  $\mathbf{B} = \mathbf{A}^{-1}$ , use the characteristic equation of  $\mathbf{A}$  to show that  $\mathbf{B}^2 = p\mathbf{I} + q\mathbf{A}$ , where  $p$  and  $q$  are constants to be determined.

.....  
 .....  
 .....  
 .....  
 [3]

Brigville the weights, in kilograms, of boys aged 16 years have a normal distribution. 99% of the boys weigh less than 97.2 kilograms and 33% of the boys weigh less than 55.2 kilograms.

- (ii) width of the 99% confidence interval is double the width of the  $x\%$  confidence interval.

Find the probability that a randomly chosen boy aged 16 years in Jimpuri weighs more than 65 kilograms.

.....  
 .....  
 .....  
 .....

[8]

- (d) the value of  $\theta$ .

Determine whether this point is a maximum or a minimum point.

.....  
 .....  
 .....  
 .....

[4]

- (a) diagram shows a uniform thin rod  $AB$  of length  $3a$  and mass  $8m$ . The end  $A$  is rigidly attached to the surface of a sphere with centre  $O$  and radius  $a$ . The rod is perpendicular to the surface of the sphere. The sphere consists of two parts: an inner uniform solid sphere of mass  $\frac{3}{2}m$  and radius  $a$  surrounded by a thin uniform spherical shell of mass  $m$  and also of radius  $a$ . The horizontal axis  $l$  is perpendicular to the rod and passes through the point  $C$  on the rod where  $AC = a$ .

.....  
 .....  
 .....  
 .....

[6]

- 12 Find the distance of  $B$  from the wall when it collides with  $A$  for the second time.  
 diagram shows part of the curve

- (b) (i) is a planet that may be considered to be an isolated uniform sphere of radius  $3.4 \times 10^6$  m.

in either order the value of  $\mu$  and the value of  $\sigma$

.....  
 .....  
 .....  
 .....

[6]

the roots of the equation  $z^3 = 27 - 27i$ , giving your answers in the form  $re^{i\theta}$ , where  $r > 0$  and  $-\pi \leq \theta < \pi$ .

- (v) potential difference (p.d.) between P and Q is  $V$ .

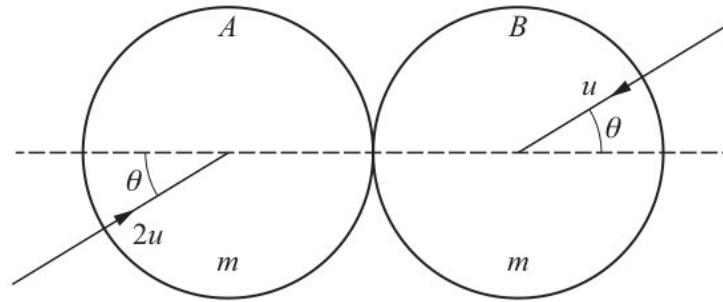
quartile: 28, Median: 39, Upper quartile: 67.

.....  
 .....  
 .....  
 .....

[6]

a transformation from  $\mathbb{R}^4$  to  $\mathbb{R}^4$ .

(iii)



Determine whether this point is a maximum or a minimum point.

.....  
 .....  
 .....  
 .....

[6]

(d) should pay particular attention to

why the variation with time of the activity of a radioactive sample is exponential in nature.

Find the area of the triangle  $ABC$ .

.....  
 .....  
 .....  
 .....

[6]

(c) matrix  $\mathbf{M}$  is given by  $\mathbf{M} = \begin{pmatrix} 1 & 2 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{pmatrix}$  where  $0 < \theta < 2\pi$

.....  
 .....  
 .....  
 .....

[8]

- 14 Find the coordinates of the turning points of  $C$ .

.....

.....

.....

.....

[8]

- 7 particle is not involved in the decay process?

the probability that the mass of peaches sold on any given day is between 56 kg and 75 kg

.....

.....

.....

.....

[4]

- 31 (a) that  $\frac{dy}{dx} = -\sqrt{1-t^2} + (1-t^2) \operatorname{sech}^{-1} t$ .

.....

.....

.....

.....

[4]

- (c) that, when  $t = 0$ ,  $x = \frac{dx}{dt} = 0$ .

- (ii)  $a$  and  $b$  are constants. It is given that  $(x+2)$  is a factor of  $p(x)$  and that, when  $p(x)$  is divided by  $(x+1)$ , the remainder is 24 .

.....

.....

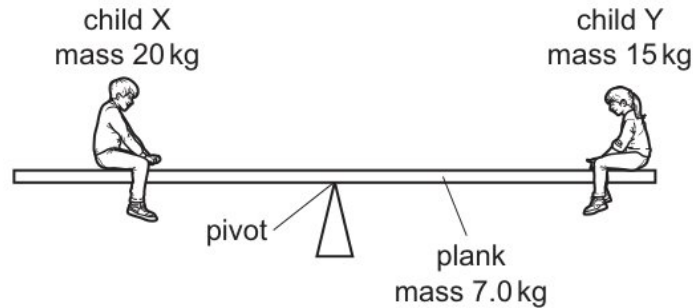
.....

.....

[4]

the grid below, draw a box-and-whisker plot to summarise the information in the cumulative frequency graph.

- (iii) helium atom may be modelled as a nucleus surrounded by two electrons in diametrically opposite circular orbits, each of radius 170 pm, as shown in Fig. 2.1.



smooth spheres  $P$  and  $Q$ , of equal radius, have masses  $m$  and  $3m$  respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere  $P$  has speed  $u$  and collides directly with sphere  $Q$  which has speed  $ku$ , where  $0 < k < 1$ . Sphere  $P$  is brought to rest by the collision. Show that the coefficient of restitution between  $P$  and  $Q$  is  $\frac{3k+1}{3(1-k)}$ .

.....  
 .....  
 .....  
 .....

[5]

a sketch of an Argand diagram, shade the region whose points represent complex numbers  $z$  which satisfy both the inequalities  $|z| < 2$  and  $|z| < |z - 2 - 2i|$ .

- (iv) the roots of the equation  $z^3 = 27 - 27i$ , giving your answers in the form  $re^{i\theta}$ , where  $r > 0$  and  $-\pi \leq \theta < \pi$ .

.....  
 .....  
 .....  
 .....

[2]

- 15 the exact value of  $\int_{\frac{1}{5}\pi}^{\frac{1}{4}\pi} 3 \cos^2 5x \, dx$

- (c) particles  $P, Q$  and  $R$ , of masses 0.6 kg, 0.4 kg and 0.8 kg respectively, are at rest in a straight line on a smooth horizontal plane. The distance from  $P$  to  $Q$  is 3 m, and the distance from  $Q$  to  $R$  is also 3 m (see diagram).  $P$  is projected directly towards  $Q$  with speed  $3 \text{ ms}^{-1}$ . After  $P$  and  $Q$  collide,  $P$  continues to move in the same direction with speed  $1.5 \text{ m s}^{-1}$ .

.....  
 .....  
 .....  
 .....

[4]

- (b) resistor of resistance  $240\Omega$  is now replaced by a new resistor  $X$  of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.

Carry out a goodness of fit test at the 10% significance level.

.....  
 .....  
 .....  
 .....

[5]

- (d) statement about nuclei is correct?

.....  
 .....  
 .....  
 .....

[5]

- 7 particle is moving in a circle of radius 2 m . At time  $t$  s its velocity is  $(t^2 - 12) \text{ ms}^{-1}$ . Find the magnitude of the resultant acceleration of the particle when  $t = 4$ .

(c) Calculate the acute angle between the planes  $p$  and  $q$ .

.....  
 .....  
 .....  
 .....

[5]

(b) show that  $PQ = 13$ ,

Find the value of  $I_2$ .

.....  
 .....  
 .....  
 .....

[6]

- 17 the matrix  $\mathbf{A}$ ,

.....  
 .....  
 .....  
 .....

[3]

- 30 A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension  $x$  of the stretching force  $F$ .

.....  
 .....  
 .....  
 .....

[6]

- 20 Show that  $\text{ff}(x) = x$ .



- (a) (iii) what is meant by the de Broglie wavelength.

counts the number of emails,  $x$ , he receives each day and notes that, over a period of  $n$  days,  $\Sigma(x - 10) = 27$  and the mean number of emails is 11.5 . Find the value of  $n$ .

is given that  $\lambda$  is an eigenvalue of the non-singular square matrix  $\mathbf{A}$ , with corresponding eigenvector  $\mathbf{e}$ .

.....  
 .....  
 .....  
 .....

[4]

values,  $x$ , in a particular set of data are summarised by

- (i) that the eigenvalues of  $\mathbf{A}$  are  $-1, 1$  and  $5$  .

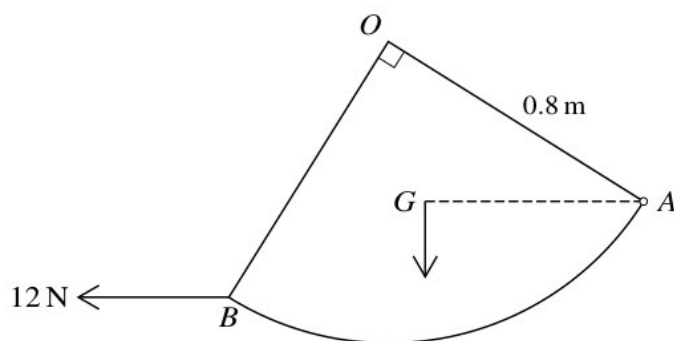
$B$  has speed  $38 \text{ m s}^{-1}$  immediately before it strikes the plane.

.....  
 .....  
 .....  
 .....

[8]

all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is  $10.3^{\circ}\text{C}$ .

(ii)



an iterative formula based on the equation in part (a) to determine  $a$  correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

.....  
 .....  
 .....  
 .....

[4]

spherical object falls through water at constant speed. Three forces act on the object.

(iv)  $a, b$  and  $c$  are constants, has two asymptotes. It is given that  $y = 2x - 5$  is one of these asymptotes.

Express  $v$  in terms of  $x$ .

.....  
 .....  
 .....  
 .....

[4]

(c) linear transformation  $T : \mathbb{R}^4 \rightarrow \mathbb{R}^4$  is represented by the matrix  $\mathbf{M} =$

$$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}.$$

.....  
 .....  
 .....  
 .....

[8]

20 battery is marked 9.0 V .

(b) Find the probability that exactly two of the selected balls have the same number.

.....  
 .....  
 .....  
 .....

[5]

(e) (iv) if there are no restrictions,

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & -2 & 3 \\ 5 & -3 & -4 & 25 \\ 6 & -4 & -6 & 28 \\ 7 & -5 & -8 & 31 \end{pmatrix}$$

lines  $l_1$  and  $l_2$  have equations

.....  
 .....  
 .....  
 .....

[8]

much charge passes a given point in wire  $R$  in a time of  $5s$  ?

(iii) Find the probability that a randomly chosen letter weighs more than 13 g .

Interval	$0 \leq x < 1$	$1 \leq x < 2$	$2 \leq x < 3$	$3 \leq x < 4$	$4 \leq x < 5$	$5 \leq x < 6$
Observed frequency	1	3	15	31	59	107

.....  
 .....  
 .....  
 .....

[5]

(c) Calculate the distance moved by the car during this acceleration.

.....  
 .....  
 .....  
 .....

[6]

- 25 The speed of the car at the bottom of the first ramp is  $14 \text{ m s}^{-1}$ . Use an energy method to find the speed of the car when it reaches the bottom of the second ramp.

hollow cylinder of radius  $r$  is fixed with its axis horizontal. Points  $A, B$  and  $O$  are in the same vertical plane perpendicular to the axis of the cylinder, with  $A$  and  $B$  on the smooth inner surface and  $O$  on the axis.  $OA$  and  $OB$  make angles  $90^\circ$  and  $\alpha$  respectively with the upward vertical through  $O$ , with  $A$  and  $B$  on opposite sides of the vertical. A particle of mass  $m$  is projected vertically downwards from point  $A$  with speed  $\sqrt{\frac{3}{2}rg}$  and moves in a vertical circle inside the cylinder (see diagram). The particle loses contact with the cylinder at point  $B$ .

.....  
 .....  
 .....  
 .....

vertical. = .....  $mb$  [10]

- 23 Determine the decay constant, in  $\text{min}^{-1}$ , of the radioactive isotope.

.....  
 .....  
 .....  
 .....

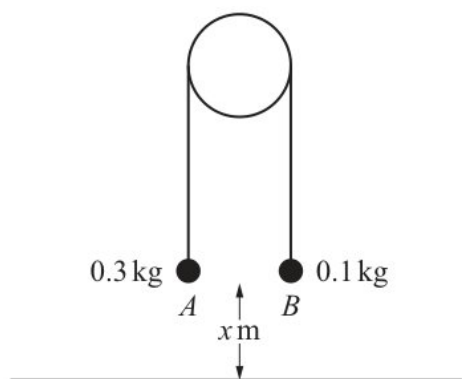
[10]

- 10 Using  $\alpha = 3$ , find the shortest distance of the point  $D$  from the line  $AC$ , giving your answer correct to 3 significant figures.

.....  
 .....  
 .....  
 .....

[3]

20



that the greatest height of  $B$  above the ground is 1.2 m , find the value of  $x$ .

.....  
 .....  
 .....  
 .....

[6]

- 11 Show how the expected value of 22.18 , for  $x = 3$ , is obtained and find the expected values for  $x = 6$  and for  $x \geq 7$ .

.....  
 .....  
 .....  
 .....

[5]

- 10 Use the trapezium rule with three intervals to estimate the value of

owns a small hotel and offers accommodation to guests. Over a period of 100 nights, the numbers of rooms,  $x$ , that are occupied each night at Roberto's hotel and the corresponding frequencies are shown in the following table.

Use the trapezium rule with two intervals to find an approximation to the area of region  $A$ . Give your answer correct to 2 decimal places.

.....  
 .....  
 .....  
 .....

[12]

- 22 Let  $z = \cos \theta + i \sin \theta$ . Show that  $z - \frac{1}{z} = 2i \sin \theta$  and hence express  $16 \sin^5 \theta$  in the form  $\sin 5\theta + p \sin 3\theta + q \sin \theta$ , where  $p$  and  $q$  are integers to be determined.

with a reason, whether it was necessary to use the Central Limit Theorem in your answer to part (b).

Find the modulus of elasticity of the string in terms of  $W$ .

.....  
 .....  
 .....  
 .....

[8]

- 12 expression has the same SI base units as pressure?

R has an amplitude of 8 cm and a period of 30 ms .

your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

.....  
 .....  
 .....  
 .....

[4]

- 25 It results in repeated measurements having different values from each other.

.....  
 .....  
 .....  
 .....

[5]

- 8 roots of the cubic equation  $x^3 + 2x^2 - 3 = 0$  are  $\alpha, \beta$  and  $\gamma$ .

(c)(vii) Find the equations of the asymptotes of  $C$ .

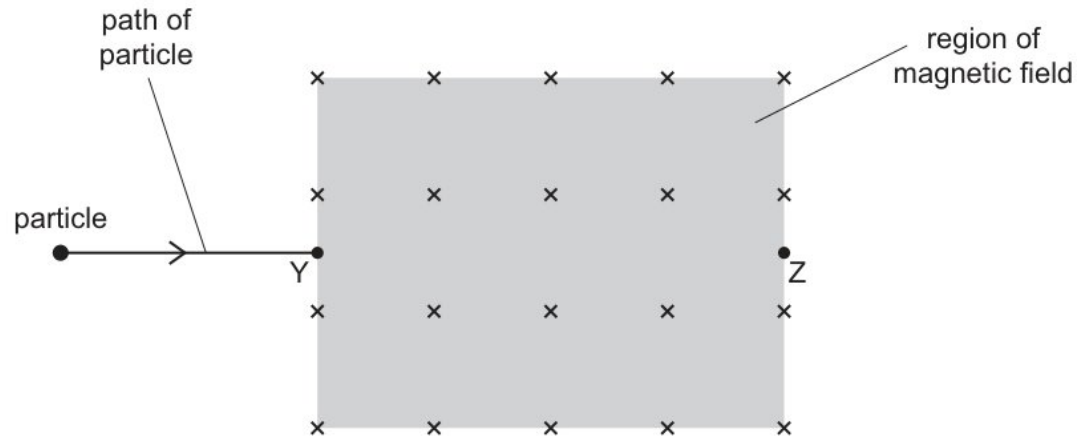
random variables  $X$  and  $Y$  have the independent distributions  $N(44, 16)$  and  $N(30, 9)$  respectively.

.....  
 .....  
 .....  
 .....

release. = .....  $te$  [10]

uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

(ii)



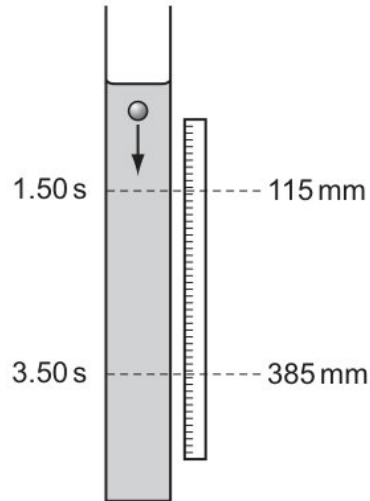
supermarket is open 7 days a week.

.....  
 .....  
 .....  
 .....

[6]

Find the solution of the equation  $\mathbf{Ax} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}$  of the form  $\mathbf{x} = \begin{pmatrix} 4 \\ 9 \\ \alpha \\ \beta \end{pmatrix}$ , where  $\alpha$  and  $\beta$  are positive integers to be found.

- (vi) how the difference in the densities of solids, liquids and gases may be related to the spacing of their molecules.



.....  
 .....  
 .....  
 .....

[2]

- (e) the subsequent collision between  $Q$  and  $R$ , these particles coalesce.

.....  
 .....  
 .....  
 .....

probability = .....  $ke$  [12]



- (b) (iv) beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

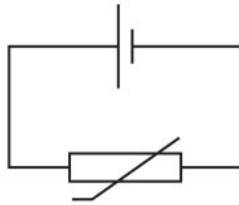
Estimate the probability of throwing a 4.

.....  
 .....  
 .....  
 .....

[3]

statement is correct?

- (i) - coming to rest instantaneously on hitting the ground.

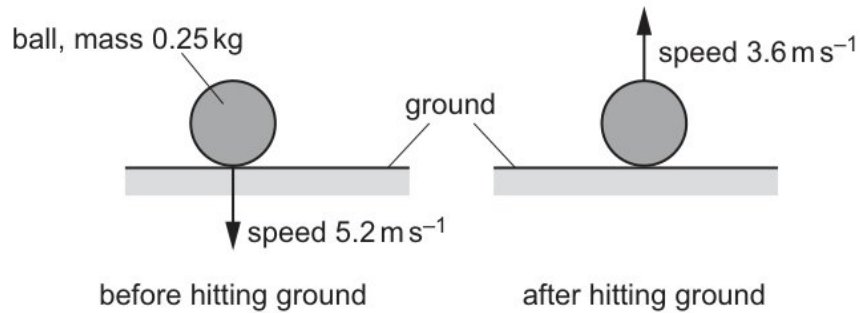


.....  
 .....  
 .....  
 .....

[4]

neutron decays to form a proton.

- (iii) eigenvectors  $\begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$ ,  $\begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$  and  $\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$ . Find the eigenvalues of the matrix  $\mathbf{AB}$ , and state corresponding eigenvectors.



.....  
 .....  
 .....  
 .....

that ensure = ..... *te* [12]

- (a) (ii) stationary loudspeaker emits sound of constant frequency. A microphone is placed near to the loudspeaker and connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.

the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution  $\text{Po}(0.7)$ . Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

.....  
 .....  
 .....  
 .....

[6]

uniform disc with centre  $O$ , mass  $m$  and radius  $a$  is free to rotate without resistance in a vertical plane about a horizontal axis through  $O$ . One end of a light inextensible string is attached to the rim of the disc and wrapped around the rim. The other end of the string is attached to a block of mass  $3m$  (see diagram). The system is released from rest with the block hanging vertically. While the block is in motion, it experiences a constant vertical resisting force of magnitude  $0.9mg$ . Find the tension in the string in terms of  $m$  and  $g$ .

- (i) logarithms to solve the equation  $3^x = 2^{x+2}$ , giving your answer correct to 3 significant figures.

280 boxes are chosen randomly. Use an approximation to find the probability that at least 30 of these boxes are rejected.

.....  
 .....  
 .....  
 .....

[4]

- 22  $a, b$  and  $c$  are integers to be determined.

no digit can be repeated,

- (b) a butternut squash seed is sown the probability that it will germinate is 0.86, independently of any other seeds. A market gardener sows 250 of these seeds. Use a suitable approximation to find the probability that more than 210 germinate.

the value of  $\mu$ .

.....  
 .....  
 .....  
 .....

[2]

- (f) the exact area of one loop of the curve.

.....  
 .....  
 .....  
 .....

terms = .....  $bq$  [5]

- 18 fair 8-sided dice has faces labelled K, A, N, G, A, R, O, O. The dice is rolled repeatedly.

- (a) (ii) Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

On a sketch of an Argand diagram, shade the region whose points represent complex numbers  $z$  satisfying both the inequalities  $|z - u| \leq 2$  and  $\operatorname{Re} z \geq 2$ , where  $\operatorname{Re} z$  denotes the real part of  $z$ .

.....  
 .....  
 .....  
 .....

[5]

Find the values of  $a$  and  $b$ .

- (i) experiment consists of throwing a biased die 30 times and noting the number of 4 s obtained. This experiment was repeated many times and the average number of 4 s obtained in 30 throws was found to be 6.21.

the period of small oscillations,

.....  
 .....  
 .....  
 .....

[3]

- (g) the equation of the tangent to the curve at the point e 3 Give your answer in the form  $y = mx + c$  where  $m$  and  $c$  are exact

	weight/N	mass/kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

.....  
 .....  
 .....  
 .....

[12]

- (d) (iii) the solution of the differential equation  
 by mathematical induction that, for all positive integers  $n$ ,

.....  
 .....  
 .....  
 .....

[8]

bolt has a circular cross-section. At end X , the diameter is  $2d$ . At end Y , the diameter is  $d$ .

(ii) is meant by elastic deformation?

a time 8.4 minutes later, the activity is 120 Bq .

.....  
 .....  
 .....  
 .....

[12]

one similarity and one difference between an electron and positron.

(iv) velocity = acceleration  $\times$  time

the value of  $x$ .

.....  
 .....  
 .....  
 .....

[10]

20 the exact volume of the solid generated

students are selected at random from the students who study Science.

(a) (ii) what can be deduced from this about the rotation of Mars on its axis.

the eigenvalues of the matrix  $\mathbf{C}$ , where

.....  
 .....  
 .....  
 .....

[10]

gas is compressed so that its temperature increases to  $3T$ .

(iii) the probability that the second A is obtained on the 6th roll of the dice.

diagram best represents the electric field surrounding the charges?

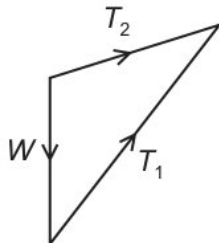
continuous random variable  $X$  has probability density function  $f$  given by

.....  
.....  
.....  
.....

[3]

adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

(iv)



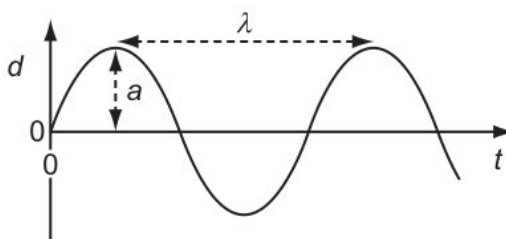
cyclist is travelling along a straight horizontal road at a speed of  $4 \text{ ms}^{-1}$  when she passes a point  $O$ . She accelerates at a constant rate for a distance of  $42 \text{ m}$ , reaching a speed of  $V \text{ m s}^{-1}$ . She maintains the speed of  $V \text{ m s}^{-1}$  for  $50 \text{ m}$  and then decelerates at  $2 \text{ m s}^{-2}$  before coming to rest. The distance travelled while decelerating is  $16 \text{ m}$ .

for a wire,

.....  
 .....  
 .....  
 .....

[6]

(d) two assumptions of the simple kinetic model of a gas.



.....  
 .....  
 .....  
 .....

[2]



- 25 Find the standard deviation of  $x$ .

.....

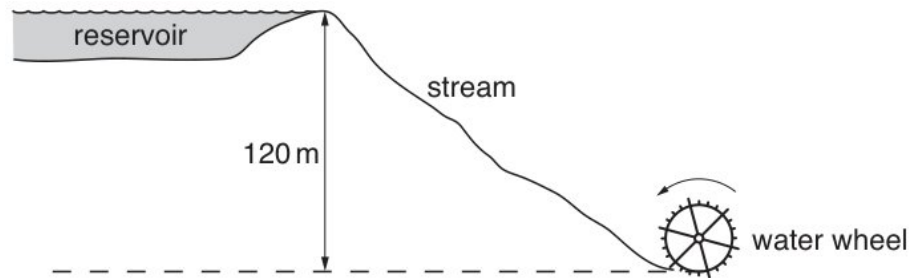
.....

.....

.....

[10]

12



the probability generating function of  $Z$ , expressing your answer as a polynomial in  $t$ .

A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension  $x$  of the stretching force  $F$ .

.....

.....

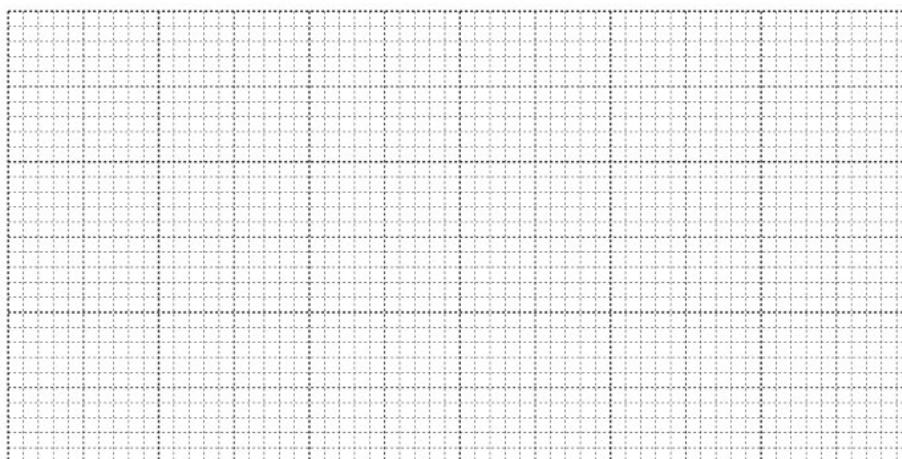
.....

.....

[12]

- 14 the value of  $\theta$  for which the transformation represented by  $\mathbf{M}$  has a line of invariant points 7

- (a) (ii) variation with time of the velocity, in  $\text{cms}^{-1}$ , of the car is shown.



specific latent heat.

.....

.....

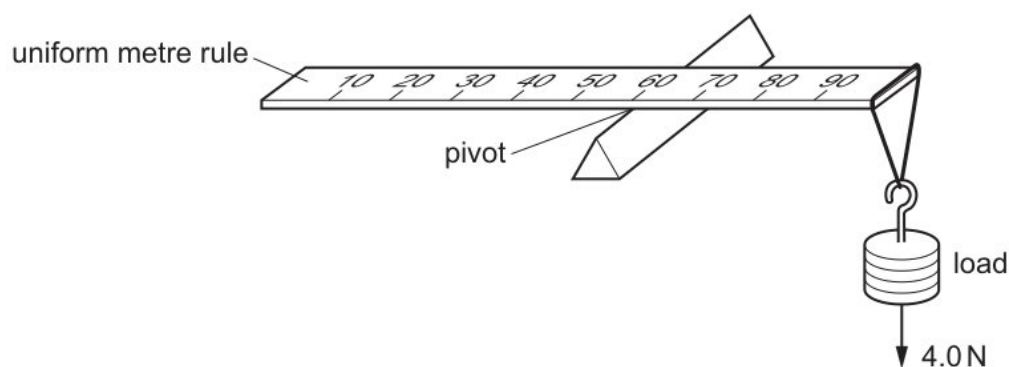
.....

.....

[6]

variable  $Y$  is related to  $X$  by  $Y = 2^X$ .

- (iii)



should pay particular attention to

.....

.....

.....

.....

[3]

Calculate the greatest deceleration of  $P$ .

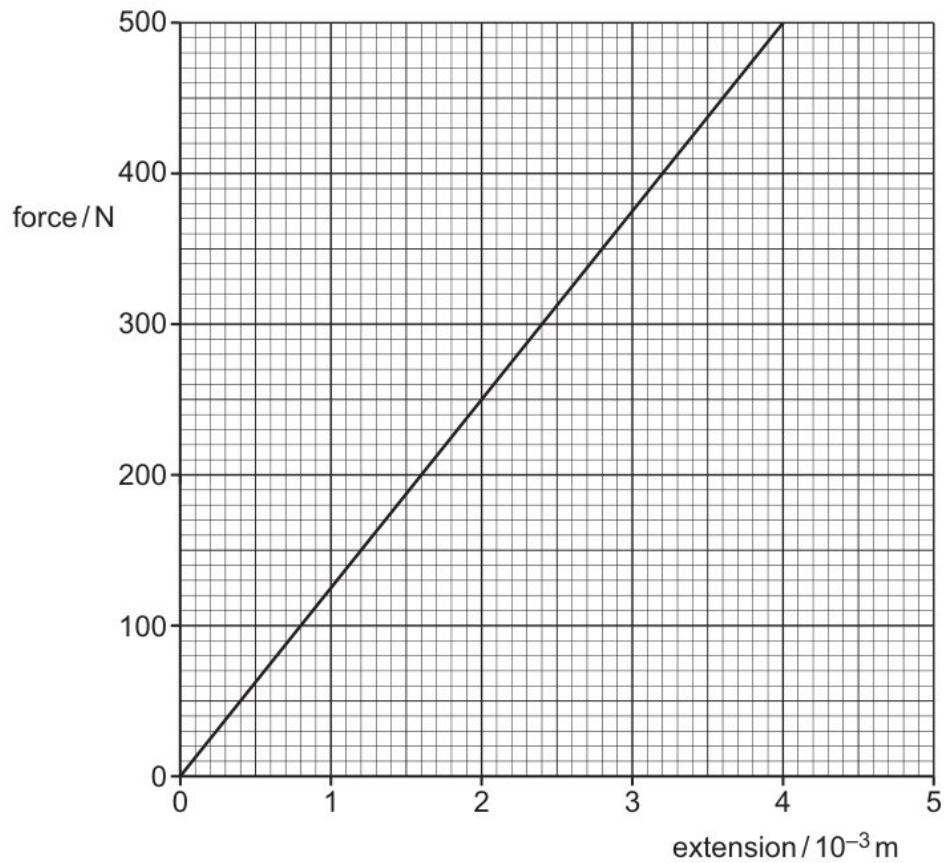
- (i) student is investigating how a volume of nitrogen gas is affected by the pressure exerted

$$\omega^4 - \omega^3 + \omega^2 - \omega = -1$$

.....  
 .....  
 .....  
 .....

[5]

variation with time  $t$  of the displacement  $s$  for a car is shown in Fig. 1.1.



- (vi) Find the value of  $\alpha$  correct to 3 decimal places. Show your working, giving each calculated value of the sequence to 5 decimal places.

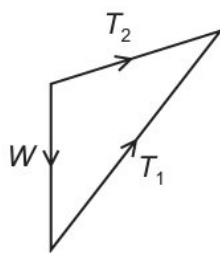
width of the 99% confidence interval is double the width of the  $x\%$  confidence interval.

the experimental observations that show radioactive decay is

.....  
 .....  
 .....  
 .....

[6]

(b) (ii)



in exact form the set of values of  $x$  for which  $\left| \frac{2x^2-5x}{2x^2-7x-4} \right| < \frac{1}{9}$ .

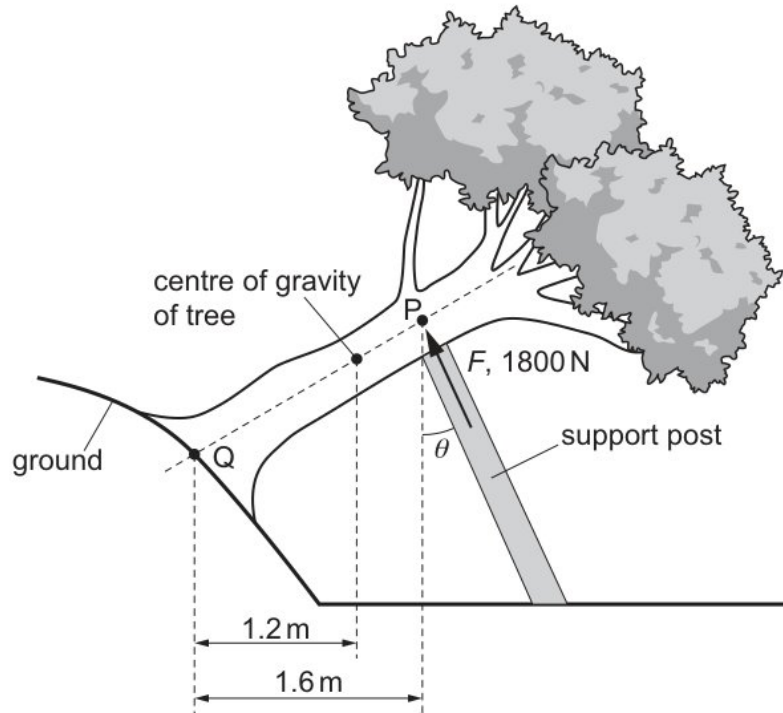
It results in repeated measurements having different values from each other.

.....  
 .....  
 .....  
 .....

[6]

only one of the following two alternatives.

(iv)



electron moving at a speed of  $4.9 \times 10^7 \text{ ms}^{-1}$  collides with a positron that is travelling at the same speed in the opposite direction. As a result of the collision, two gamma-ray photons are produced.

variation with time of the velocity, in  $\text{cms}^{-1}$ , of the car is shown.

.....  
 .....  
 .....  
 .....

[4]

- (c) fixed hollow sphere with centre  $O$  has a smooth inner surface of radius  $a$ . A particle  $P$  of mass  $m$  is projected horizontally with speed  $2\sqrt{ag}$  from the lowest point of the inner surface of the sphere. The particle loses contact with the inner surface of the sphere when  $OP$  makes an angle  $\theta$  with the upward vertical.

is a planet that may be considered to be an isolated uniform sphere of radius  $3.4 \times 10^6 \text{ m}$ .

.....  
 .....  
 .....  
 .....

coincide = ..... ov [10]

- (e) (iv) Find the greatest height that  $P$  reaches above the level of  $O$ .

sample of a radioactive substance emits particles that are positively charged and have a continuous range of kinetic energies.

the kinetic model of gases and Newton's laws of motion to explain how a gas exerts a pressure on the sides of its container.

.....  
 .....  
 .....  
 .....

[4]

a cartesian equation of the plane  $\Pi$  containing  $l_1$  and  $l_2$ .

- (vi) how many ways can a team of 4 people be chosen from 10 people if 2 of the people, Ross and Lionel, refuse to be in the team together?

how many ways can a team of 4 people be chosen from 10 people if 2 of the people, Ross and Lionel, refuse to be in the team together?

.....  
 .....  
 .....  
 .....

[3]

- 8 that the eigenvalues of  $\mathbf{A}$  are  $-1, 1$  and  $5$ .

- (e) (iv) the other root and hence find the values of  $b$  and  $c$ .

$$V = V_0 e^{-\alpha n t}$$

Find the probability that a randomly chosen boy aged 16 years in Jimpuri weighs more than 65 kilograms.

.....  
 .....  
 .....  
 .....

[8]

the probability density function of  $Y$

- (iii) particle  $P$  of mass  $0.2 \text{ kg}$  is released from rest at a point  $O$  on a smooth horizontal surface. A horizontal force of magnitude  $te^{-v} \text{ N}$  directed away from  $O$  acts on  $P$ , where  $v \text{ m s}^{-1}$  is the velocity of  $P$  at time  $t \text{ s}$  after release. Find the velocity of  $P$  when  $t = 2$ .

parametric equations of a curve are

.....  
 .....  
 .....  
 .....

[5]

- (a) (iii) Use de Moivre's theorem to show that

Find the value of  $\alpha$  correct to 3 decimal places. Show your working, giving each calculated value of the sequence to 5 decimal places.

.....  
 .....  
 .....  
 .....

village = ..... wa [6]



many electrons pass a point in the conductor in one minute?

$x$	1	2	3	6
$P(X = x)$	0.15	$p$	0.4	$q$

- (i) student is being weighed. The student, of weight  $W$ , stands 0.30 m from end A of a uniform plank AB, as shown in Fig. 3.1.

Table 4.1 to show, in terms of some or all of  $W$ ,  $T$  and  $U$ , the work done on the gas, the thermal energy supplied to the gas and the increase in internal energy of the gas for each of the two processes.

.....  
 .....  
 .....  
 .....

[3]

- 21 (b) temperature  $\theta_R$  of the laboratory is measured using a thermometer.

Find the greatest height that  $P$  reaches above the level of  $O$ .

.....  
 .....  
 .....  
 .....

[8]

- (d) force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

- (iv) electron moving at a speed of  $4.9 \times 10^7 \text{ ms}^{-1}$  collides with a positron that is travelling at the same speed in the opposite direction. As a result of the collision, two gamma-ray photons are produced.

.....  
 .....  
 .....  
 .....

[6]

block of mass 12 kg is placed on a rough plane inclined at an angle of  $\alpha$  to the horizontal, where  $\alpha = \tan^{-1} 0.5$ . A force of  $X$  N is applied to the block, directly up the plane (see diagram). The coefficient of friction between the block and the plane is  $\mu$ .

- (iii)  $k$  is a positive constant. The relevant expected frequencies are given in the following table.

.....
.....
.....
.....

[2]

the characteristic equation of  $\mathbf{A}$  to show that  $(\mathbf{A} - 2\mathbf{I})^3 = a\mathbf{A}^2 + b\mathbf{A} + c\mathbf{I}$  where  $a, b$  and  $c$  are constants to be determined.

- (i) expressing the equation  $\tan(\theta + 60^\circ) + \tan(\theta - 60^\circ) = \cot \theta$  in terms of  $\tan \theta$  only, solve the equation for  $0^\circ < \theta < 90^\circ$ .

Find the probability that a box is rejected.

.....
.....
.....
.....

[8]

The point  $A$  on the line of intersection of  $p$  and  $q$  has  $y$ -coordinate equal to 2 . Find the equation of the plane which contains the point  $A$  and is perpendicular to both the planes  $p$  and  $q$ . Give your answer in the form  $ax + by + cz = d$ .

- (ii) Write down matrices  $\mathbf{P}$  and  $\mathbf{D}$  such that  $\mathbf{P}^{-1}\mathbf{A}\mathbf{P} = \mathbf{D}$ , where  $\mathbf{D}$  is a diagonal matrix, and hence find the matrix  $\mathbf{A}^n$  in terms of  $n$ , where  $n$  is a positive integer.

.....  
 .....  
 .....  
 .....

[6]

- (a) Find the coordinates of any intersections with the coordinate axes.

a large college, all students who study Science also study exactly one of Art or Drama or Music. 20% of these students study Art, 45% study Drama and 35% study Music.

- (iii) lowest mark was 17 and the highest mark was 74 .

$$f(t) = \begin{cases} 0 & t < 0 \\ \lambda e^{-\lambda t} & t \geq 0 \end{cases}$$

Find the perpendicular distance of the point  $A$  from the line  $BC$ .

.....  
 .....  
 .....  
 .....

[4]

battery is marked 9.0 V .

- (iv) particle is moving in a circle of radius 2 m . At time  $t$  s its velocity is  $(t^2 - 12) \text{ ms}^{-1}$ . Find the magnitude of the resultant acceleration of the particle when  $t = 4$ .

Express  $v$  in terms of  $x$ .

.....  
 .....  
 .....  
 .....

[5]

- 17 the distance moved by the particle between the time at which its acceleration is zero and the time at which its velocity is zero.

Patient	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>
Before	183	165	172	165	143	176	161	153
After	164	148	164	149	134	153	155	148

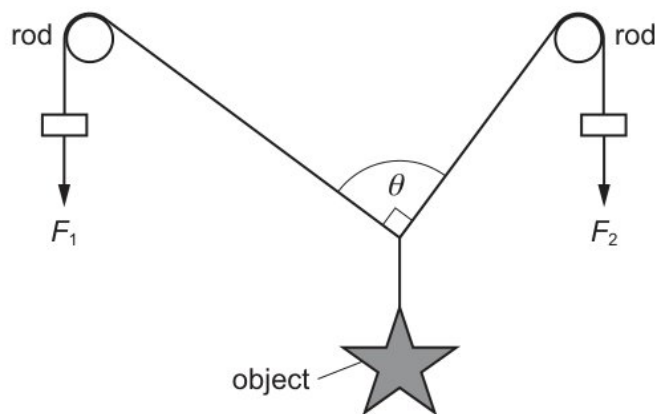
wavelength of the wave and the width of the gap are both changed by a small amount.

.....  
 .....  
 .....  
 .....

[12]

- 12 Show that  $a = 19$  and find the values of  $b$  and  $c$ .

shaded region is bounded by the curve and the two axes.



(a) (iv) 1,2 and 3

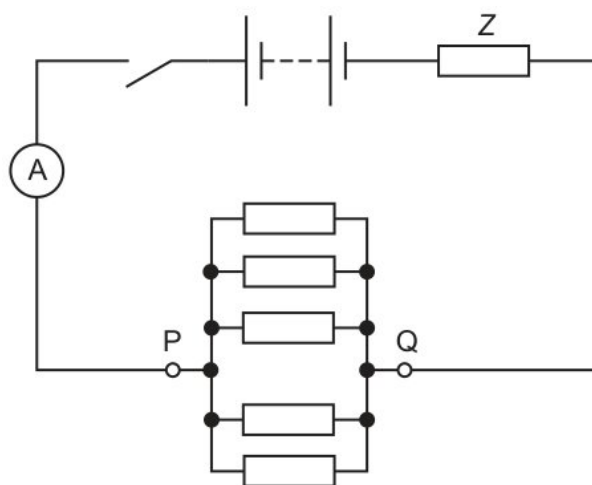
$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2.$$

.....  
 .....  
 .....  
 .....

[8]

considering the sum of the areas of these rectangles, show that

(i)



copper wire of cross-sectional area  $2.0 \text{ mm}^2$  carries a current of  $10 \text{ A}$  .

.....  
 .....  
 .....  
 .....

[8]

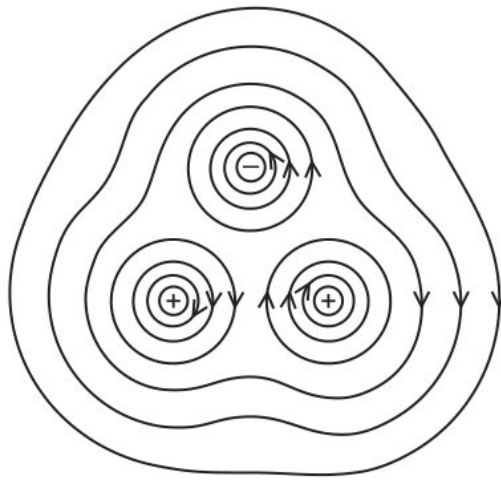
there are no restrictions,

- (vi) Show that the acceleration of the particle between  $t = 3.5$  and  $t = 6$  is  $-10 \text{ m s}^{-2}$ .  
a cubic equation with roots  $\alpha, \beta$  and  $\gamma$ , given that

.....  
 .....  
 .....  
 .....

[15]

- (b) (ii) tension in the string of the pendulum is  $T$ . The weight of the pendulum bob is  $W$ . The string is held at an angle of  $30^\circ$  to the vertical.



.....  
 .....  
 .....  
 .....

[5]

find the moment of inertia of the body about an axis  $l$ , through  $A$ , in the plane of the body and tangential to the circle.

- (iii) Its speed decreases to a value greater than zero, then increases to a value greater than  $20 \text{ ms}^{-1}$ .

$$\cos \theta + 4 \cos 2\theta = 3,$$

.....  
 .....  
 .....  
 .....

[8]

- (e) matrix  $\mathbf{M}$  represents a sequence of two geometrical transformations in the  $x - y$  plane. system is released from rest with  $OP$  making a small angle  $\alpha$  with the downward vertical. Find

.....  
 .....  
 .....  
 .....

[20]

- (c) (iv) the roots of the equation  $z^3 = 27 - 27i$ , giving your answers in the form  $re^{i\theta}$ , where  $r > 0$  and  $-\pi \leq \theta < \pi$ .

the time that it takes for the block to move 2 m down the plane from rest.

experiment consists of throwing a biased die 30 times and noting the number of 4 s obtained. This experiment was repeated many times and the average number of 4 s obtained in 30 throws was found to be 6.21.

.....  
 .....  
 .....  
 .....

figures. = ..... *cf* [5]

sequence  $x_1, x_2, x_3, \dots$  defined by

- (i) particle  $P$  is moving in simple harmonic motion with centre  $O$ . When  $P$  is 5 m from  $O$  its speed is  $V \text{ m s}^{-1}$ , and when it is 9 m from  $O$  its speed is  $\frac{3}{5}V \text{ m s}^{-1}$ . Show that the amplitude of the motion is  $\frac{15}{2}\sqrt{2} \text{ m}$ .

curve  $C$  has parametric equations  $x = e^t \cos t, y = e^t \sin t$ , for  $0 \leq t \leq \pi$ . Find the arc length of  $C$ .

.....  
 .....  
 .....  
 .....

[4]

Nucleus  $X$  undergoes  $\beta^-$  decay to form nucleus  $Z$ .

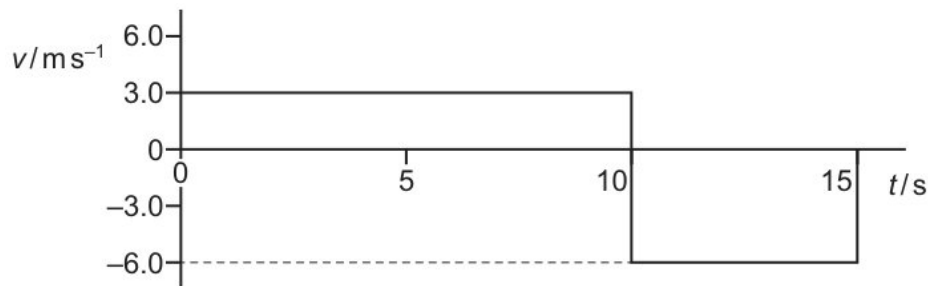
- (ii) The particle comes to rest at  $B$  at time  $T$  s. Given that the total distance travelled by the particle between  $t = 0$  and  $t = T$  is 100 m , find the value of  $T$ .

$$g(t) = \begin{cases} \frac{1}{2} \cos t & -\frac{1}{2}\pi \leq t \leq \frac{1}{2}\pi \\ 0 & \text{otherwise} \end{cases}$$

.....  
 .....  
 .....  
 .....

[5]

- 6 Q has mass 2.0 kg and is moving at a speed of  $4.2 \text{ m s}^{-1}$  at an angle of  $35^\circ$  to the path of  $P$ .



- (d) does the amplitude  $a$  of the vibrating air molecules vary with the distance  $r$  from the source?

$$\mathbf{i} - 2\mathbf{k}, \quad \mathbf{i} + 2\mathbf{j} + 2\mathbf{k}, \quad 2\mathbf{i} - \mathbf{j} - \mathbf{k}$$

is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of  $0.2g$  ?

.....  
 .....  
 .....  
 .....

[8]

- (b) the quotient and remainder when  $x^3 + 5x^2 - 2x - 15$  is divided by  $x^2 - 3$ .

.....  
 .....  
 .....  
 .....

[1]



- 15 Calculate the gravitational potential  $\phi$  at the surface of Mars. Give a unit with your answer.

.....

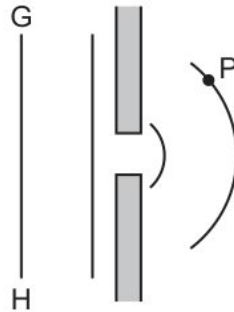
.....

.....

.....

[5]

31



density of the water is  $\rho$ . The water does not rebound from the wall.

the probability that fewer than 10 of these customers bought a computer made by company  $F$ .

.....

.....

.....

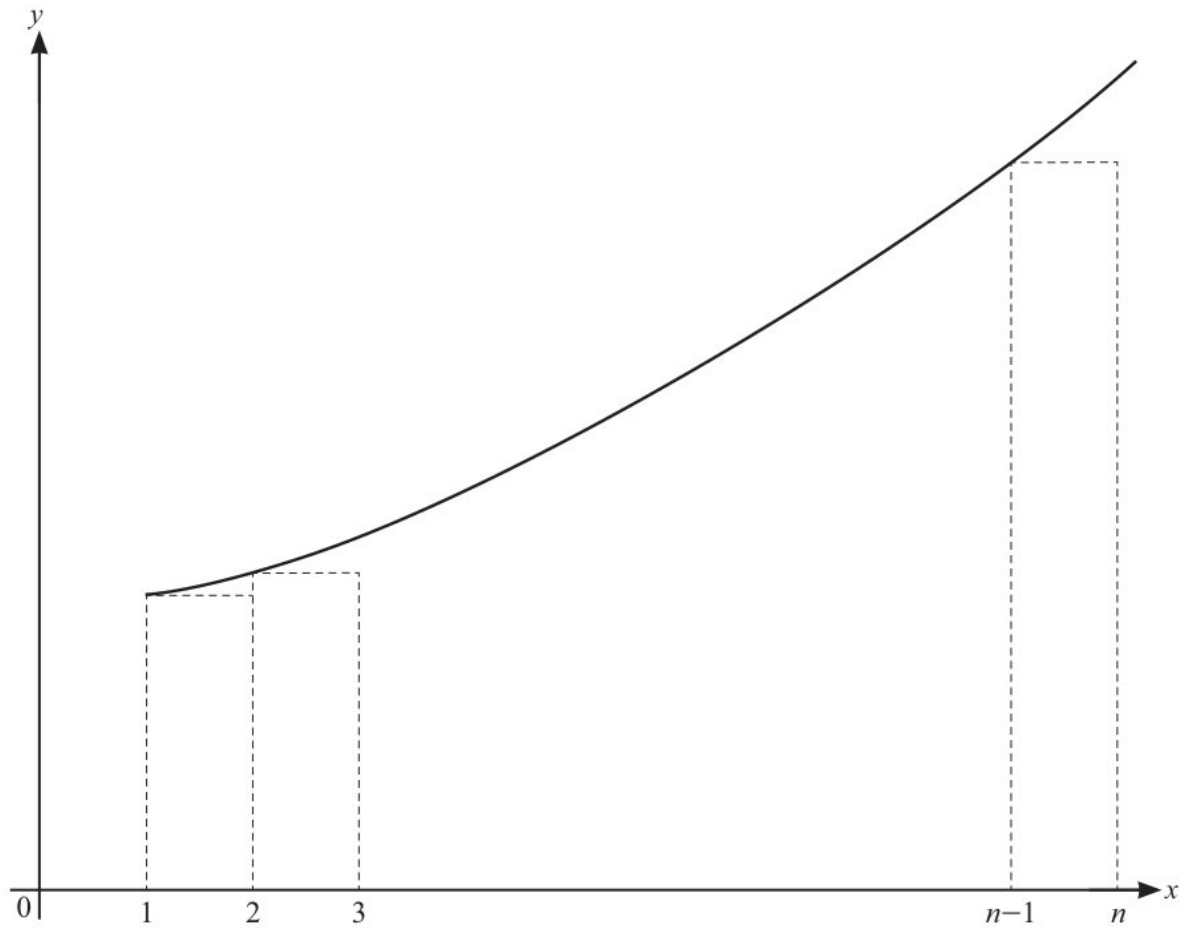
.....

[10]

- 29 statement describes the speed of the object after it is fired until immediately before it reaches the ground again?

that  $v = y^3$ , show that

graph is correctly labelled?



.....  
 .....  
 .....  
 .....

years. = ..... *ra* [1]

- 12 By using the substitution  $y = \frac{1}{x^2}$ , find the cubic equation with roots  $\frac{1}{\alpha^2}$ ,  $\frac{1}{\beta^2}$  and  $\frac{1}{\gamma^2}$ .

volume of oil. Pressure is applied by a pump. The applied pressure is measured on a  
Given instead that  $G = 0$  and the forces are in equilibrium, find the values of  $F$  and  $\alpha$ .

.....  
.....  
.....  
.....

[8]

- 13 equation  $x^2 + px + q = 0$ , where  $p$  and  $q$  are constants, has roots -3 and 5 .

.....  
.....  
.....  
.....

[10]

- 11 that  $(z_1 z_2)^* = z_1^* z_2^*$ .

force  $F$  acts on a mass  $m$  along a straight line for a distance  $s$ . The acceleration of the  
mass is  $a$  and the speed changes from an initial speed  $u$  to a final speed  $v$ .

(d) Show that  $a = 19$  and find the values of  $b$  and  $c$ .

.....  
.....  
.....  
.....

[5]

(g) throws three coins at the same time.

.....  
.....  
.....  
.....

answer region integers = ..... ur [5]

- (b) (i) microphone connected to a cathode ray oscilloscope (c.r.o.) is positioned between L and S as shown in Fig. 6.1. The trace obtained on the c.r.o. is shown in Fig. 6.2.

three quantities that are conserved during the decay.

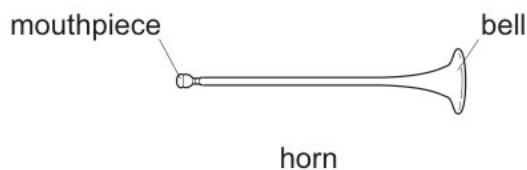
curve has equation  $x^2 + 2y^2 + 5x + 6y = 10$ . Find the equation of the tangent to the curve at the point  $(2, -1)$ . Give your answer in the form  $ax + by + c = 0$ , where  $a, b$  and  $c$  are integers.

.....  
 .....  
 .....  
 .....

[8]

lengths, in millimetres, of rods produced by a machine are normally distributed with mean  $\mu$  and standard deviation 0.9. A random sample of 75 rods produced by the machine has mean length 300.1 mm .

- (ii) random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.



student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).

.....  
 .....  
 .....  
 .....

[5]

is given instead that the kinetic energy of  $P$  is twice the elastic potential energy stored in the string.

- (iv) volume of oil. Pressure is applied by a pump. The applied pressure is measured on a

Find the rate of working of the tension at this instant.

.....  
 .....  
 .....  
 .....

[4]

Use the iterative formula  $x_{n+1} = \tan^{-1}(x_n + \pi)$  to determine  $x$  correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

(vii) bolt is subjected to a tensile force, as shown.

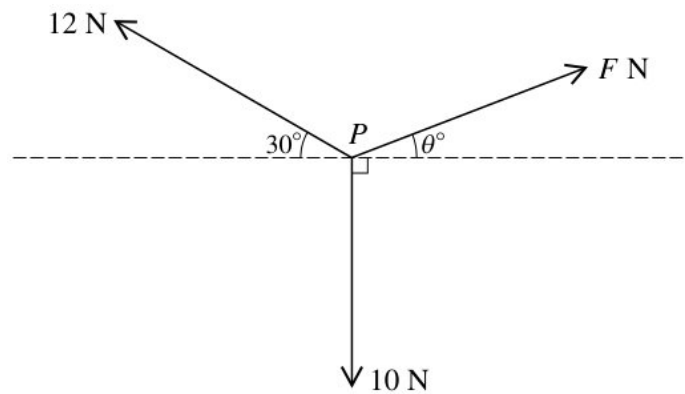
$$x^3 + px^2 + qx + r = 0$$

.....  
 .....  
 .....  
 .....

[6]

- 13 smooth spheres  $P$  and  $Q$ , of equal radius, have masses  $m$  and  $3m$  respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere  $P$  has speed  $u$  and collides directly with sphere  $Q$  which has speed  $ku$ , where  $0 < k < 1$ . Sphere  $P$  is brought to rest by the collision. Show that the coefficient of restitution between  $P$  and  $Q$  is  $\frac{3k+1}{3(1-k)}$ .

(b) (iii)



Find the equations of the asymptotes of  $C$ .

.....  
 .....  
 .....  
 .....

[8]

the period of small oscillations,

- (i) the exact solutions of the equation  $f(x) = 1$ .

cells are connected to a load resistor of resistance  $3.0\Omega$ . The electromotive force (e.m.f). and the internal resistance of each of the cells is shown.

the median and the interquartile range of the times of the runners from the Gulls.

.....  
 .....  
 .....  
 .....

[8]

- (c) decides to choose 35 students at random. If 3 or fewer of these students are left-handed, Amir will reject his belief.

the equation of the plane  $ABC$ , giving your answer in the form  $ax + by + cz = d$ .

.....  
 .....  
 .....  
 .....

[3]

- (a) (i) the gradients of the tangents to the curve when  $x = 0$ .

Use the trapezium rule, with two intervals, to estimate the value of

Find the coordinates of this stationary point, giving your answers correct to 3 decimal places.

.....  
 .....  
 .....  
 .....

[6]

weight of the parachutist is 850 N .

- (ii)  $C$ , stating the coordinates of the intersections with the axes.  
the term ultimate tensile stress.

.....  
 .....  
 .....  
 .....

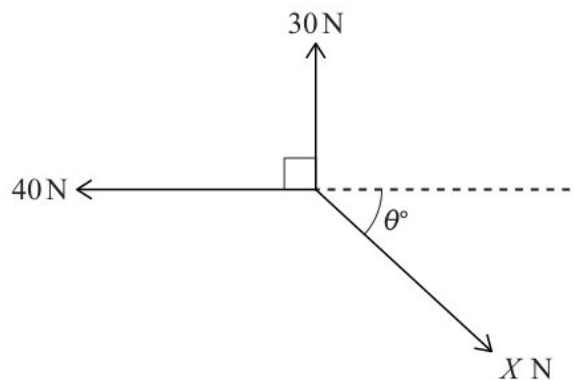
[8]

- 16 from the definitions of  $\tanh$  and  $\operatorname{sech}$  in terms of exponentials, prove that

.....  
 .....  
 .....  
 .....

[8]

- 8 Find the probability that at least 2 of a random sample of 7 letters have weights which are more than 12 g above the mean.



- (d) random variable  $Y$  is defined by  $Y = X^3$ . Find

wires  $X$  and  $Y$  are made of different metals. The Young modulus of wire  $X$  is twice that of wire  $Y$ . The diameter of wire  $X$  is half that of wire  $Y$ .

.....  
 .....  
 .....  
 .....

[4]



- (c) cell of electromotive force (e.m.f.)  $E$  and internal resistance  $r$  is connected in series with a switch  $S$  and an external resistor of resistance  $R$ .

of wavelength 567 nm is incident normally on a diffraction grating. The grating has 400 lines per mm. A number of diffraction maxima are observed on the far side of the grating.

.....  
 .....  
 .....  
 .....

[20]

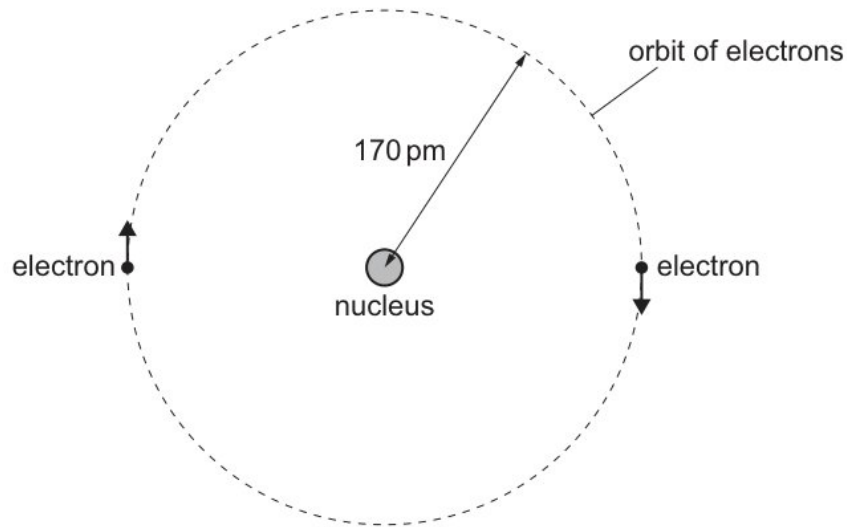
- (b) the sum to infinity of the progression.

Show that  $P(X = 3) = \frac{1}{15}$ .

.....  
 .....  
 .....  
 .....

[6]

(a)



small smooth ring  $R$ , of mass  $0.6 \text{ kg}$ , is threaded on a light inextensible string of length  $100 \text{ cm}$ . One end of the string is attached to a fixed point  $A$ . A small bead  $B$  of mass  $0.4 \text{ kg}$  is attached to the other end of the string, and is threaded on a fixed rough horizontal rod which passes through  $A$ . The system is in equilibrium with  $B$  at a distance of  $80 \text{ cm}$  from  $A$  (see diagram).

.....  
 .....  
 .....  
 .....

[10]

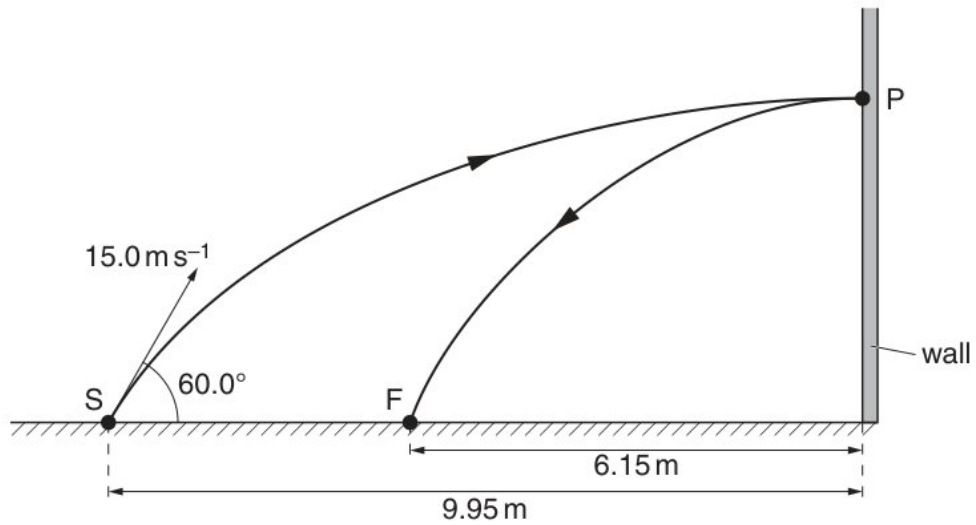
22 velocity = acceleration  $\times$  time

.....  
 .....  
 .....  
 .....

[5]

- 16 Show that  $m = 0.9$ .

sample contains a single radioactive isotope that decays to form a stable isotope.



- (c) (vi) the probability that the sum of three independent values of  $X$  is between 3 and 5 inclusive. [3]

It limits the precision of the measured value.

.....  
 .....  
 .....  
 .....

[8]

is the relationship between the amplitude of a wave and its intensity?

- (iii) Show that  $f(n+1) + f(n) = 28(3^{3n}) + 7(6^{n-1})$ .

adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

.....  
 .....  
 .....  
 .....

[3]

- (b) (i) that  $u_{2n}$  is divisible by  $u_n$  for  $n \geq 1$ .

object weighs 6.0 N on Earth.

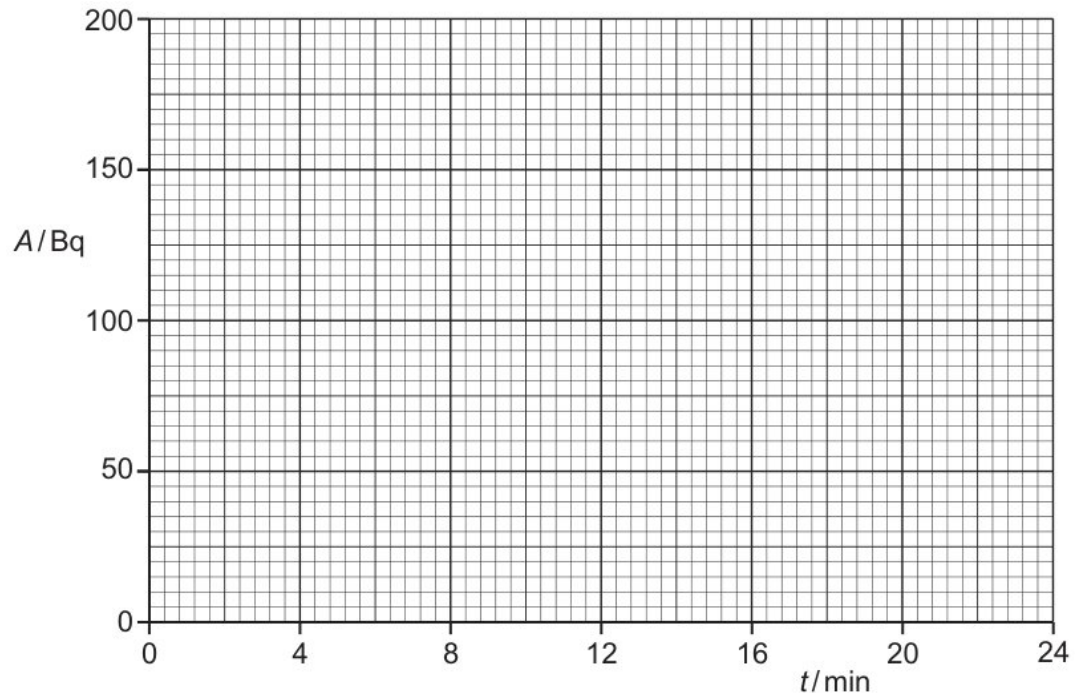
.....  
 .....  
 .....  
 .....

[8]

Find the initial speed and the angle of projection of  $B$ .

- (iii) the exact area of one loop of the curve.

molecule of mass  $m$  travelling horizontally with velocity  $u$  hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.



.....  
 .....  
 .....  
 .....

[2]

- (f) at the 2.5% significance level whether this evidence supports Mr Lee's assertion.  
 - coming to rest instantaneously on hitting the ground.

.....  
 .....  
 .....  
 .....

[20]

- 11 (c) Find the values of  $a$  and  $b$ .

Derive an expression for  $v$  in terms of  $B$  and the electric field strength  $E$ .

Find the probability that exactly two of the selected balls have the same number.

.....  
 .....  
 .....  
 .....

[5]

- (a) a cartesian equation of the plane  $\Pi$  containing  $l_1$  and  $l_2$ .

- (iii) Use implicit differentiation to show that

$\sum_{r=1}^n (4r - 3)(4r + 1)$ , giving your answer in its simplest form.

is the approximate range of wavelengths in free space for infrared radiation?

.....  
 .....  
 .....  
 .....

[8]

time taken by  $P$  to travel directly from  $L$  to  $M$  is 2 s .

- (vi) Its speed decreases to a value greater than zero, then increases to a value greater than  $20 \text{ ms}^{-1}$ .

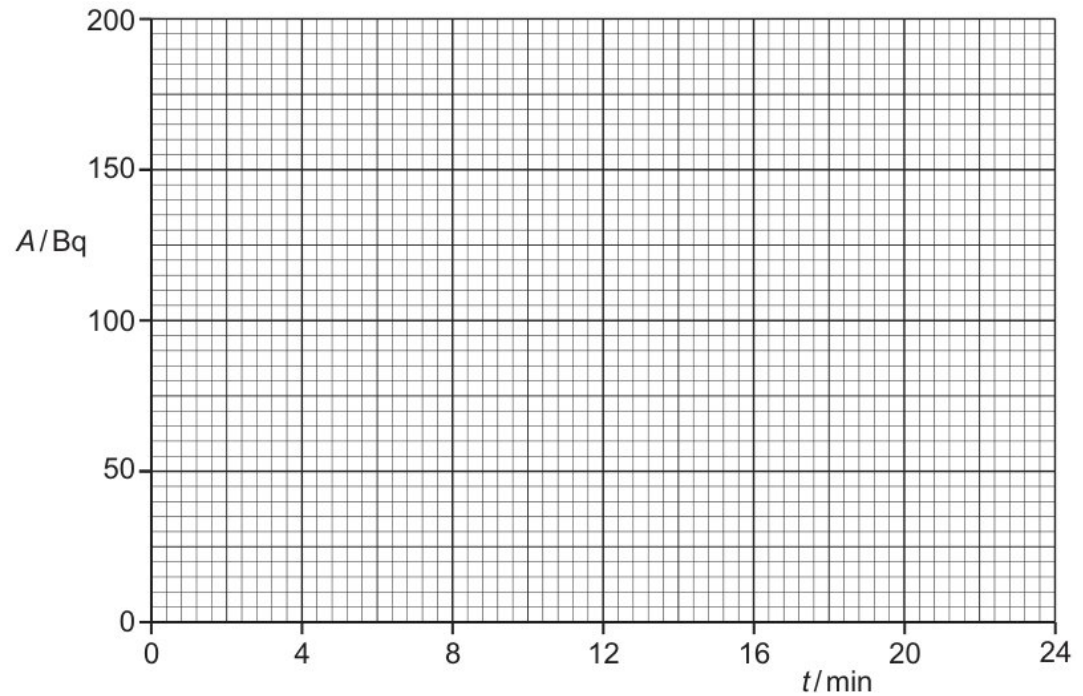
discrete random variable  $X$  has the following probability distribution.

.....  
 .....  
 .....  
 .....

[8]

cube has volume  $V$  and is made of a material with resistivity  $\rho$ . The connections to the cube have negligible resistance.

- (iv) For the case where  $\theta = 15$  and the plane on which  $B$  rests is smooth, find the acceleration of  $B$ .



Find the rank of  $\mathbf{M}$ .

.....  
 .....  
 .....  
 .....

[10]

- (e) the subsequent motion find, in terms of  $r$ , the greatest height above  $O$  reached by the particle.

Find  $\Sigma x^2$ .

- (i) the values of  $t$  such that the shortest distance between the lines  $AB$  and  $CD$  is  $\sqrt{2}$ .

Show that there is no point on  $C$  for which  $\frac{1}{3} < y < 3$ .

$$\mathbf{Ax} = p \begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q \begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix}$$

.....  
 .....  
 .....  
 .....

[8]



tension in the string of the pendulum is  $T$ . The weight of the pendulum bob is  $W$ . The string is held at an angle of  $30^\circ$  to the vertical.

(iii) diagram shows four forces applied to a circular object.

farmer is investigating whether using a new fertiliser will increase the yield of tomato plants. The farmer selects 40 tomato plants at random and gives them the new fertiliser. The crop mass,  $x$  kg, of each of these 40 plants is recorded. The farmer selects a further 60 tomato plants at random and gives them a standard fertiliser. The crop mass,  $y$  kg, of each of these 60 plants is recorded. The results are summarised as follows.

.....  
 .....  
 .....  
 .....

[5]

6 why, for a substance, the specific latent heat of vaporisation is usually greater than the specific latent heat of fusion.

.....  
 .....  
 .....  
 .....

[15]

15 It consists of two quarks that do not need to be the same flavour.

.....  
 .....  
 .....  
 .....

[10]

11 Find the rank of  $\mathbf{A}$  and show that  $\left\{ \begin{pmatrix} 2 \\ 2 \\ -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 3 \\ 0 \\ 1 \end{pmatrix} \right\}$  is a basis for the null space of the transformation.

- (e) as shown in Fig. 2.1.

.....

.....

.....

.....

[8]

- (d) (i) The weight of the plank is causing a clockwise moment.  
Find the tension in the string.

.....

.....

.....

.....

[8]

has 10 different books from the series Squares and Circles. The books look similar except for their colour. There are 3 blue books, 2 red books, 2 yellow books, 1 orange book, 1 purple book and 1 green book.

- (iii) the differential equation to obtain an expression for  $y^2$  in terms of  $x$ .

labels on the graphs are intended to show the wavelength  $\lambda$ , the period  $T$  and the amplitude  $a$  of the wave, but only one graph is correctly labelled.

Find the weight exceeded by the heaviest 5% of pineapples.

.....

.....

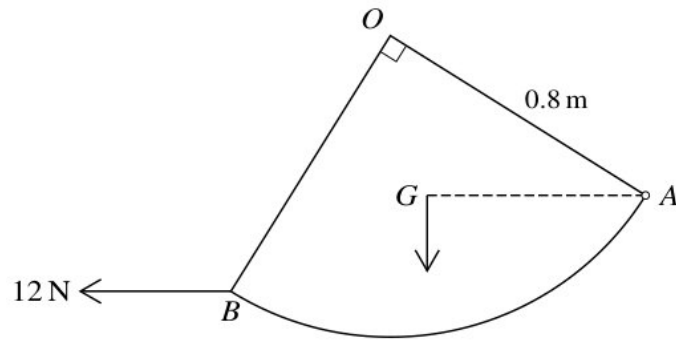
.....

.....

[3]

the area of the region bounded by  $C$  and the initial line, giving your answer in the form  $(p\pi^2 + q\pi + r)e^{\frac{1}{2}\pi} + s$ , where  $p, q, r$  and  $s$  are integers to be determined.

(v)



Find the tension in the string.

.....

.....

.....

.....

[10]

- 22  $\frac{1}{(2r+1)(2r+3)}$  in partial fractions and hence use the method of differences to find a value, to three significant figures, for the specific latent heat of fusion of water.

Find the coordinates of the turning points of  $C$ .

Find the rank of  $\mathbf{A}$  and a basis for the null space of  $\mathbf{T}$ .

- (c) In a nuclear reaction, proton number and neutron number are conserved. Other than proton number and neutron number, state a quantity that is conserved in a nuclear reaction.

.....

.....

.....

.....

[4]

- (a) (iv) frame consists of a horizontal rod  $XY$  and a rod  $YZ$  that is at an angle of  $30^\circ$  to the horizontal. Rod  $XY$  is attached to the wall by a hinge at  $X$  and has length  $0.50\text{ m}$ . Assume that the weights of the rods are negligible.

graph shows how the acceleration of an object moving in a straight line varies with time.

projectile is thrown at an angle to the ground.

.....  
 .....  
 .....  
 .....

centre = .....  $ht$  [3]

that  $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$  is an eigenvector of the matrix  $\mathbf{D}$ , where

(iii) Find the matrix product  $\mathbf{A} \begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$  and hence find the general solution of the

$$\text{equation } \mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}.$$

if there are no restrictions,

the number of different 3-digit numbers greater than 300 that can be made from the digits 1, 2, 3, 4, 6, 8 if

.....  
 .....  
 .....  
 .....

[8]

circuit symbol does not represent an electric component that is designed to emit sound waves?

copper wire of cross-sectional area  $2.0 \text{ mm}^2$  carries a current of  $10 \text{ A}$  .

(vi) density of the water is  $\rho$ . The water does not rebound from the wall.

variables  $x$  and  $y$  satisfy the differential equation

.....  
 .....  
 .....  
 .....

[8]

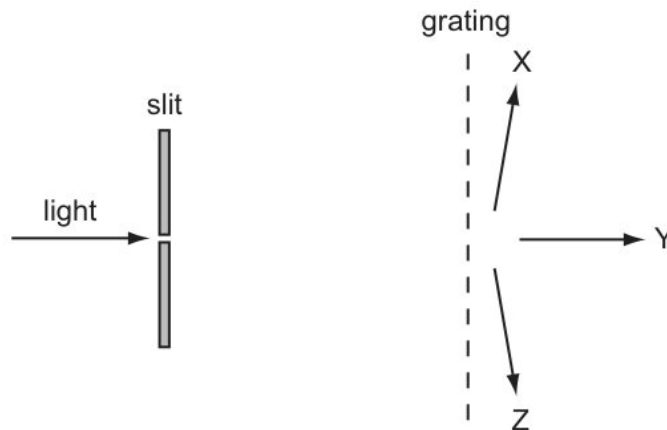
13 (c) uniform rod of length  $1.5 \text{ m}$  and weight  $2.4 \text{ N}$  is shown in Fig. 2.1.

(iii) a similar method to find, in terms of  $n$ , a lower bound for  $\sum_{r=1}^n \frac{1}{\sqrt{r}} e^{\sqrt{r}}$ .

.....  
 .....  
 .....  
 .....

[1]

the equations of the asymptotes of  $C$ .



(iv) many images of the slit does he see?

.....  
 .....  
 .....  
 .....

[1]

- (e) that, at the point of  $C$  furthest from the initial line,

Show that the length of the arc of  $C$  from the pole to the point furthest from the pole is given by

the number of different ways in which the 6 musicians can be selected if there must be at least 3 guitarists, at most 2 pianists and exactly 1 drummer.

- (iii) a positron and an antineutrino

.....  
 .....  
 .....  
 .....

[8]

The acceleration of the particle between  $t = 6$  and  $t = 10$  is  $7.5 \text{ m s}^{-2}$ . When  $t = 10$  the velocity of the particle is  $V \text{ m s}^{-1}$ . Find the value of  $V$ .

- (ii) Show that the equation

.....  
 .....  
 .....  
 .....

[4]

- (b) is given that  $\sum x = 175.0$  and that the mean of  $y$  is 8.4 .

- (ii) will the powers to the resistors change when resistor W is removed?

.....  
 .....  
 .....  
 .....

[12]

the probability density function of  $Y$ ,

- (i) with a reason, whether  $f$  has an inverse.

Use your answer in (c)(i) to determine the half-life, in min, of the radioactive isotope.

.....  
 .....  
 .....  
 .....

[2]

variable  $Y$  is related to  $X$  by  $Y = 2^X$ .

- (iii) Find the area of the region enclosed by  $C$ .

.....  
 .....  
 .....  
 .....

[5]

a large college, all students who study Science also study exactly one of Art or Drama or Music. 20% of these students study Art, 45% study Drama and 35% study Music.

- (iv) that, at the point  $(4, \frac{1}{3})$  on  $C$ ,  $\frac{dy}{dx} = -\frac{1}{2}$ .

.....  
 .....  
 .....  
 .....

[2]

- 19 P and Q collide and stick together.

.....  
 .....  
 .....  
 .....

[8]