

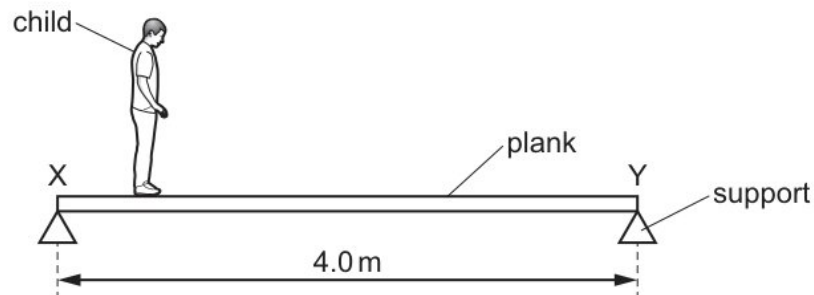
the exact value of  $\int_{\frac{1}{5}\pi}^{\frac{1}{4}\pi} 3 \cos^2 5x \, dx$

9 row of the table gives an angle  $\theta$  of  $90^\circ$  ?

direction. = .....  $tx$  [8]

13 metal electrical conductor has a resistance of  $5.6\text{k}\Omega$ . A potential difference (p.d.) of  $9.0\text{ V}$  is applied across its ends.

(c)



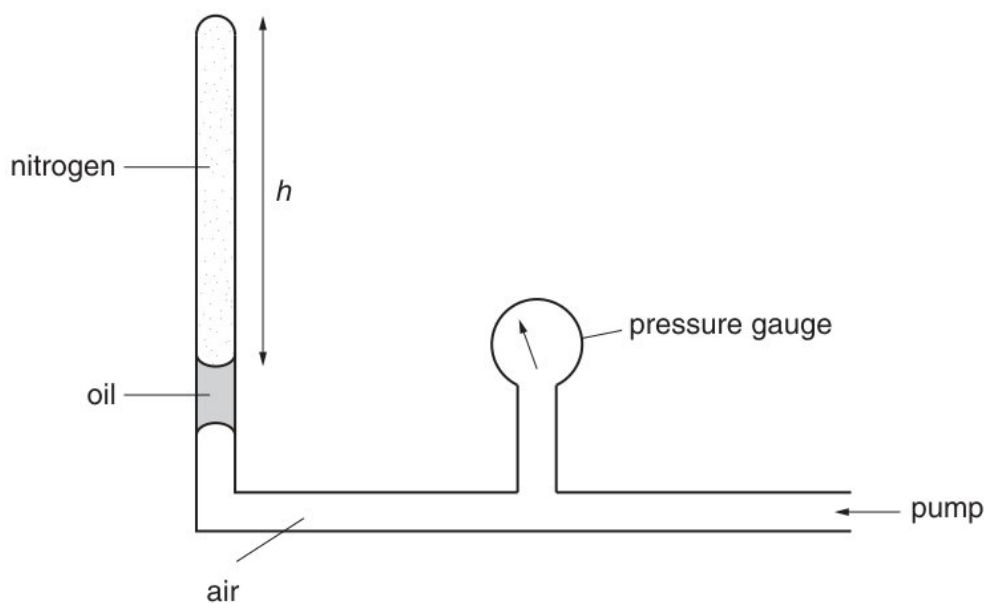
Find the value of  $a$  and show that  $b = -7$ .

[4]

(b) year, an online store sold a large number of computers. 55% of the computers were made by company  $F$ , 30% were made by company  $G$  and 15% were made by company  $H$ .

[8]

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



- (c) (ii) the speed of the body is increased to  $40 \text{ ms}^{-1}$ , what is its new kinetic energy?

$$x_{n+1} = \frac{1}{2} (\pi - \tan^{-1}(4x_n))$$

[20]

- (i) curve  $C$  has equation

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

[6]

- (iii) the rank of  $\mathbf{M}$  and a basis for the range space of  $T$ ,

lifetime, in hours, of a 'Trulite' light bulb is a random variable  $T$ . The probability density function  $f$  of  $T$  is given by

[8]

- (f) (i) Q always hears a sound of higher frequency than person P .

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

an estimate for the mean length of these 250 leaves.

[6]

- (iii) sample of 216 observations of the continuous random variable  $X$  was obtained and the results are summarised in the following table.

many electrons pass through a given cross-section of the wire in one second?

an assumption necessary for the test in part (a) to be valid.

[10]

- (iv) 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.

following table shows most of the corresponding expected frequencies, correct to 2 decimal places, using a Poisson distribution with mean 3.25.

[10]

- (d) (iii) the probability density function of  $Y$ ,

curve  $C$  has equation  $y = x^{\frac{3}{2}}$ . Find the coordinates of the centroid of the region bounded by  $C$ , the lines  $x = 1, x = 4$  and the  $x$ -axis.

curve  $C$  has equation  $y = \frac{1}{2}(e^x + e^{-x})$  for  $0 \leq x \leq 4$ .

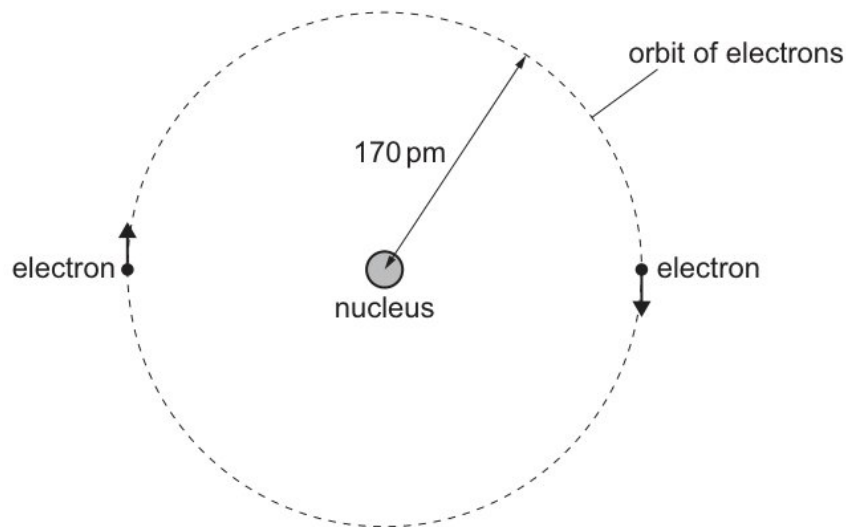
[3]

- (i) On Fig. 3.2, sketch the variation with  $x$  of  $F$  for a brittle material up to its breaking point.

out a Wilcoxon rank-sum test at the 5% significance level to test the researcher's claim.

$$\text{rests} = \dots kf \quad [2]$$

(b)



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.

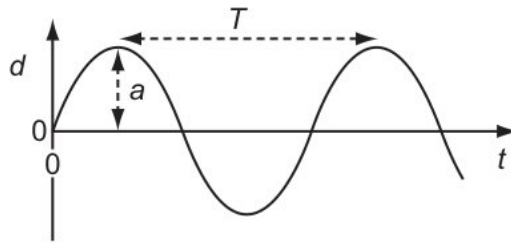
adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

diagram shows a sketch of the curve  $y = \frac{3}{\sqrt{(9-x^3)}}$  for values of  $x$  from -1.2 to 1.2 .

$$\text{modulus} = \dots \quad hb \quad [3]$$

an electron and a neutrino

16 that  $y = 0$  when  $x = 3$  Give your answer in an exact form



[6]

the geometric effects of multiplying  $z_1$  and  $z_2$  by  $\omega$

- 12 one similarity and one difference between an electron and positron.

load on the lower end is increased from zero and then decreased again back to zero.

$$\Sigma b = 92.0 \quad \Sigma b^2 = 216.5 \quad \Sigma g = 129.8 \quad \Sigma g^2 = 288.8$$

The total momentum of each object in the system is the product of its mass and velocity.

[10]

- 15 Find the cartesian equation of  $\Pi_2$ .

6.1 shows a circuit that rectifies an alternating input voltage  $V_{\text{IN}}$  and produces an output voltage  $V_{\text{OUT}}$  across a resistor  $R$ .

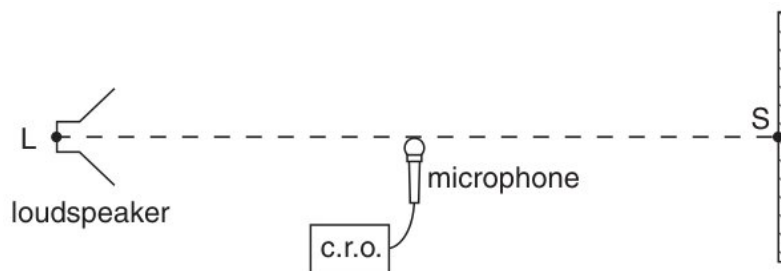
the team contains more boys than girls.

- (a) (i) curve  $C$  has polar equation  $r = 2a \cos(2\theta + \frac{1}{2}\pi)$  for  $0 \leq \theta < 2\pi$ , where  $a$  is a positive constant.

the SI base units of resistivity.

[4]

- (vi) an electron and a neutrino



the solution of the differential equation

[5]

- (ii) It consists of two quarks that must both be the same flavour.

athletics coach believes that, on average, the time taken by an athlete to run 200 metres decreases between the beginning and the end of the year by more than 0.2 seconds.

[15]

- (f) (v) random variable,  $X$ , has the distribution  $\text{Po}(31)$ . Use the normal approximation to the Poisson distribution to find  $P(X > 40)$ .

the moment of a force about a point.

taken = ....  $mp$  [8]

- (ii) the significance level of the test.

the median value of  $X$ .

[8]

- (d) (iii) the equation representing this decay.

is given that  $z_1 = 3e^{\frac{1}{4}\pi i}$ ,  $z_2 = \frac{3}{2}e^{\frac{1}{6}\pi i}$  and  $\omega = 2e^{\frac{1}{2}\pi i}$

number = .....  $zl$  [10]

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

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

[4]

- (i) 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.

the period of small oscillations,

[6]

- (c) the acute angle between the planes  $ABC$  and  $ABD$ .

[10]

a vector equation for the line  $l_1$ .

- 14 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.

[6]

- 18 (d) Under 25 178 181 183 192 203 209 223 231

moving = ..... cm [2]

- (h) The extension of the wire is proportional to the tensile force.

[5]



light elastic string of natural length 1.2 m and modulus of elasticity 24 N is attached to fixed points  $A$  and  $B$  on a smooth horizontal surface, where  $AB = 1.2$  m. A particle  $P$  is attached to the mid-point of the string.  $P$  is projected with speed  $0.5 \text{ m s}^{-1}$  along the surface in a direction perpendicular to  $AB$  (see diagram).  $P$  comes to instantaneous rest at a distance 0.25 m from  $AB$ .

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

[15]

$\mathbf{A} = \begin{pmatrix} 2 & 3 \\ 0 & 1 \end{pmatrix}$ . Prove by mathematical induction that, for every positive integer  $n$ ,

- 17 wave pattern produced in (b) is shown in Fig. 7.1.

that times. = .....  $uf$  [5]

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

- 10 body of mass  $m$  moves vertically through a distance  $h$  near the Earth's surface. Use the defining equation for work done to derive an expression for the gravitational potential energy change of the body.

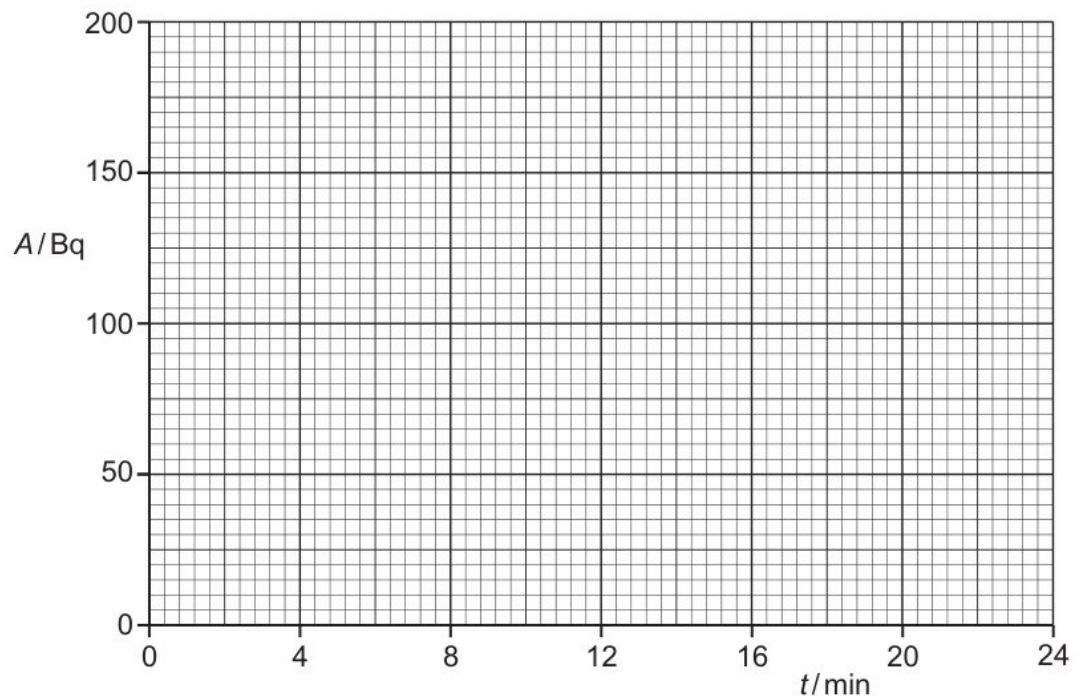
that = .....  $cy$  [5]

- 21 diagram shows the curve  $y = \cos x \sqrt{\sin 2x}$  for  $0 \leq x \leq \frac{1}{2}\pi$ . The curve has a maximum point at  $M$ , where  $x = a$ .

the probability that more than 7 study Art or Music.

an assumption necessary for the test in part (a) to be valid.

(c) (ii)



Potential difference is energy per unit current.

sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a

[2]

(vi) the value of  $(\alpha^3 - 1)^3 + (\beta^3 - 1)^3 + (\gamma^3 - 1)^3$ .

$$x_{n+1} = \frac{1}{2}(\pi - \tan^{-1}(4x_n))$$

[6]

(d) 1 Which quantity is a scalar quantity?

Explain = ..... my [12]

(e) object consists of a uniform lamina with a particle attached. The uniform lamina  $ABCEFD$  of mass  $m$  is formed from a rectangle  $ABCD$  and an isosceles triangle  $CEF$ , where  $F$  is the midpoint of  $CD$ . The rectangle has sides  $AB = 2a$  and  $AD = a$ . The triangle  $CEF$  has base  $a$  and height  $2a$ . The particle of mass  $km$  is attached to the lamina at  $E$ . The object rests in a vertical plane with its edge  $AD$  on horizontal ground (see diagram).

[5]

$\lambda$  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.

15  $p$  and  $q$  are given real numbers, then

State the gradient of the curve at the point  $(-1, 2)$  and sketch the curve.

Find the value of  $x$  for which  $P$  reaches its maximum velocity, and calculate this maximum velocity.

[4]

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

22 the range of  $f$ ,

Use the iterative formula

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

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.

[5]

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

[3]

(d) order to test the effect of a drug, a researcher monitors the concentration,  $X$ , of a certain protein in the blood stream of patients. For patients who are not taking the drug the mean value of  $X$  is 0.185 . A random sample of 150 patients taking the drug was selected and the values of  $X$  were found. The results are summarised below.

through = .....  $hl$  [12]

(e) the type of each transformation, and make clear the order in which they are applied.  
the acute angle between the directions of  $l_1$  and  $l_2$ .

(v) 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.

[2]

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

[2]

- (i) 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.
- on the graph would the elastic limit be found?

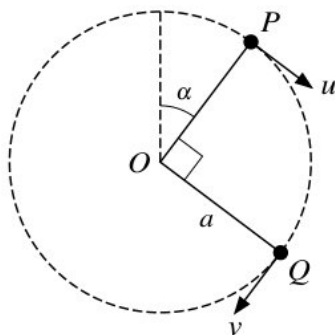
[8]

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  $\frac{15}{2}\sqrt{2} \text{ m}$ .

23 not have a unique solution.

[10]

17 the acute angle between the directions of  $l_1$  and  $l_2$ .



(d) (ii) diagram shows the curve  $y = x^2 e^{-x}$ .

$$\tan 4\theta = \frac{4 \tan \theta - 4 \tan^3 \theta}{1 - 6 \tan^2 \theta + \tan^4 \theta}$$

with = .....  $md$  [4]

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

	$\alpha$ -particle	$\beta$ -particle	$\gamma$ -radiation
charge			0
mass	$4u$		
speed		up to $0.99c$	

[6]

(f) the range of  $f$ ,

[8]

the team contains more boys than girls.

The weight of the plank is causing a clockwise moment.

21 resistivity of copper is  $1.8 \times 10^{-8} \Omega \text{ m}$ .

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

Verify that  $\frac{2r+1}{r(r+1)(r+2)} = \frac{1}{2} \left\{ \frac{(2r+1)(2r+3)}{(r+1)(r+2)} - \frac{(2r-1)(2r+1)}{r(r+1)} \right\}$ .

$\mathbf{a} \times \mathbf{b}$  and deduce the area of the triangle  $OAB$ .

[4]

a cubic equation whose roots are  $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$ .

the data to carry out a goodness of fit test at the 5% significance level to test the scientist's claim.

- 11 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.

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

[5]

- 15  $\frac{\beta}{k}, \beta, k\beta$ , where  $p, q, r, k$  and  $\beta$  are non-zero real constants. Show that  $\beta = -\frac{q}{p}$ .

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.

Calculate the speed of the star relative to the Earth.

$$9y^2 - 3\sinh^{-1}(xy) = 1 - 3\ln 3.$$

$B$  now strikes a wall that is perpendicular to its path, rebounds and collides with  $A$  again. The coefficient of restitution between  $B$  and the wall is  $e$ . Given that the second collision between  $A$  and  $B$  brings  $A$  to rest, find  $e$ .

- (d) (v) velocity = acceleration  $\times$  time

that  $\mathbf{e}$  is an eigenvector of  $\mathbf{A}^3$  with corresponding eigenvalue  $\lambda^3$ .

[20]

- (iii) 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  $0 < \theta < 2\pi$

random variable  $X$  is the number of heads obtained.

[4]

- (a) Find the area of the sector of  $C$  between  $\theta = 0$  and  $\theta = \frac{1}{3}\pi$ .

onto = ..... ko [5]



student determines the ratio  $\frac{\text{upthrust acting on the object}}{\text{weight of the object}}$ .

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

[8]

26 be written as a quadratic equation in  $x$ .

(iv) The battery supplies 9.0 J to an external circuit for each coulomb of charge.

$$\mathbf{a} = 3\mathbf{i} + 2\mathbf{j} - \mathbf{k}, \quad \mathbf{b} = 4\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}, \quad \mathbf{c} = 3\mathbf{i} - \mathbf{j} - \mathbf{k}$$

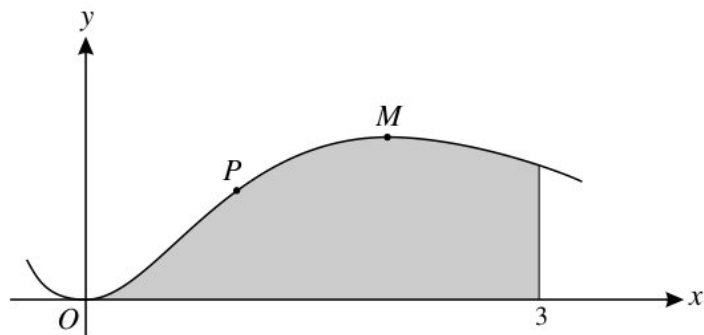
[6]

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

statement about nuclei is correct?

[8]

(a)



and explain whether the output power of the car is greater than less than or the same as the output power just before  $t = 5.8$  s

[5]

- (e) the probability of a Type II error.  
find corresponding eigenvectors.

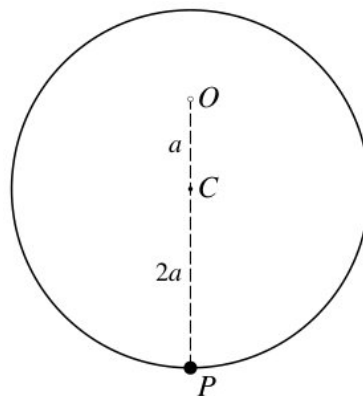
sample, that = .....  $kj$  [10]

Find the acceleration of the particle during the first 5 seconds of motion.

- 32 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.

Find the angle that the force acting on the rod at  $A$  makes with the horizontal.

de Moivre's theorem to prove that



[10]

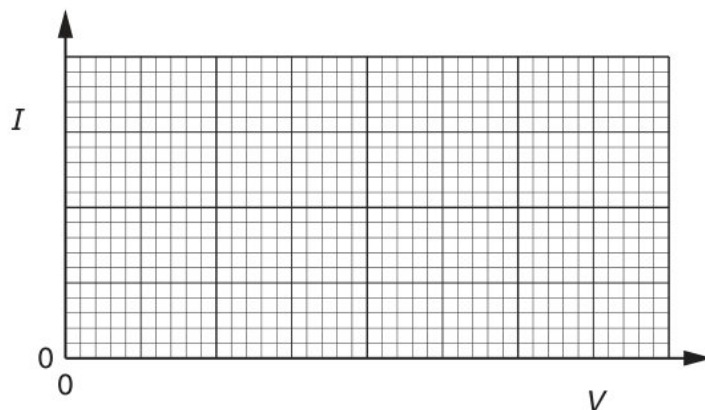
Show that  $\text{ff}(x) = x$ .

- 20 is the total displacement of the ball from its original position after 1.5s ?

[3]

sequence  $u_1, u_2, u_3, \dots$  is such that  $u_1 = 5$  and  $u_{n+1} = 6u_n + 5$  for  $n \geq 1$ .

15 diagram shows the electric field between the plates?



[5]

$$\frac{\text{mass} \times (\text{time})^2}{\text{length}}$$

18 that  $T = \frac{U}{2g}(\sqrt{2} + \sqrt{6})$ .

curves  $C_1$  and  $C_2$  have polar equations

plans hypothesis, = .....  $tq$  [12]

The weight of the plank is causing an anticlockwise moment.

16 measuring instrument should be used?

[5]

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

20 isotopes of the element uranium are  ${}_{92}^{235}\text{U}$  and  ${}_{92}^{238}\text{U}$ .

How many possible arrangements are there of seating Mary, Ahmad, Wayne, Elsie and John assuming there are no restrictions?

Find = .....  $ae$  [2]

what is meant by centre of gravity.

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

[6]

Find the product moment correlation coefficient for the data.

	M	N
A	microwaves	visible light
B	microwaves	$\gamma$ -rays
C	$\gamma$ -rays	microwaves
D	visible light	microwaves

9 a positron and a neutrino

[6]

results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

12 box contains 6 identical-sized discs, of which 4 are blue and 2 are red. Discs are taken at random from the box in turn and not replaced. Let  $X$  be the number of discs taken, up to and including the first blue one.

[15]

is given that  $2 \ln p + \ln(p-1) - \frac{1}{2} \ln(q+1) = 3$ .

10 Over 50 198 212 217 229 235 242

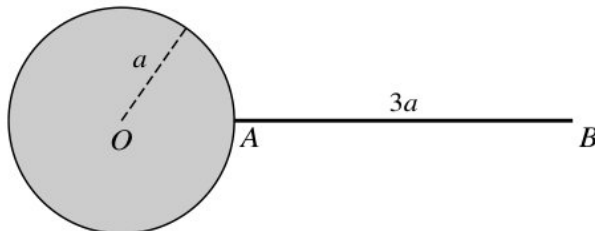
$$\mathbf{A} = \begin{pmatrix} \frac{3}{2} & 3 & 8 \\ 0 & 3 & 4 \\ 0 & 0 & -1 \end{pmatrix}.$$

[8]

Show that the substitution  $u = 1 + \sin \theta$  reduces this integral for  $s$  to  $(\sqrt{2})a \int_0^2 \frac{1}{\sqrt{(2-u)}} du$ . Hence evaluate  $s$ .

Calculate the greatest deceleration of  $P$ .

6



an estimate for the mean length of these 250 leaves.

is the reading on the ammeter?

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.

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

$$\text{surface} = \dots\dots\dots \text{ig} \quad [5]$$

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

13 student investigates the cooling of a liquid in a beaker.

$$\text{equation where found.} = \dots\dots\dots \text{mz} \quad [10]$$

diagram shows the curve  $y = x - 2 \ln x$  and its minimum point  $M$ .

- 13 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.

[12]

- 21 pendulum bob is held stationary by a horizontal force  $H$ . The three forces acting on the bob are shown in the diagram.

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

small smooth ring  $R$ , of mass 0.6 kg, is threaded on a light inextensible string of length 100 cm. One end of the string is attached to a fixed point  $A$ . A small bead  $B$  of mass 0.4 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 cm from  $A$  (see diagram).

Earth's = .....  $ju$  [4]

- (iii) if the 4 vowels A, E, E, I must all be together.

curve  $C$  has polar equation  $r = \theta e^{\frac{1}{8}\theta}$ , for  $0 \leq \theta \leq 2\pi$ .

Interval	$0 \leq x < 1$	$1 \leq x < 2$	$2 \leq x < 3$	$3 \leq x < 4$	$4 \leq x < 5$	$5 \leq x < 6$
Expected frequency	1	7	$a$	$b$	$c$	91

junction = .....  $xk$  [10]

- (v) internal diameter of the beaker is  $0.05 \text{ m} \pm 3\%$ .

standard results from the list of formulae (MF19) to show that

hotel. Roberto's = .....  $pv$  [5]

- (b) (i)  $C$  in the case  $p = -1$ . Your sketch should indicate the coordinates of any intersections with the axes, but need not show the coordinates of any turning points.

On Fig. 3.2, sketch the variation with  $x$  of  $F$  for a brittle material up to its breaking point.

[10]

- (iii) marks of the pupils in a Physics examination are summarised as follows.

$$\Sigma x = 18.7 \quad \Sigma x^2 = 106.43 \quad \Sigma y = 34.7 \quad \Sigma y^2 = 133.43 \quad \Sigma xy = 92.01$$

[4]

- (d) is the mass of the car?

[12]

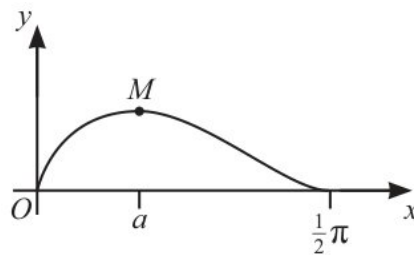
- 22 Use a different object that has half the volume and the same density as the original object.

Hence show that the differential equation

speeds of the particles.

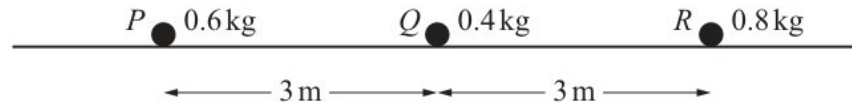
matrix  $\mathbf{A}$  is given by

- (c) load on the lower end is increased from zero and then decreased again back to zero.



[12]

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



[8]

- (i) time taken by  $P$  to travel directly from  $L$  to  $M$  is 2 s .  
the differential equation to obtain an expression for  $y^2$  in terms of  $x$ .

distributed 59.1 = ..... *og* [6]

- (d) (iii) curve  $C$  has equation  $y = \frac{2x^2-5x}{2x^2-7x-4}$

that the forces are in equilibrium, find the values of  $\theta$  and  $X$ .

a matrix  $\mathbf{P}$  and a diagonal matrix  $\mathbf{D}$  such that  $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$ .

[15]

- (v) the value of  $\sum_{r=1}^{\infty} \frac{1}{(2-3r)(5-3r)}$ .

Find the value of  $\frac{d^2y}{dx^2}$  at  $A$ .

[10]

1.1 shows a thin coil of cross-sectional area  $A$  and length  $l$  connected to a resistor of resistance  $S$  and two terminals.

19 row best specifies the correct  $I - V$  graphs for the lamp and the diode?

weight = ..... *fo* [6]



the solution of the differential equation

8 Show that the cartesian equation of  $C$  is

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

nucleus  $X$  has 14 nucleons and  $p$  protons. The ratio of charge to mass for nucleus  $X$  is  $4.1 \times 10^7 \text{ C kg}^{-1}$ .



[4]

19 the value of  $c$  such that  $P(-c < t < c) = \frac{1}{2}$ .

(b) (i) is suggested that the e.m.f.  $V$  is related to the number  $n$  of glass sheets by the equation

$\lambda$  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.

[3]

(ii) the exact volume of the solid generated

set of friends consists of 7 men and 4 women. Three of the men are brothers: Ali, Ben and Charlie.

[2]

(iii) Find the values of  $p$  and  $q$ .

only one of the following two alternatives.

[20]

(vi)  $V$  decreases because there is a p.d. across  $r$ .

that  $a = \exp\left(\frac{1}{6}\left(\frac{5}{a^2} + 3\right)\right)$  where  $\exp(x)$  denotes  $e^x$

[3]

(a) does this mean?

[8]

that the object is on the point of toppling in its vertical plane about the vertex  $D$ , find the value of  $k$ .

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

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

a crossword competition the times,  $x$  minutes, taken by a random sample of 6 entrants to complete a crossword are summarised as follows.

is the density of the mixture with volume  $2.0 \text{ m}^3$  ?

[4]

the principle of superposition.

19 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.

car. stop = .....  $qy$  [5]

diagram shows part of the curve

- 10 Show that the cartesian equation of  $C$  is  
Find the period of the motion.

metres = .....  $sb$  [20]

- 20 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  $O$ .

- (c) (i) Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

diagram shows the curve  $y = x^2e^{-x}$ .

[4]

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

Q always hears a sound of higher frequency than person P .

an experiment to demonstrate two-source interference of light, a beam of light is split into two beams using two slits 0.50 mm apart. These two beams are incident on a laboratory wall at a distance of 4.0 m .

[8]

- (a) and explain whether the output power of the car is greater than less than or the same as the output power just before  $t = 5.8$  s

classified under = .....  $qy$  [6]

student wishes to investigate projectile motion.

- 11 by induction that  $u_n = 6^n - 1$  for all positive integers  $n$ .

horizontal. = .....  $rr$  [8]

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

- 12 diagram shows a car travelling at a constant speed in a straight line between person P and person Q from point X to point Y .

Prove the identity  $\frac{\cos \theta}{\tan \theta(1 - \sin \theta)} \equiv 1 + \frac{1}{\sin \theta}$ .

[10]

Explain why the observed wavelength and the emitted wavelength have different values.

- 7 particle  $P$  of mass  $m$  is attached to one end of a light elastic string of natural length  $a$  and modulus of elasticity  $mg$ . The other end of the string is attached to a fixed point  $O$  on a rough plane inclined at an angle of  $30^\circ$  to the horizontal. The particle  $P$  is held at rest at point  $O$  before being released. The frictional force acting on  $P$  as it slides down the plane is  $\frac{11}{30}mg$ .

For this value of  $k$ , find the set of possible solutions, giving your answer in the form

$$\text{each} = \dots\dots dh \quad [6]$$

- 13 Express  $u$  in the form  $x + iy$ , where  $x$  and  $y$  are real.

(c) (iv) parametric equations of a curve are

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.

Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

[10]

- (ii) the exact value of  $\operatorname{cosec}^2 15^\circ - \sec^2 15^\circ$ .

The total momentum is conserved only in elastic collisions.

[4]

- (b)  $B$  contains 5 red marbles and 3 blue marbles.

[3]

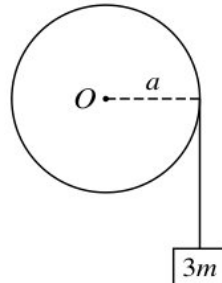
- (d) are no resistive forces acting on the block.

[20]

- 29 pendulum bob is held stationary by a horizontal force  $H$ . The three forces acting on the bob are shown in the diagram.

The region  $R$  is bounded by  $C$ , the  $x$ -axis, the  $y$ -axis and the line  $x = 4$ . Find, in terms of  $e$ , the coordinates of the centroid of the region  $R$ .

- (c) (iv) Amplitude is inversely proportional to velocity.



[4]

- (v) the inequality  $|x + 2| > \left|\frac{1}{2}x - 2\right|$ .

of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of  $4.91 \times 10^{-7}$  m.

this compression, work  $W$  is done on the gas.

[6]

- (ii) independent variables  $X$  and  $Y$  have distributions with the same variance  $\sigma^2$ . Random samples of  $N$  observations of  $X$  and  $2N$  observations of  $Y$  are taken, and the results are summarised by

independent variables  $X$  and  $Y$  have distributions with the same variance  $\sigma^2$ . Random samples of  $N$  observations of  $X$  and  $2N$  observations of  $Y$  are taken, and the results are summarised by

is the force on an electron when it is in the uniform electric field between the plates?

[5]

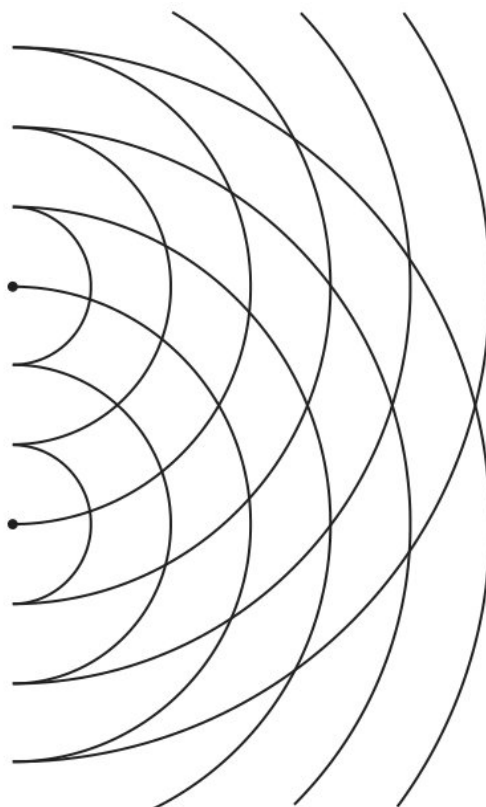
- (e) car of mass  $1400\text{ kg}$  is travelling on a straight, horizontal road at a constant speed of  $25\text{ m s}^{-1}$ . The output power from the car's engine is  $30\text{ kW}$ .

much charge passes a given point in wire  $R$  in a time of  $5\text{ s}$ ?

Draw a fully labelled tree diagram to illustrate this situation.

[4]

- (f) Find angle  $ABC$ .



student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).  
only one of the following two alternatives.

[2]

Form two simultaneous equations and hence find  $x$  and  $v$ .

- 20 Speed is distance travelled per second.

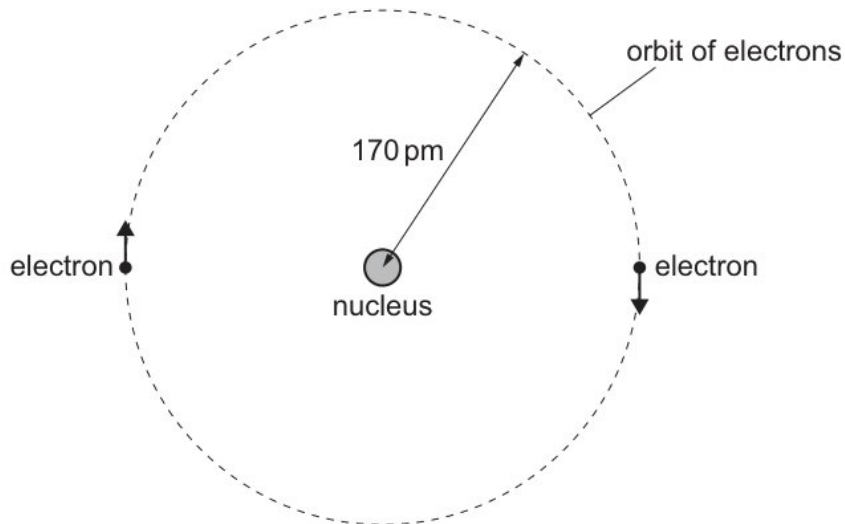
Show that  $r = -2a \sin 2\theta$  and sketch  $C$ .

particle  $P$  moves on a straight line in simple harmonic motion. The centre of the motion is  $O$ , and the amplitude of the motion is 2.5 m. The points  $L$  and  $M$  are on the line, on opposite sides of  $O$ , with  $OL = 1.5$  m. The magnitudes of the accelerations of  $P$  at  $L$  and at  $M$  are in the ratio 3 : 4.

[6]

- 12 that  $\frac{dy}{dx} = \frac{y^2 - ye^x}{xe^x + 2y}$ .

Form two simultaneous equations and hence find  $x$  and  $v$ .



- (a)  $a$  is a positive constant. Sketch  $C_1$  and  $C_2$  on the same diagram.

[6]

- (e) team of 5 is chosen from 6 boys and 4 girls. Find the number of ways the team can be chosen if

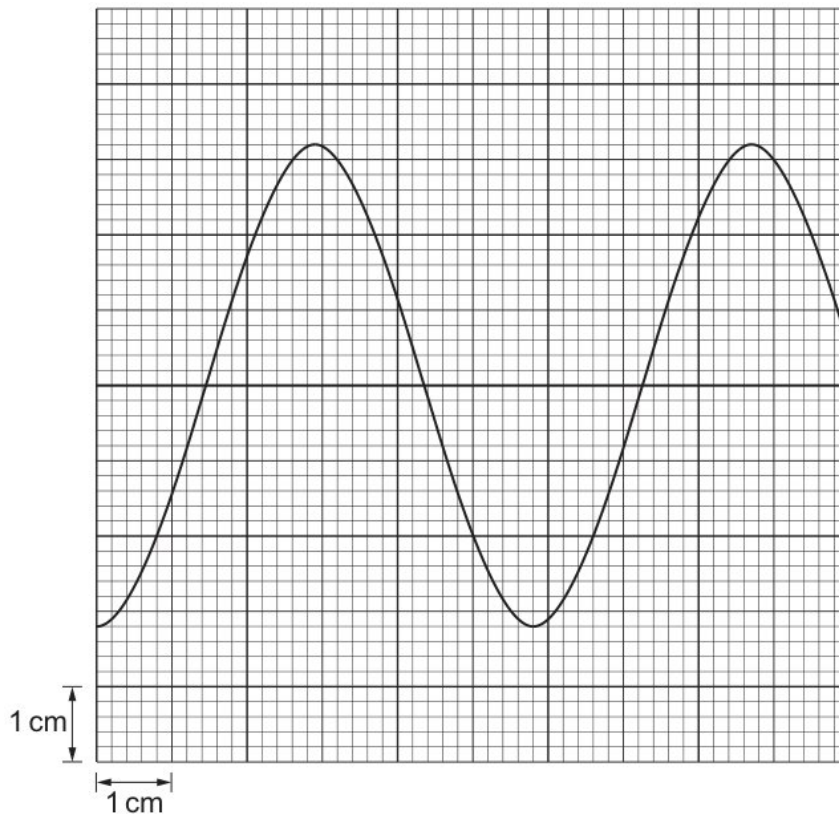
[10]



Use a different object that has half the volume and the same density as the original object.

- 13 a period of time Julian finds that on long-distance flights he flies economy class on 82% of flights. On the rest of the flights he flies first class. When he flies economy class, the probability that he gets a good night's sleep is  $x$ . When he flies first class, the probability that he gets a good night's sleep is 0.9 .

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  $AC = a$ .



[8]

- 11 lifetime, in hours, of a 'Trulite' light bulb is a random variable  $T$ . The probability density function  $f$  of  $T$  is given by

diagram shows the curve with equation  $y = \frac{1}{x^2+1}$  for  $0 \leq x \leq 1$ , together with a set of  $n$  rectangles of width  $\frac{1}{n}$ .

- (a) at the 2% significance level whether the population mean time for this year is less than 62.4 seconds.

[10]

- (e) the probability of a Type I error.

[8]

- (f) Hence obtain the expansion of  $\frac{5x-x^2}{(1+x)(2+x^2)}$  in ascending powers of  $x$ , up to and including the term in  $x^3$ .

uniform = .....  $ah$  [8]

- 9 (c) Show that the possible values of  $\alpha$  are 3 and 5 .

Find the value of  $\frac{d^2y}{dx^2}$  at  $A$ .

village = .....  $cw$  [15]

- (e) show that  $PQ = 13$ ,

[4]

- (d) Use a different object that has twice the volume and the same density as the original object.

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

[12]

- (a) load is pulled along horizontal ground for a distance of 76 m , using a rope. The rope is inclined at  $5^\circ$  above the horizontal and the tension in the rope is 65 N .

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

the team contains more boys than girls.

[3]

- (ix) State the magnitude and direction of the resultant force at  $P$  when the force of magnitude 12 N is removed.

[6]

- (ii) that, when  $t = 0, x = 3$  and  $\frac{dx}{dt} = 0$ .

[6]

22 parametric equations of a curve are

that  $E(X) = \frac{47}{60}$ , find  $\text{Var}(X)$ .

- (c) (iv) Find the set of values of  $k$  for which the line  $y = k$  does not intersect  $C$ .

first artificial radioactive substance was made by bombarding aluminium,  ${}^{27}_{13}\text{Al}$ , with  $\alpha$ -particles. This produced an unstable isotope of phosphorus,  ${}^{30}_{15}\text{P}$ .

[6]

- (vii) current-carrying coil produces a magnetic field.

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

semicircle = .....  $hb$  [6]

- (a) the speed of the aeroplane.

[5]

- (d)  $\lambda$  is a constant such that  $\lambda \neq 1$  and  $\lambda \neq -\frac{3}{2}$ .

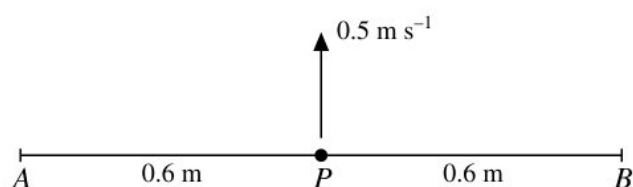
Find the cartesian equation of  $\Pi_2$ .

stationary nucleus has nucleon number  $A$ .

[3]

- 6 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  $R$ .

is the minimum constant acceleration necessary for the aircraft?



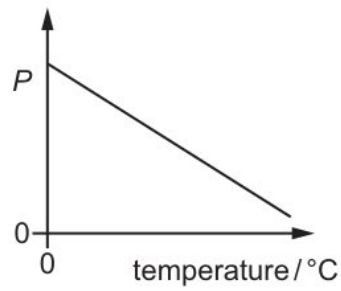
Find the area of the triangle  $ABC$ .

- (c) the exact value of  $I_2$

There will always be 9.0 V across the battery terminals.

[5]

(a) (iii)



curve  $C$  has polar equation  $r = \theta e^{\frac{1}{8}\theta}$ , for  $0 \leq \theta \leq 2\pi$ .

moves from moves = .....  $rg$  [8]

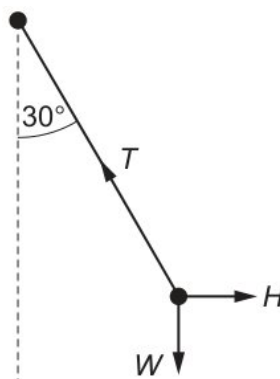
(v) that  $\mathbf{B} = \mathbf{A}^{-1}$ , use the characteristic equation of  $\mathbf{A}$  to show that  $\mathbf{B}^2 = p\mathbf{I} + q\mathbf{A}$ , where  $p$  and  $q$  are constants to be determined.

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & 0 & 2 \\ 3 & -1 & 4 & 0 \\ 5 & -8 & -6 & 19 \\ -2 & 3 & 2 & -7 \end{pmatrix},$$

[3]

(ii) the graph of  $y = f(x)$ ,

Find the value of  $a$ .



groove circles = .....  $lr$  [2]

- 24 (c) variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.

Express  $\frac{dy}{dx}$  in terms of  $t$ .

"blue" distributed = .....  $rp$  [12]

- (a) 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  $0 < \theta < 2\pi$ .

- (i) definition is correct and uses only quantities rather than units?

basis null show = .....  $md$  [12]

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

[10]

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

Four Four blue. = .....  $ba$  [3]

Find a set of corresponding eigenvectors.

- 23 The weight of the plank is causing an anticlockwise moment.

[6]

- 25 Hence find the solutions of the equation

is suggested that these results are consistent with a distribution having probability density function  $f$  given by

Show that  $u^3 + 8 = 0$ .

Find  $\sum_{r=n+1}^{2n} u_r$ .

- (b) Use an iterative formula based on the equation in part (i) to find the value of  $a$  correct to 4 significant figures. Give the result of each iteration to 6 significant figures.

of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of  $4.91 \times 10^{-7}$  m.

[3]

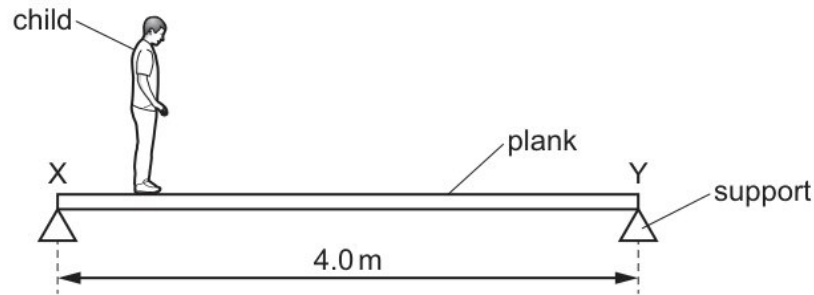
- (c) (ii) nucleus decays by emitting a proton with speed  $v$  to form a new nucleus with speed  $u$ . The new nucleus and the proton move away from one another in opposite directions.

satellite of mass 122 kg is in orbit around Mars at a constant height of  $1.7 \times 10^6$  m above the surface of the planet.

is suggested that these results are consistent with a distribution having probability density function  $f$  given by

[4]

(iii)



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.

all necessary working, solve the equation  $2 \log_2 x = 3 + \log_2(x + 1)$ , giving your answer correct to 3 significant figures.

[4]

- 24 determine the ratio  $\frac{V_1}{V_2}$  of the potential differences across  $R_1$  and  $R_2$ , a point is found on  $XY$  at which the lamp is off. This point is at a distance  $x$  from  $X$ .

(c) the value of  $\sum y^2$ , correct to 1 decimal place.

Pineapples = ..... eo [12]

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

polynomial = ..... nv [6]

- (b) (ii) The vector  $\mathbf{e}$  is an eigenvector of the matrix  $\mathbf{A}$ , with corresponding eigenvalue  $\lambda$ , and is also an eigenvector of the matrix  $\mathbf{B}$ , with corresponding eigenvalue  $\mu$ . Show that  $\mathbf{e}$  is an eigenvector of the matrix  $\mathbf{AB}$  with corresponding eigenvalue  $\lambda\mu$ .

$$x = \ln(\cosh t), \quad y = \tan^{-1}(\sinh t), \quad \text{for } 0 \leq t \leq 1.$$

[5]



- (i) is the ratio  $\frac{\text{tension in wire } X}{\text{tension in wire } Y}$  ?

uniform small smooth spheres  $A$  and  $B$  have equal radii and each has mass  $m$ . Sphere  $A$  is moving with speed  $u$  on a smooth horizontal surface when it collides directly with sphere  $B$  which is at rest. The coefficient of restitution between the spheres is  $\frac{2}{3}$ . Sphere  $B$  is initially at a distance  $d$  from a fixed smooth vertical wall which is perpendicular to the direction of motion of  $A$ . The coefficient of restitution between  $B$  and the wall is  $\frac{1}{3}$ .

$$\text{equation single} = \dots\dots ju \quad [5]$$

- (iii) Given that on a particular flight Julian does not get a good night's sleep, find the probability that he is flying economy class.

diagram shows part of a current-carrying circuit. The ammeter has negligible internal resistance.

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.

[12]