11 Find the distance OM.

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

force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

Find the x-coordinate of the maximum point M on the curve.

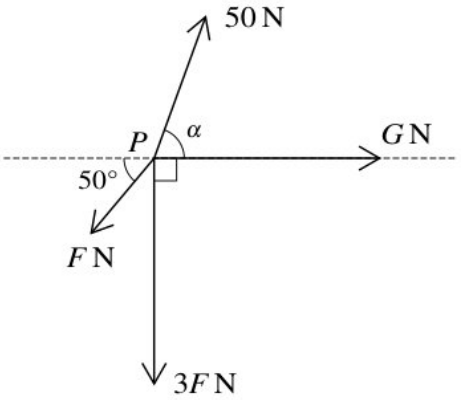
[5]

(i) is the percentage uncertainty in the calculated density of the liquid?

cell of e.m.f. 2.0 V and negligible internal resistance is connected to a variable resistor R and a metal wire, as shown in Fig. 5.1.

[10]

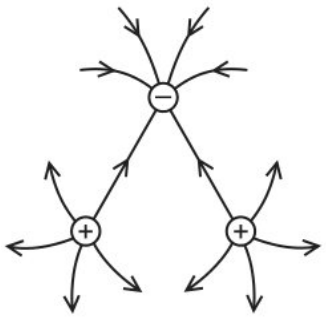
(c) (ii) to the origin O, the position vectors of the points A, B and C are given by



[1]

(iv) 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.

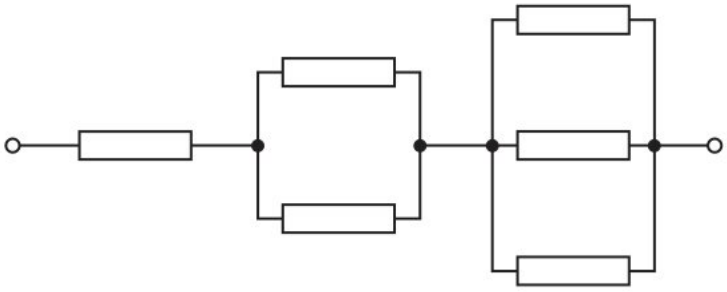
polarised beam of light with intensity I is incident normally on a polarising filter.



[4]

(i) considering the sum of the areas of these rectangles, show that

the expected value and variance of Y.



where = ... ph **[6]**

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

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

[8]

(ii) roller-coaster car (including passengers) has a mass of 840 kg . The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

$a =$ ..

$b =$ ..

$x =$ ..

$y =$ ..

[3]

projected = ... aw **[6]**

(e) (ii) points A, B, C have position vectors

[15]

(i) object is fully submerged in a liquid.

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

[5]

19 the exact value of a.

particles A and B of masses 0.9 kg and 0.4 kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with A on a smooth plane inclined at angle $\theta°$ to the horizontal and B on a plane inclined at angle 25° to the horizontal. The string is taut and the particles can move on lines of greatest slope of the two planes. A force of magnitude 2.5 N is applied to B acting down the plane (see diagram).

(d) (i) Find the frictional and normal components of the contact force acting on B.

a sketch of an Argand diagram with origin O show the points A, B, C and D representing the complex numbers $z_1, z_2, \omega z_1$ and ωz_2 respectively

[15]

(iii) 6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

$$\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{x^3 + 5x^2 - 2x - 15}{6y\,(x^2 - 3)}.$$

[2]

(ii)

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

wire is extended by a tensile force so that its deformation is elastic.

[5]

(b) (iv) graph shows the variation with temperature of power, P, dissipated in the thermistor?

tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

[5]

(v) m.f. for $n = 0$.

that $\tan 2a = -4a$

polarised beam of light with intensity I is incident normally on a polarising filter.

[12]

(iii) the circuit shown, XY is a length L of uniform resistance wire. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a small signal lamp S .

is the speed of the block at the bottom of the slope?

the speed of the body is increased to 40 ms^{-1}, what is its new kinetic energy?

[12]

20 the expected value and variance of Y.

(g) (ii) process does not require energy to be supplied?

Q hears a sound of decreasing frequency.

the exact solutions of the equation $\mathrm{f}(x) = 1$.

[4]

(iii) that $k = 3$ and $p = 26$.

many images of the slit does he see?

[5]

(i) the gas has a volume V_1 and is in equilibrium with the external pressure p. The gas is then heated slowly so that it expands at constant pressure, pushing the piston back until the volume of the gas has increased to V_2.

block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N , acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion.

[20]

(c) (iii) that, at the point of C furthest from the initial line,

$$\int_2^5 (x - 2\ln x)\mathrm{d}x$$

diagram best represents the electric field surrounding the charges?

[5]

(i) 1.1 shows the measurements for cube A.

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

that, at the point of C furthest from the initial line,

[6]

18 sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

the exact volume of the solid generated

(i) (c) beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

many competitors would you expect to have times within 1.2 minutes of the mean time?

Given that $\tan 2\theta \cot \theta = 8$, show that $\tan^2 \theta = \frac{3}{4}$.

[4]

(d) 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.

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 ms^{-1}. After P and Q collide, P continues to move in the same direction with speed 1.5 m s^{-1}.

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

[5]

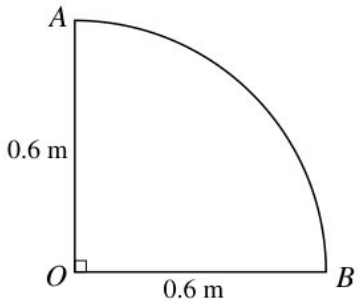
(a) matrix $\mathbf{A}$ is given by

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

[6]

(vi) (a) that $k = 3$ and $p = 26$.

The mass of the car is 920 kg . At time $t = 0$, the car is at rest. At time $t = 5.8$ s, its velocity is 17 ms^{-1}.



[6]

(b) object is free to rotate about the axis l. The object is held so that CA makes an angle α with the downward vertical and is released from rest.

continuous random variable X has probability density function f given by

[4]

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

the value of n.

[6]

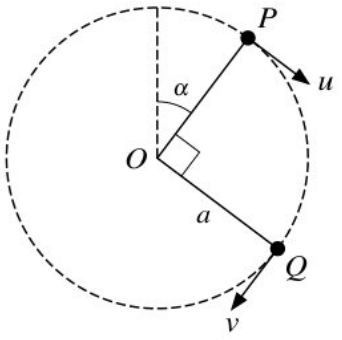
(b) Find the period of the motion.

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

if the 4 vowels A, E, E, I must all be together.

[15]

(ii) (b)



Given that $v = 2.5$, find x.

light is incident on the front of a photocell, an e.m.f. is generated in the photocell.

[4]

(c) filter is rotated about the normal axis through an angle θ.

the value of α.

[3]

(a) what is meant by a fundamental particle.

much energy is stored in the compressed column?

$$x_1 = 1, \quad x_{n+1} = \frac{1}{2}\sqrt[3]{\left(x_n^2 + 6\right)}$$

[2]

8 The force F is removed from the materials in (d) just before the breaking point is reached. Describe the subsequent change in the extension for

(a) (ii) Find angle ABC.

the speed of the aeroplane.

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

[8]

(iii) are no resistive forces acting on the block.

Hence show that $\sum_{r=1}^{n} \frac{2r+1}{r(r+1)(r+2)} = \frac{1}{2}\left\{\frac{(2n+1)(2n+3)}{(n+1)(n+2)} - \frac{3}{2}\right\}$.

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

[10]

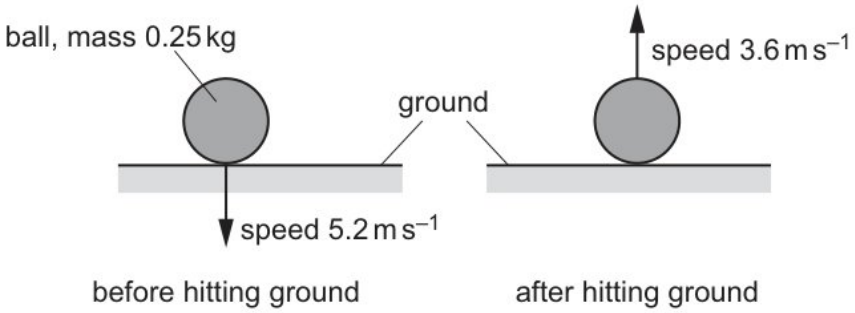
(d) (iv) Express u in the form $x + \mathrm{i}y$, where x and y are real.

It consists of two quarks that must both be the same flavour.

diagram shows the force-extension graph produced.

[1]

(i) the past, the population mean time was 62.4 seconds.



[10]

(e) (ii) Obtain another equation relating u^2, v^2, a and g, and hence find u in terms of a and g.

an election 153 adults, from a random sample of 200 adults, said that they had voted. Using this information, an $\alpha\%$ confidence interval for the proportion of all adults who voted in the election was found to be 0.695 to 0.835 , both correct to 3 significant figures. Find the value of α, correct to the nearest integer.

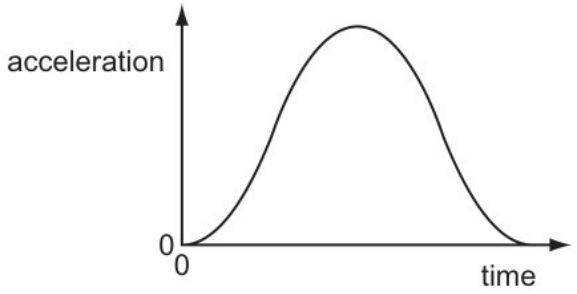
off. = ... zh **[4]**

(i) Use the result for integrating $\frac{1}{x^2+a^2}$ with respect to x, in the List of Formulae (MF10), to find the value of I_1 and deduce that

Find the values of F and θ.

[12]

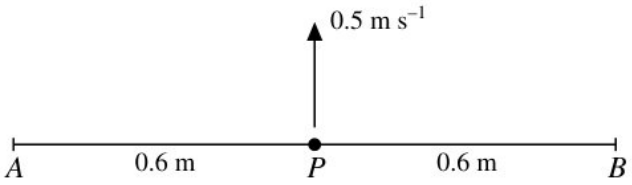
(iii) the period of small oscillations,



[8]

10 the probability of a Type I error.

(b) (iii)



Find the value of I_2.

[4]

(ii) Find the value of the product moment correlation coefficient for this sample.

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

$$\int_2^5 (x - 2\ln x)\mathrm{d}x$$

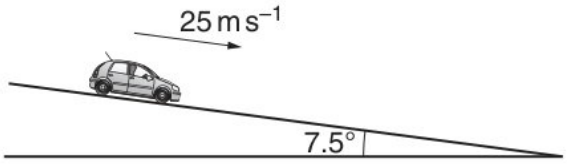
[5]

(i) how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

plank has a mass of 7.0 kg and has a pivot at its midpoint. The plank is horizontal and in equilibrium.

[8]

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



[6]

(iv) is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

[4]

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

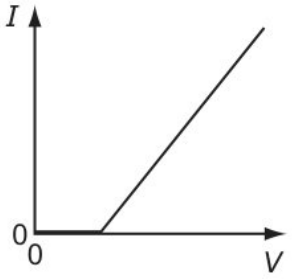
transmitted light has intensity I.

[12]

15 is the average useful power at which he is working?

where α is a positive integer. It is given that the shortest distance between the line AB and the line CD is equal to $2\sqrt{2}$.

(iii) (a) the value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ at P,



[4]

(b) 1 Which quantity is a scalar quantity?

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.

rigid body is made from uniform wire of negligible thickness and is in the form of a square $ABCD$ of mass M enclosed within a circular ring of radius a and mass $2M$. The centres of the square and the circle coincide at O and the corners of the square are joined to the circle (see diagram). Show that the moment of inertia of the body about an axis through O, perpendicular to the plane of the body, is $\frac{8}{3}Ma^2$.

[6]

(f) 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 θ with the upward vertical.

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

[5]

(e) fair six-sided dice with faces labelled $1, 2, 3, 4, 5, 6$ is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X.

student takes measurements to calculate the density of a liquid in a beaker.

[10]

(ii) (c) overall efficiency of the turbine and generator system is 90%. The density of water is 1000 kg m^{-3}.

Find the cartesian equation of the plane through A, B and C.

[4]

(a) only one of the following two alternatives.

the values of a for which the system of equations

Find the coordinates of the turning points of C.

[12]

(i) (d) gas is then cooled at constant volume so that its temperature decreases to $2T$.

body travelling with a speed of 10 ms^{-1} has kinetic energy 1500 J .

sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.

[15]

(a) the period of small oscillations,

800 nm to 1000μ m

[3]

(c) Find the greatest height that P reaches above the level of O.

[5]

23 short time after passing point B truck R moves in a straight line on horizontal ground. The driver of the truck applies the brakes. Fig. 3.2 shows the variation with time of the momentum of the truck.

(f) (iv) Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

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

[5]

(ii) the exact value of $\lim_{n\to\infty}\sum_{r=1}^{n}\frac{n}{n^2+r^2}$.

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.

company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

[5]

(v) progressive wave of frequency 300 Hz is travelling with a speed of 600 m s^{-1}.

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.

the graph of $y = |2x - 3|$.

[6]

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

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.

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[12]

(iii) 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).

tractor comes to a hill inclined at 4° above the horizontal. The power output is increased to 25 kW and the resistance to motion is unchanged.

[4]

15 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.

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

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° and α 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.

radius = ... yz **[5]**

(iv) sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

Find the value of $(\alpha + 1)(\beta + 1)(\gamma + 1)$.

[5]

(i) variation with time t of the velocity v of the car is shown.

up to antidown

[15]

(a) (vi) Draw a sketch of C for the case $\lambda > 3$.

find the probability that in 15 throws the number of 4 s obtained is 2 or more.

[8]

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

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

[12]

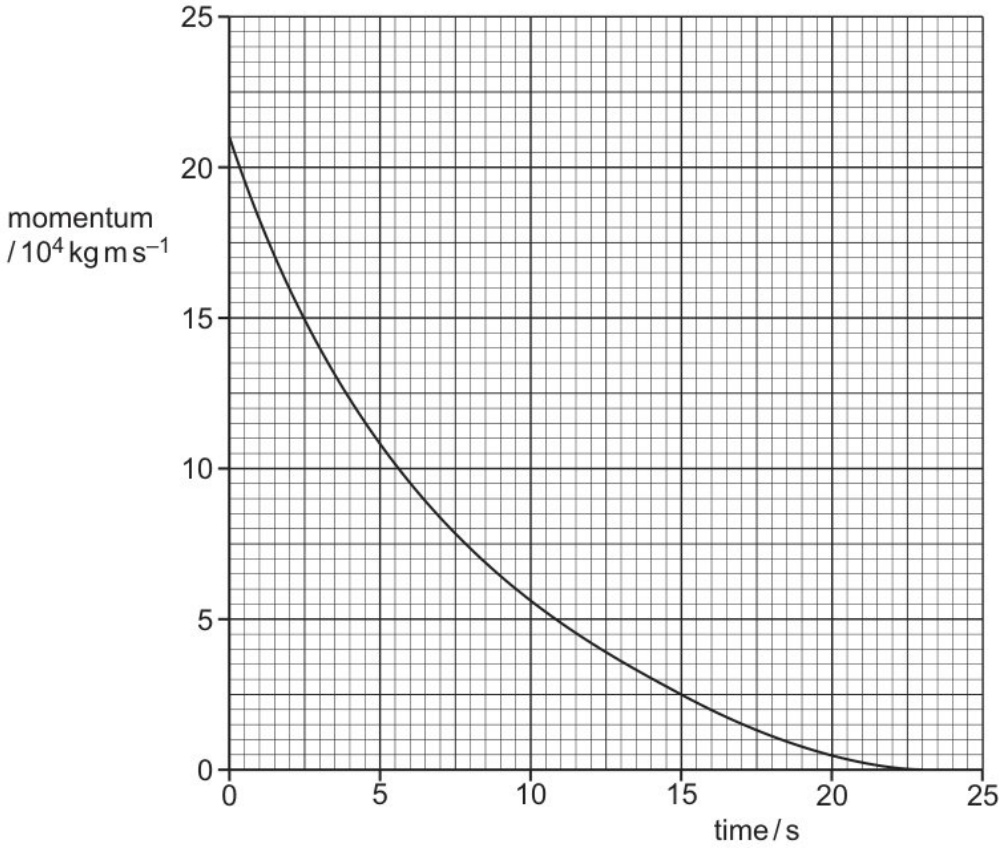
(d) (iv) Prove that, for $n \geqslant 2$,

doctor is investigating the concentration of blood glucose in patients at risk of developing type 2 diabetes where blood glucose is measured in appropriate units The doctor claims that a particular intervention reduces the concentration by more than k units on average A group of 8 at risk patients is selected at random and each patient follows the intervention for six months The blood glucose concentrations before and after the intervention are given in the following table

[6]

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

chooses an appropriate random sample of 60 students. She finds that 45 of these students think that the sports facilities are good.



[4]

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

variables x and y satisfy the differential equation

[5]

21 (a) Explain why the observed wavelength and the emitted wavelength have different values.

(ii) the ratio $H : D$.

[8]

(iv) the type of each transformation, and make clear the order in which they are applied.

the values of a, b, x and y.

[15]

(i) Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

[5]

(iii) Calculate the density, in kgm^{-3}, of the material from which the paving slab is made.

[8]

(b) that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

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

(i) village hall has seats for 40 people, consisting of 8 rows with 5 seats in each row. Mary, Ahmad, Wayne, Elsie and John are the first to arrive in the village hall and no seats are taken before they arrive.

row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

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

[8]

(v) the vertical and horizontal components of velocity at time t.

diagram illustrates successive wavefronts.

[3]

(ii) Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.

[5]

(d) Q hears a sound of decreasing frequency.

the set of values of p for which C has two distinct turning points.

(iv) and explain whether the nuclei in the sample are undergoing α-decay, β^+decay or β^-decay.

[8]

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

[15]

36 Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

(c) (i) person's eye colour may be categorised as "brown", "blue" or "other". A scientist claims that these eye colours are uniformly distributed and hence are equally likely to occur in the population. A survey of 120 people from this population found that 38 people had brown eyes, 52 people had blue eyes and 30 people had eyes which were neither brown nor blue.

by calculation that a lies between 2 and 2.1.

weights of letters posted by a certain business are normally distributed with mean 20 g . It is found that the weights of 94% of the letters are within 12 g of the mean.

[15]

(ii) polynomial $ax^3 - 3x^2 - 11x + b$, where a and b are constants, is denoted by $\mathrm{p}(x)$. It is given that $(x+2)$ is a factor of $\mathrm{p}(x)$, and that when $\mathrm{p}(x)$ is divided by $(x+1)$ the remainder is 12 .

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

[3]

(iii) statement is correct when S is changed from open to closed?

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

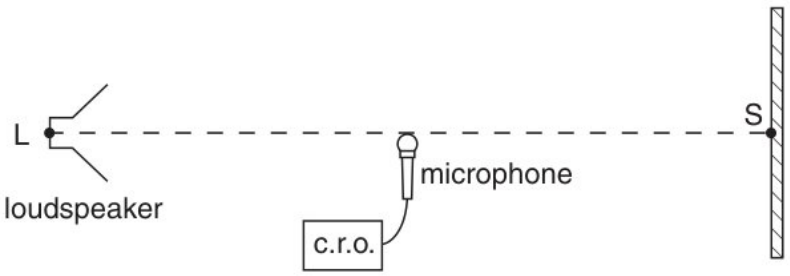
[15]

(d) (i) the probability density function of Y,

Draw box-and-whisker plots in a single diagram on graph paper to illustrate the marks for History and Physics.

[6]

(v)



Find the value of k such that $\mathrm{P}(k < X < 610) = 0.3$.

[10]

10 activity of a radioactive sample.

(c) (iv) Hence solve the equation

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

[4]

(v) 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 $\frac{3k+1}{3(1-k)}$.

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

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

[6]

(i) the geometric effects of multiplying z_1 and z_2 by ω

P is projected vertically downwards from the equilibrium position, and comes to instantaneous rest at a point 1.6 m below AB.

equation of a curve is $xy + y^2\mathrm{e}^{-x} = 4$.

[8]

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

OAB is a uniform lamina in the shape of a quadrant of a circle with centre O and radius 0.8 m which has its centre of mass at G. The lamina is smoothly hinged at A to a fixed point and is free to rotate in a vertical plane. A horizontal force of magnitude 12 N acting in the plane of the lamina is applied to the lamina at B. The lamina is in equilibrium with AG horizontal (see diagram).

[6]

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

continuous random variable X has probability density function f given by

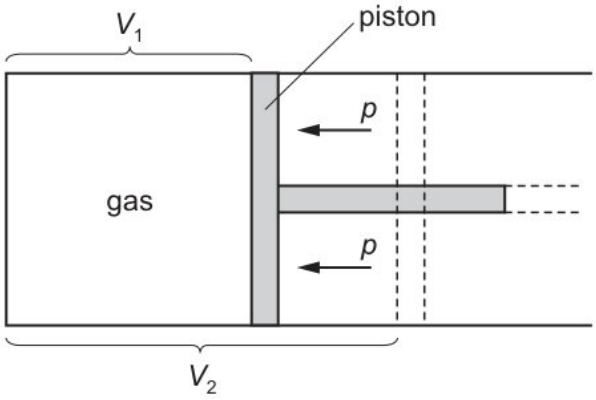
[8]

(b) (ii) is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

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

[2]

(iv)



Find the cartesian equation of the plane through A, B and C.

[8]

31 The power to X will increase and the powers to Y and Z will remain unaltered.

(a) (iii) that for $n \geqslant 2, \quad I_n = -1 + n(n-1)I_{n-2}$

Show by calculation that a lies between 2 and 4 .

[6]

(iv) particle oscillates in simple harmonic motion with centre O. When its distance from O is 3 m its speed is 16 m s^{-1}, and when its distance from O is 4 m its speed is 12 m s^{-1}. Find the period and amplitude of the motion.

is the efficiency of the process?

[6]

(vii) Without using a calculator, find the exact values of

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.

[5]

(i) Find the total work done against the resistance force as the car ascends the first ramp and descends the second ramp.

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 2\frac{\mathrm{d}x}{\mathrm{d}t} + 5x = 4 - 5t^2$$

[4]

(b) (ii) Show that $\mathrm{f}(n+1) + \mathrm{f}(n) = 28\left(3^{3n}\right) + 7\left(6^{n-1}\right)$.

an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

[6]

(iv) Given that $v = 2.5$, find x.

Find the equations of the asymptotes of C.

[10]

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

(d) (i) continuous random variable X has probability density function f given by

State one difference, which can be seen from the diagram, between the marks for History and Physics.

a value, to three significant figures, for the specific latent heat of fusion of water.

[8]

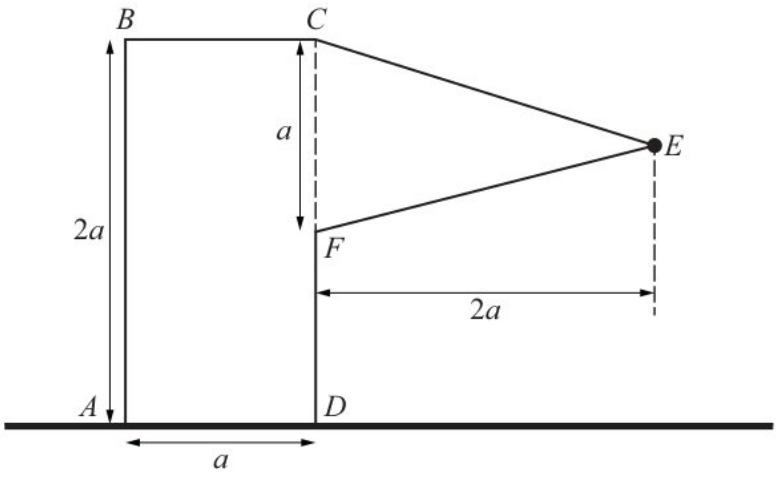
(iv) curve C has polar equation $r = 2\cos 2\theta$. Sketch the curve for $0 \leqslant \theta < 2\pi$.

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

[5]

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

projectile is thrown at an angle to the ground.



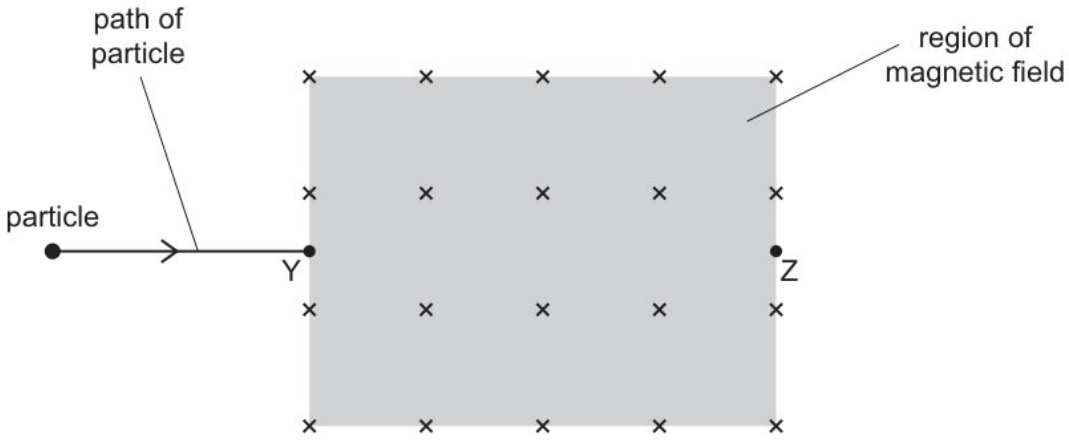
[6]

(i) row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

Nucleon numbers of nuclei are unchanged by the emission of β-particles.

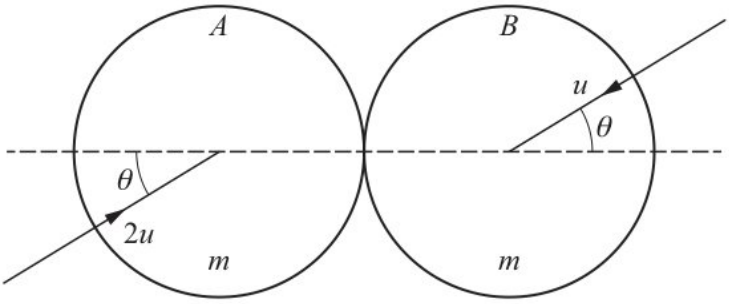
[4]

(a) (iii) the exact value of $\text{cosec}^2 15° - \sec^2 15°$.



[3]

(ii) Find the value of I_2.



a, b and c are integers to be determined.

[4]

(i) bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

Find the value of a.

[5]

11 The vector **e** is an eigenvector of the matrix **A**, with corresponding eigenvalue λ, and is also an eigenvector of the matrix **B**, with corresponding eigenvalue μ. Show that **e** is an eigenvector of the matrix **AB** with corresponding eigenvalue $\lambda\mu$.

(c) (i) Find the median of X.

Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m , calculate the greatest possible value of ω and the corresponding tension in the string.

[3]

(ii) Find the coordinates of A and M.

etween time $t = 0$ and time $t = 5.8$ s the work done against resistive forces is 4.7×10^4 J

[8]

(d) (vi) with a reason, whether you agree with Nikki's friend.

In the case where $k = 2$,

electric potential difference across a component.

[8]

(i) skateboarder and her skateboard have a total mass of 70 kg . She pushes on the ground with her foot to create a forward force F of 25 N on herself and the skateboard, as shown in the diagram.

the other root and hence find the values of b and c.

resistor of resistance 240Ω is now replaced by a new resistor X of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.

[8]

(ii) Find the value of x.

random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

[15]

(a) (i) narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m . The disc rotates with angular velocity ωrads^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.

[12]

(iii) transmitted light has intensity $0.75I$.

Find the distance OM.

obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

[6]

(iv) gravitational potential at a point.

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

[1]

25 100 nm to 400 nm

$$\mathrm{f}(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{2} & 1 \leqslant x \leqslant 3 \\ 0 & x > 3 \end{cases}$$

the time that it takes from when P is initially projected until the instant at which P collides with the combined particle

$$\tan x = x + \pi.$$

(b) (i) the kinetic energy of the car at time $t = 5.8$ s.

system is released from rest with OP making a small angle α with the downward vertical. Find

weights of letters posted by a certain business are normally distributed with mean 20 g . It is found that the weights of 94% of the letters are within 12 g of the mean.

[5]

(ii) is the average useful power at which he is working?

$I_n = \int_0^1 x^n (1-x)^{\frac{1}{2}}\ \mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

[12]

(iv) the position vector of the foot of the perpendicular from the point with position vector $\mathbf{i} + 10\mathbf{j} + 3\mathbf{k}$ to Π.

potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) $V_{\text{in.}}$ The p.d. across R_1 is V_{out} .

[12]

(iii) down to antiup

gas is then cooled at constant volume so that its temperature decreases to $2T$.

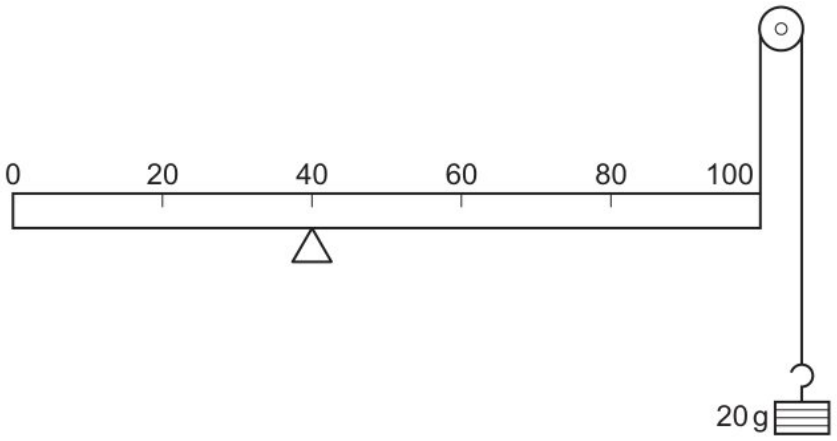
[8]

(e) (iii) how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

$$y = \frac{ax^2 + bx + c}{x - 1}$$

[5]

(i)



The same force is used to change the speed of the car from 30 ms^{-1} to 45 ms^{-1}. Explain why the distance moved is not the same as that calculated in (i).

[5]

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

the ductile material,

[5]

(ii) that the mean of these 40 values is 124.0 , find the value of k.

$$\mathbf{i} + \mathbf{j} + 3\mathbf{k}, \quad 3\mathbf{i} - \mathbf{j} + 5\mathbf{k}, \quad 3\mathbf{i} - \mathbf{j} + \mathbf{k}, \quad 5\mathbf{i} - 5\mathbf{j} + \alpha\mathbf{k},$$

[3]

(v) Find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

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.

the value of σ.

[5]

(c) (ii) the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution 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.

mid-day temperature, x°C, and the amount of sunshine, y hours, were recorded at a winter holiday resort on each of 12 days, chosen at random during the winter season. The results are summarised as follows.

[15]

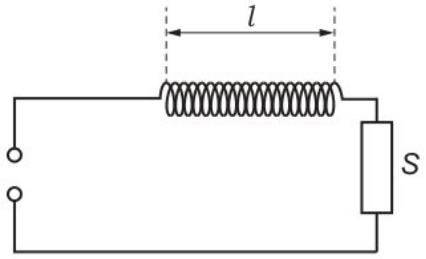
(iii) suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

determine a correct to 3 decimal places. Give the result of each iteration to 5 decimal places.

$$\mathbf{M} = \begin{pmatrix} 3 & 4 & 2 & 5 \\ 6 & 7 & 5 & 8 \\ 9 & 9 & 9 & 9 \\ 15 & 16 & 14 & 17 \end{pmatrix}.$$

[8]

(iv) a basis for the null space of T .



[5]

15 manufacturer claims that the machine produces rods with mean length 300 mm .

(a) (v) graph shows the variation with time of the velocity of the object?

point $P(2, 1)$ lies on the curve with equation

[8]

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

circuit is set up as shown in Fig. 2.1.

[6]

(iv) car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

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

C, stating the coordinates of the intersections with the axes.

[8]

(i) company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

Find the exact value of the arc length of C.

cable has tensions T_1 and T_2 as shown.

[8]

(c) (i) R has an amplitude of 8 cm and a period of 30 ms .

Show that the possible values of α are 3 and 5 .

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

[20]

(iii) are the frequencies of the next two higher notes for this air column?

Its speed decreases to a value greater than zero, then increases to 20 ms^{-1}.

basic principle of note production in a horn is to set up a stationary wave in an air column.

[5]

(d) (iii) verify that this equation has a root between 5 and 5.05.

man has a mass of 80 kg . He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1}.

[1]

(iv) is the average velocity of the toy car for the journey shown by the graph?

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

[8]

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

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

[8]

(ii) lowest mark was 17 and the highest mark was 74 .

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.

[5]

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

(e) (iii) Find the eigenvalues and corresponding eigenvectors of the matrix $\mathbf{A}$, where

up to antidown

[3]

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

Prove by mathematical induction that, for all positive integers n,

$$\frac{1}{x} = \sin x$$

[5]

(b) (i) Find the eigenvalues and corresponding eigenvectors of the matrix **A**, where the ratio $H : D$.

[10]

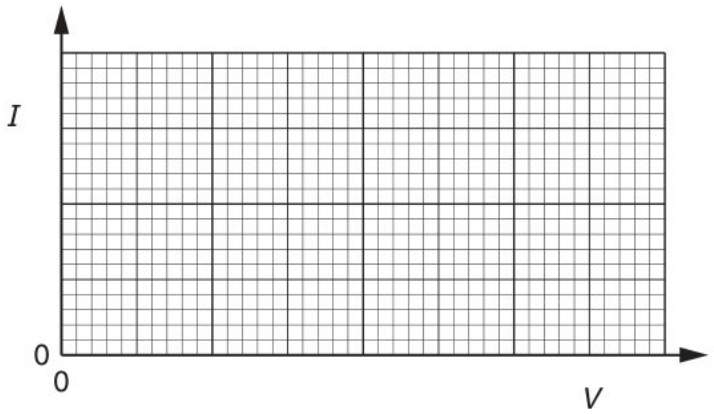
(ii) the probability that all three cars are the same colour.

bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

[6]

10 row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

(b) (iii)

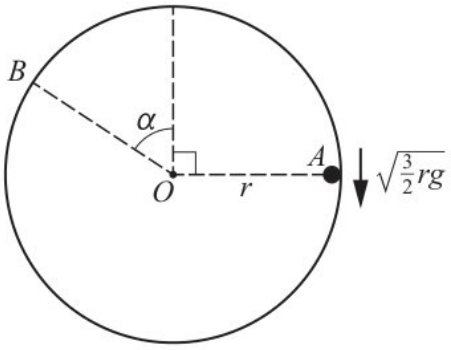


Using a 5% significance level, test whether there is non-zero correlation between the variables.

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

[4]

(i)



the term elastic limit.

[1]

(iv) Show that the mass of Mars is 6.4×10^{23} kg.

sheets between a light source and the front of the photocell.

[6]

(c) (i)

Gulls	7.9	8.2	8.3	8.6	8.6	8.8	9.2	9.7	9.8	10.0	10.4
Herons	9.5	9.9	8.5	8.1	9.2	10.8	8.3	9.7	9.3	9.9	8.7

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

[10]

(iii) the distribution function of X.

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

statements about what person P and person Q hear during the motion of the car are correct?

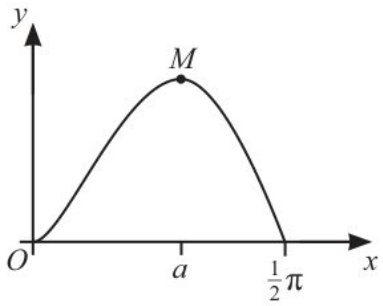
[6]

(ii) Use the information in (d)(iv) to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.

V decreases because there is a p.d. across r.

[4]

(a) (iv) labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.



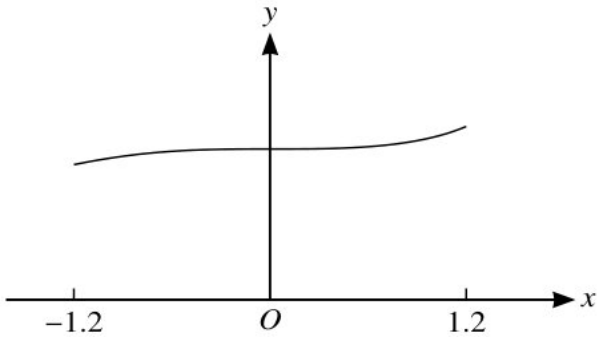
[12]

(iii) $I_n = \int_0^1 x^n (1-x)^{\frac{1}{2}}\, \mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

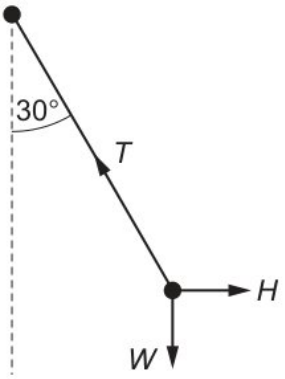
Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{\sin\theta \cos^3\theta}$.

[6]

(d) (ii)



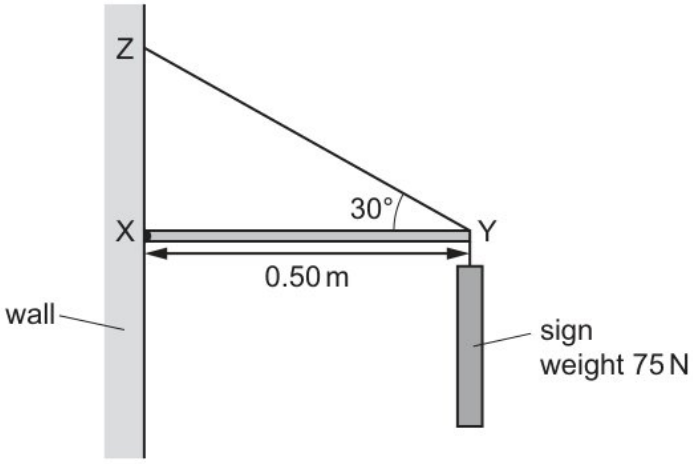
the equation for this decay.



[6]

(iv) the kinetic energy of the car at time $t = 5.8$ s.

sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.



[4]

15 exactly at point T

(iii) (a) diagram shows part of the curve $y = 4\sqrt{x} - x$. The curve has a maximum point at M and meets the x-axis at O and A.

Show that $v^2 = u^2 + \frac{14}{5}ag$.

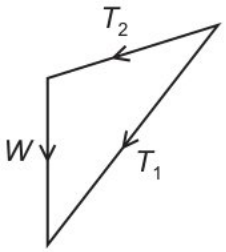
[5]

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

524 526 520 523 530

[4]

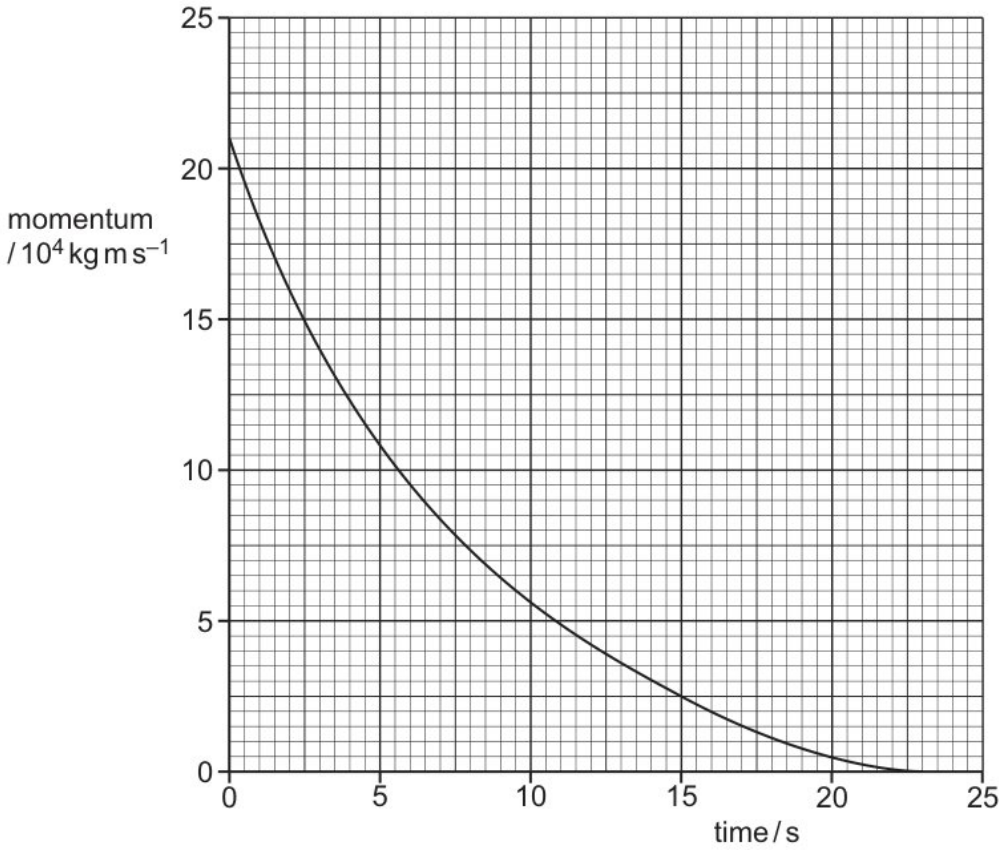
(ii) (b)



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

[5]

(a)



Find the weight of the lamina.

[10]

30 body travelling with a speed of 10 ms^{-1} has kinetic energy 1500 J .

(a) (iii) $\frac{\text{force}}{\text{length} \times \text{speed}}$

for $0° \leqslant \theta \leqslant 180°$ the equation $\sin^2 2\theta \left(\text{cosec}^2 \theta - \sec^2 \theta\right) = 3$,

[10]

(i) particle of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle is moving in complete vertical circles with the string taut. When the particle is at the point P, where OP makes an angle α with the upward vertical through O, its speed is u. When the particle is at the point Q, where angle $QOP = 90°$, its speed is v (see diagram). It is given that $\cos\alpha = \frac{4}{5}$.

solve the equation $\cot^2 x - \tan^2 x = 5 \sec 2x$ for $0° < x < 90°$.

[6]

(d) (iii) P is projected vertically downwards from the equilibrium position, and comes to instantaneous rest at a point 1.6 m below AB.

Velocity is proportional to wavelength.

[5]

(v)

Use the iterative formula

tomato = ... ql **[5]**

(i) how the pattern of interfering waves may be observed.

Find the equations of the asymptotes of C.

respect to the origin O, the points A, B and C have position vectors given by

angle = ... au **[4]**

(ii) It consists of two quarks that do not need to be the same flavour.

a similar method to find a lower bound for $\sum_{r=1}^{n} \frac{n}{n^2+r^2}$. Give your answer in terms of n and π.

[10]

(b) (i) Find the position vector of D.

student wishes to investigate projectile motion.

[8]

(iii) the solution of the differential equation

Sound waves are transverse waves and light waves are longitudinal waves.

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]

(iv) that $k = 3$ and $p = 26$.

1.1 shows the measurements for cube A.

[8]

(ii) Use implicit differentiation to show that

is the efficiency of the process?

the probability of a Type I error.

[10]

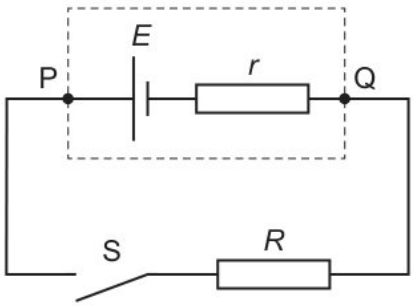
11 time T, particle P is moving at an angle of 60° below the horizontal.

(a) (iv) State the equation of the other asymptote.

much energy is stored in the compressed column?

[5]

(iii)



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

[12]

(ii) that $y = 0$ when $x = 0$. Give your answer in an exact form.

CDs are packed in boxes of 30 . The probability that a blank CD is faulty is 0.04 . A box is rejected if more than 2 of the blank CDs are faulty.

Calculate the acute angle between the planes.

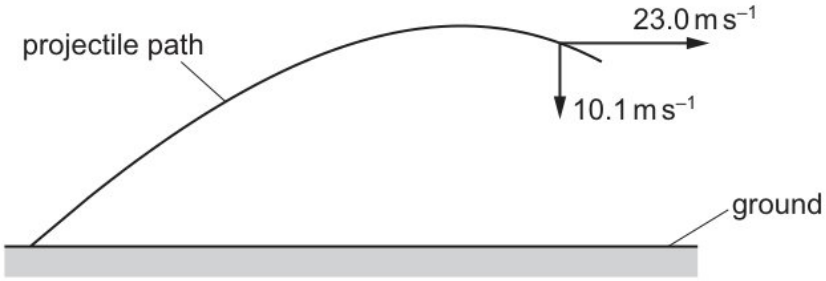
[4]

(b) (iii) the values of the constants k_1 and k_2 are to be determined.

cell of e.m.f. 2.0 V and negligible internal resistance is connected to a variable resistor R and a metal wire, as shown in Fig. 5.1.

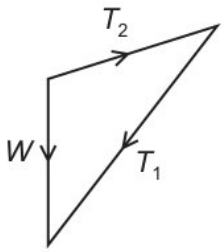
[12]

(ii) are the amplitude and period of the wave?



[10]

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



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

[6]

(i) row describes the momentum and kinetic energy of the two bodies after the collision?

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

[5]

(d) (i) student wishes to investigate the effect of adding various thicknesses of glass in front of

$$t^4 - 4t^3 - 6t^2 + 4t + 1 = 0,$$

electric potential difference across a component.

[6]

(iv) could M and N be?

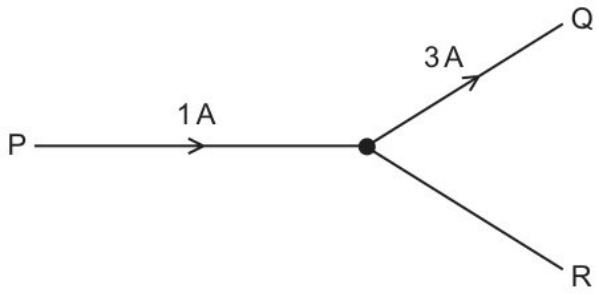
the probability that the mass of peaches sold on any given day is between 56 kg and 75 kg

[8]

22 Find the value of x.

the Young modulus.

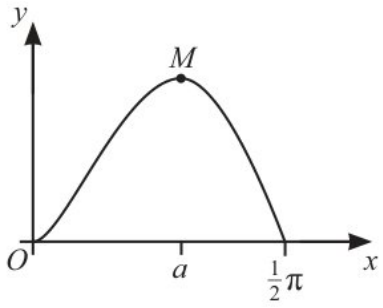
(d) (ii) curve C has equation $y = x^{\frac{3}{2}}$. Find the coordinates of the centroid of the region bounded by C, the lines $x = 1, x = 4$ and the x-axis.



is now given that the true value of p is 0.05 .

[6]

(iv) Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.



[6]

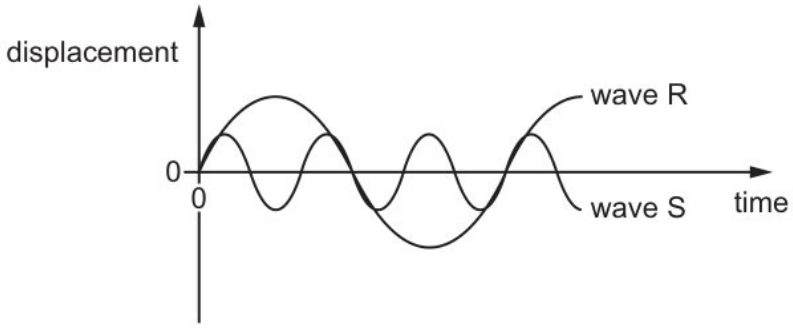
(i) three quantities that are conserved during the decay.

Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

Show that $m = 0.9$.

[3]

(b) (iv)



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

[12]

(i) rod in (b) is removed from the pin and supported by ropes A and B , as shown in Fig. 2.2.

the distance AC.

[8]

(a) (iv) 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 .

your answers in the form $\tan k\pi$, where k is a rational number.

[8]

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

row describes the resultant force and resultant torque on the object?

is the phase difference between two points on the wave that are a distance of 0.50 m apart?

[8]

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

the number of different arrangements of the 8 letters in the word KANGAROO in which the two As are together and the two Os are not together.

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.

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

(b) (i) State the work W done by F.

$$y = \frac{3x - 9}{(x-2)(x+1)}$$

[8]

(ii) Find the area of the region enclosed by C.

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

[6]

(vi) roller-coaster car (including passengers) has a mass of 840 kg . The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

Find the probability that a box is rejected.

[4]

(d) (iii) Lee asserts that boys are slower than girls at completing a particular mathematical puzzle. In order to test his assertion, a random sample of 40 boys and a random sample of 60 girls are selected from a large group of students who attempted the puzzle. The times taken by the boys, b minutes, and the times taken by the girls, g minutes, are summarised as follows.

cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

[12]

(i) Determine the decay constant, in min^{-1}, of the radioactive isotope.

and N are two electromagnetic waves.

[6]

(a) (i) polarised beam of light with intensity I is incident normally on a polarising filter.

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

velocity = acceleration $\times$ time

[6]

(v) transmitted light has intensity $0.75I$.

car sounds its horn continuously as it travels. The horn emits sound of constant frequency.

[10]

(iv) The weight of the plank is causing an anticlockwise moment.

$$_{88}Q \longrightarrow {}^{222}_{\cdots}R + {}^{4}_{2}Q$$

[8]

16 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.

(a)(vii) the coordinates of C,

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

[3]

(i) specific heat capacity of water is 4.18 J $\text{g}^{-1\circ}\text{C}^{-1}$.

is given that P remains at rest in this new position.

[6]

(vi) the inequality $|x| < |5 + 2x|$.

Explain how an electric field can be used with the magnetic field to ensure that the Explain how an electric field can be used with the magnetic field to ensure that the particle in (b) now passes through point Z. particle in (b) now passes through point Z.

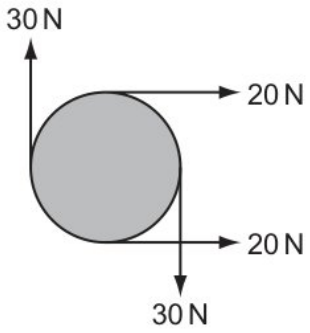
[12]

(c) (iv)

do each of the symbols represent for an electric current in a metal wire?

[4]

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



[12]

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

diagram shows four forces applied to a circular object.

fair six-sided dice with faces labelled $1, 2, 3, 4, 5, 6$ is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X.

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

(d) (iv) weight of the parachutist is 850 N .

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

[12]

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

wavelength of light is 550 nm .

[6]

(b) (iii) Find the value of a.

Show that $2\cos 2x \cos\left(2x + \frac{1}{6}\pi\right)$ can be expressed in the form

Hence solve the equation $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4$, for $0° \leqslant \theta \leqslant 360°$.

[4]

(v)

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

random sample of 140 customers who each bought a computer from this store is chosen.

[4]

(iv) anywhere between point R and point S

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

[6]

(ii) Find the standard deviation of the weights of the letters.

first coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{3}$.

[6]

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

polynomial p(x) is defined by

[4]

(ii) line L_1 passes through the points $A(2, 5)$ and $B(10, 9)$. The line L_2 is parallel to L_1 and passes through the origin. The point C lies on L_2 such that AC is perpendicular to L_2. Find

$$\frac{1}{x} = \sin x$$

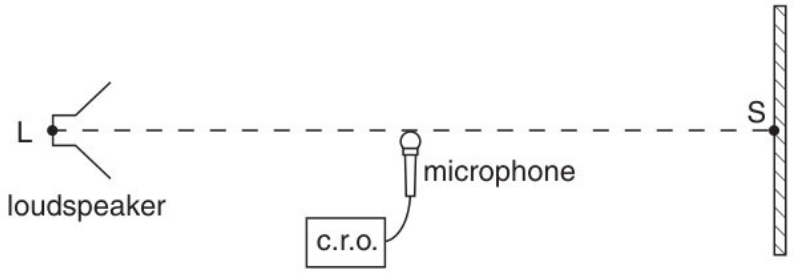
strikes find wall = ... *ve* **[12]**

12 small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is p and the horizontal displacement of the ball is q, as shown in Fig 1.1.

the exact volume of the solid generated

the other root and hence find the values of b and c.

(d) (iv)



Find the work done by the tension.

[3]

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

graph shows the relationship between force acting on a compression spring and change in length of the spring.

[4]

(b) (vi) the time from release until OP makes an angle $\frac{1}{2}\alpha$ with the downward vertical for the first time.

The waves must have equal amplitudes.

[15]

(ii) Find the tension in the string.

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.

[6]

21 cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

(b) (vi) copper wire of cross-sectional area 2.0 mm^2 carries a current of 10 A .

an unbiased estimate of E(T), and show that an unbiased estimate of Var(T) is 14.44.

women = ... *do* **[6]**

(iii) the exact value of $\int_{\frac{1}{5}\pi}^{\frac{1}{4}\pi} 3\cos^2 5x \, \mathrm{d}x$

The curve C has equation $y = \sec^3 x$ for $0 \leqslant x \leqslant \frac{1}{4}\pi$. The region R is bounded by C, the x-axis, the y-axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x-axis.

[8]

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

acceleration of free fall on Pluto is 0.66 m s^{-2}.

[8]

(ii) The wavelength of maximum intensity of emission is used to determine a value for the surface temperature of the star.

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

Event X is 'exactly two of the selected balls have the same number'. Event Y is 'the ball selected from bag A has number 2'. Showing your working, determine whether events X and Y are independent or not.

[8]

7 Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

(e) (i) Deduce the value of $\sum_{r=1}^{\infty} \frac{2r+1}{r(r+1)(r+2)}$.

is given that $x = t^{\frac{1}{2}}$, where $x > 0$ and $t > 0$, and y is a function of x.

$$x + 3y + kz = 4$$
$$4x - 2y - 10z = -5$$
$$x + y + 2z = 1$$

carriers charge = ... *al* **[10]**

(iii) parametric equations of a curve are

Find the position vector of D.

$$\Sigma x = 1416 \quad \Sigma x^2 = 41100 \quad \Sigma y = 888 \quad \Sigma y^2 = 20140$$

[4]

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

by mathematical induction, that $\sum_{r=1}^{n} r \ln\left(\frac{r+1}{r}\right) = \ln\left(\frac{(n+1)^n}{n!}\right)$ for all positive integers n.

[8]

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

$$\int_2^5 (x - 2\ln x)\mathrm{d}x$$

[1]

(a) (iii) the solution of the differential equation

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

s friend says,"This survey is about sports facilities, so you should choose a sample of students from the school sports teams."

[6]

(ii) Given that the total number of cars sold during the 5 days is 5 , carry out the test.

The curve C has equation $y = \sec^3 x$ for $0 \leqslant x \leqslant \frac{1}{4}\pi$. The region R is bounded by C, the x-axis, the y-axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x-axis.

the distribution function of X.

[6]

(v) gas is then cooled at constant volume so that its temperature decreases to $2T$.

$$\sin 4y \frac{\mathrm{d}y}{\mathrm{d}x} = x \sin 2y \sin 3x$$

continuous random variable, X, has probability density function given by

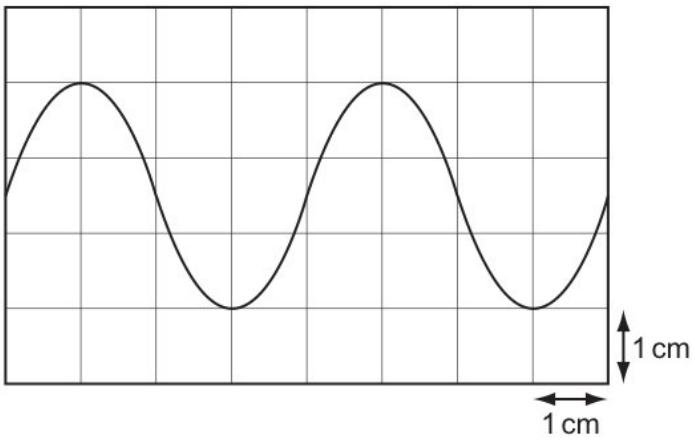
[4]

(i) that l_1 and l_2 do not intersect.

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

[8]

(d) (i) object is fired upwards from horizontal ground. The object has an initial velocity of 20 ms^{-1} at an angle of 45° to the horizontal. Air resistance is negligible.



[8]

(ii) is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

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 θ with the upward vertical.

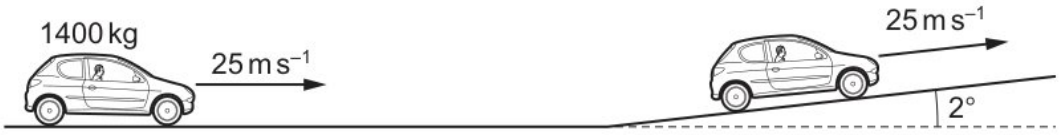
curves C_1 and C_2 intersect at the point with polar coordinates (a, β). State the value of β.

[15]

14 believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p, is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $\mathrm{H}_0 : p = 0.2$, against the alternative hypothesis, $\mathrm{H}_1 : p < 0.2$.

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

(d) (i)



displacement = velocity × time

[8]

(ii) one similarity and one difference between an electron and positron.

transmitted light has intensity $0.75I$.

mean least that = ... vj **[10]**

(c) (i) cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

[8]

(iii) Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

resistance of a metal cube is measured by placing it between two parallel plates, as shown.

[3]

(ii) a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.

V increases because there is a p.d. across R.

[3]

(a) (ii) Show that the mean number of rooms that are occupied each night is 3.25 .

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.

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

[8]

(iv) where α is a positive integer. It is given that the shortest distance between the line AB and the line CD is equal to $2\sqrt{2}$.

State what happens to the electron and to the positron.

[4]

(vi) 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 $\mathrm{G}_X(t) \times \mathrm{G}_Y(t)$.

Draw up a probability distribution table for X.

[10]

23 to the value α.

(b) (i) resistors, each of resistance R, are connected as shown.

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.

[6]

(iii) Nucleus X undergoes β^-decay to form nucleus Z.

Use the confidence interval found in part (i) to comment on this claim.

[8]

(ii) 1.1 shows two identical cylindrical metal conductors P and Q, each of length L and cross-sectional area A.

State what happens to the electron and to the positron.

[15]

(a) (ii) procedure to be followed,

is the charge, in terms of the elementary charge e, on a charm quark?

In some nuclear processes, mass-energy is not conserved.

[4]

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

Its speed decreases to a value greater than zero, then increases to a value greater than 20 ms^{-1}.

[6]

(f) (ii) k is a positive constant. The relevant expected frequencies are given in the following table.

Find the least tension in the string during the motion.

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 $ax + by + cz = d$.

[5]

(iii) third coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{5}$.

cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

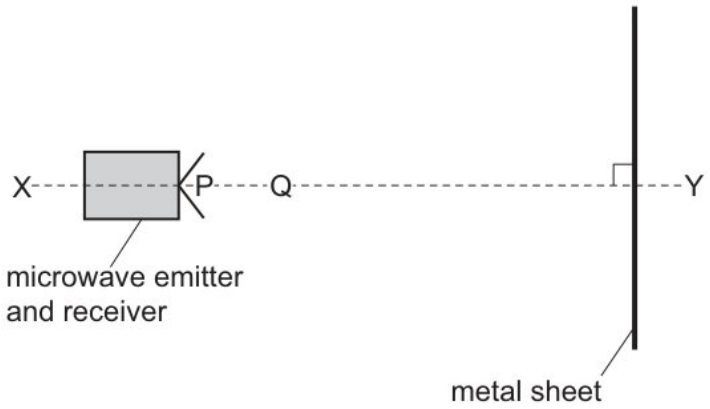
time = ... su **[3]**

(c) (ii) lengths of 250 leaves of a certain type of plant are measured, correct to the nearest centimetre. The results are summarised in the table below.

Find the value of a for which $\arg(u^*) = \frac{3}{4}\pi$, where u^* denotes the complex conjugate of u.

[2]

(i)



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

no digit can be repeated,

[6]

(iii) parametric equations of a curve are

State what happens to the electron and to the positron.

[4]

(iv) Determine whether this point is a maximum or a minimum point.

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

[4]

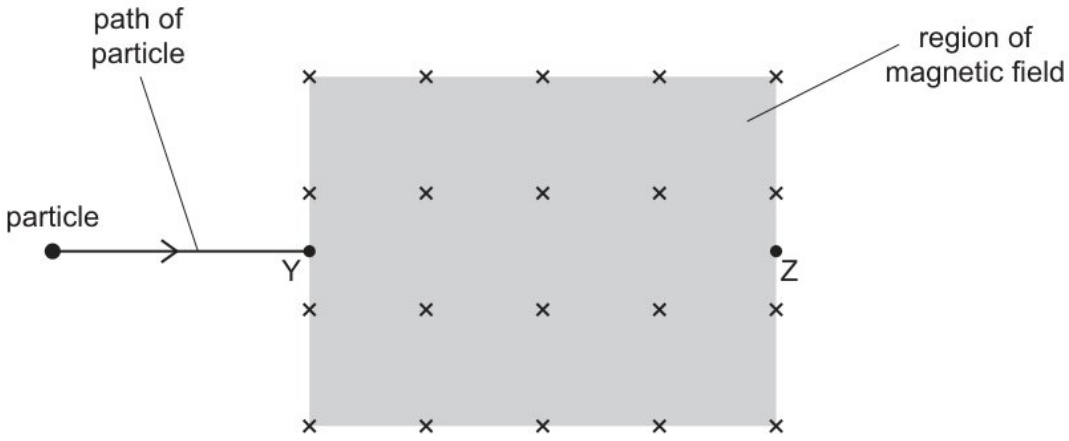
(ix) the subsequent collision between Q and R, these particles coalesce.

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

[20]

21 the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

(d) (i) Find the exact value of the arc length of C.



by calculation that a lies between 2 and 2.1.

[5]

(ii) Find the interquartile range of X.

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.

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

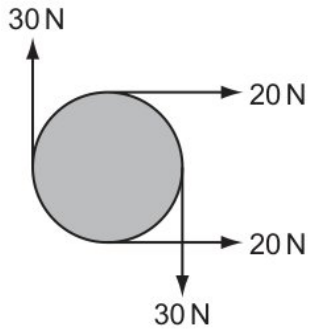
[8]

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

Obtain another equation relating u^2, v^2, a and g, and hence find u in terms of a and g.

[12]

(vi)



variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

the probability density function of Y,

[6]

(c) (iv) of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

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

[4]

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

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 $AC = a$.

[1]

(iii) matrix **A** is given by

are the amplitude and period of the wave?

[10]

(e) (i) a vector equation for l.

that l_1 and l_2 do not intersect.

[10]

(ii) curve C has equation

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

the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $\left(4, \frac{1}{3}\right)$.

[2]

12 the kinetic energy of the car at time $t = 5.8$ s.

(d) (i) The extension of the wire is proportional to the tensile force.

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

[5]

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

Find the work done by the tension.

[12]

(ii) **a** and **b** are vectors and t is a scalar.

Use the information in (d)(iv) to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.

curves C_1 and C_2 have polar equations

[5]

(c) (iii) resistance of a metal cube is measured by placing it between two parallel plates, as shown.

Show that the cartesian equation of C is

[6]

(ix) the graph of $y = |3x - 2a|$, where a is a positive constant.

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

[8]

(i) of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

[6]

14 Find the value of x.

(a) (iv) Saturday, a particular community holds a 'Puzzle' event to raise money for a new Leisure Centre. Competitors attempt to solve a puzzle as quickly as possible.

that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.

[6]

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

battery is marked 9.0 V .

astronauts = ... dv **[6]**

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

The matrix **B**, where

[6]

(iii) There will always be 9.0 V across the battery terminals.

$$I = \frac{P}{4\pi r^2}$$

the term elastic limit.

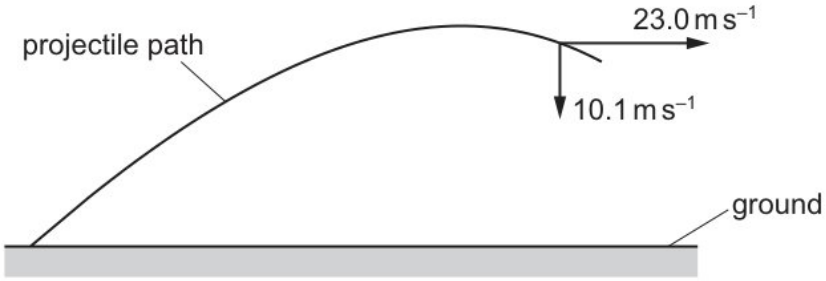
[4]

(c) (iv) are no resistive forces acting on the block.

copper wire is 6.4 m long and has a resistance of 0.92Ω.

[10]

(ii) Find the weight exceeded by the heaviest 5% of pineapples.



[4]

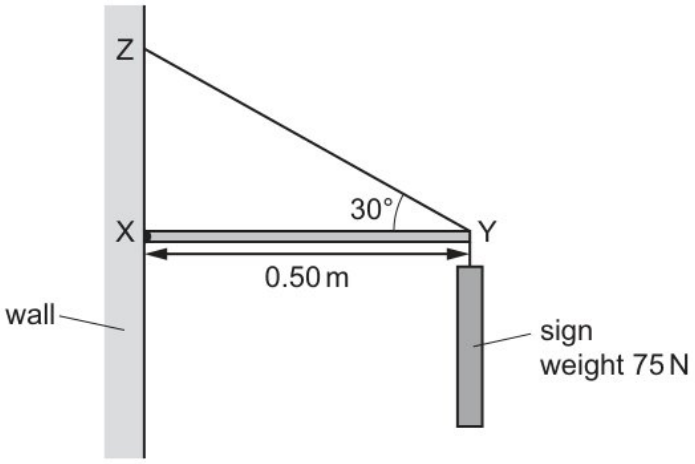
12 cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

the general solution of the differential equation

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

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

(a) (iii) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .



[2]

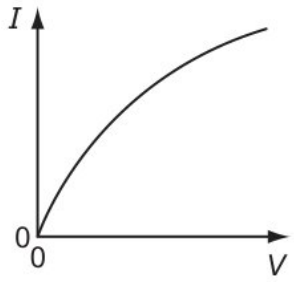
(vii)

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.

sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

[6]

(d) (iv)



Find the speed of P when it passes through L.

The mass of the car is 920 kg . At time $t = 0$, the car is at rest. At time $t = 5.8$ s, its velocity is 17 ms^{-1}.

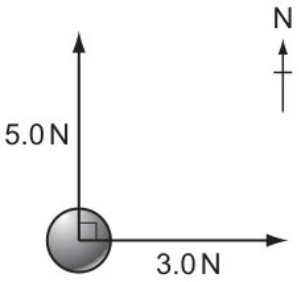
[6]

(ii) up the probability distribution table for X.

lamina is freely suspended at A and hangs in equilibrium.

[4]

(v)



the standard deviation of these 40 values of x.

There will always be 9.0 V across the battery terminals.

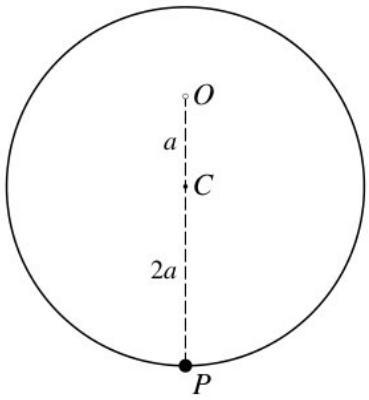
[3]

(e) (iii) cubic polynomial p(x) is defined by

V decreases because there is a p.d. across r.

[5]

(ii) object is fired upwards from horizontal ground. The object has an initial velocity of 20 ms^{-1} at an angle of 45° to the horizontal. Air resistance is negligible.



[2]

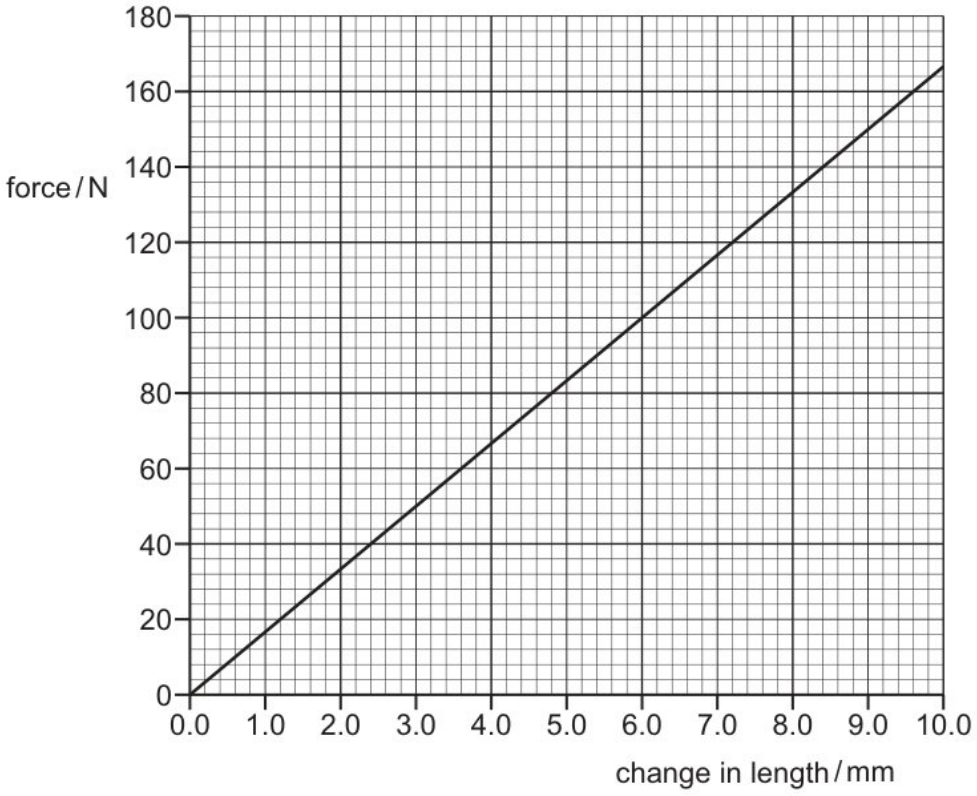
(i) photocell. This may be carried out in the laboratory by varying the number of identical thin

object of mass 8 kg slides down a line of greatest slope of an inclined plane. Its initial speed at the top of the plane is 3 m s^{-1} and its speed at the bottom of the plane is 8 m s^{-1}. The work done against the resistance to motion of the object is 120 J . Find the height of the top of the plane above the level of the bottom.

[12]

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

a value, to three significant figures, for the specific latent heat of fusion of water.



[20]

15 is given that $f(n) = 3^{3n} + 6^{n-1}$.

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

(b) (iii) and N are two electromagnetic waves.

short time after passing point B truck R moves in a straight line on horizontal ground. The driver of the truck applies the brakes. Fig. 3.2 shows the variation with time of the momentum of the truck.

suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

[5]

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

graph shows the variation with temperature of power, P, dissipated in the thermistor?

[5]

(c)(vii) Find a 99% confidence interval for μ, giving your answer correct to 2 decimal places.

Given instead that $G = 0$ and the forces are in equilibrium, find the values of F and α.

[4]

(i) State what is meant by the internal energy of a system.

Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

$$y = \frac{3x - 9}{(x - 2)(x + 1)}$$

[5]

(f) (iii) constant a is such that $\int_1^a 6x \ln x \, \mathrm{d}x = 4$

Find the product moment correlation coefficient for the data.

[5]

(ii) cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

f(x) is divided by $(x+2a)$ the remainder is $-22a^3$ When f(x) is divided by $(3x-a)$ the remainder is $-a^3$

many different colour arrangements are there of the 10 books?

[6]

16 1 Which quantity is a scalar quantity?

is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

(a) (iii) the mean of the times taken by all 50 runners.

Both light waves and sound waves show the Doppler effect.

[8]

(ii) polynomial $ax^3 - 3x^2 - 11x + b$, where a and b are constants, is denoted by p(x). 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 12 .

$$2xy^2 + 3x^2y = 1$$

[8]

(i) gravitational potential at a point.

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

[8]

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

continuous random variable, X, has probability density function given by

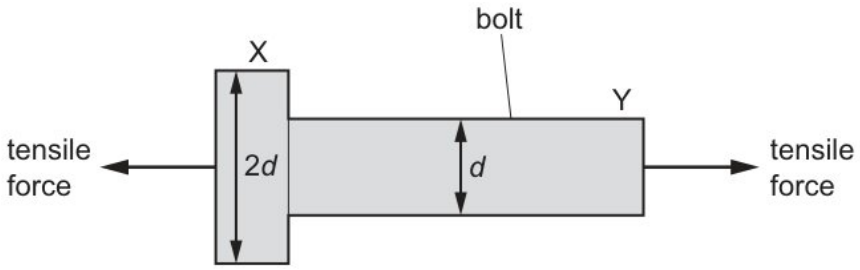
[8]

(ii) is the mass of the car?

$$\Sigma x = 210.9 \quad \Sigma(x - \bar{x})^2 = 151.2$$

[3]

(v)



that $k = 3$ and $p = 26$.

[10]

8 Find the probability that the die lands on 4 and the number of times the coin shows heads is 2 .

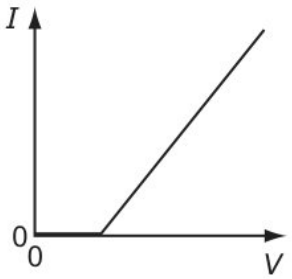
Determine the decay constant, in min^{-1}, of the radioactive isotope.

(c) (i) specific heat capacity of water is 4.18 J $\text{g}^{-1\circ}\text{C}^{-1}$.

line L_1 passes through the points $A(2, 5)$ and $B(10, 9)$. The line L_2 is parallel to L_1 and passes through the origin. The point C lies on L_2 such that AC is perpendicular to L_2. Find

[20]

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



[4]

(b) (iii) $\frac{\text{force}}{\text{length} \times \text{time}}$

is suggested that the strength B of the magnetic field at the centre of a flat circular coil is inversely proportional to the radius r of the coil.

$$\log_2(x + 5) = 5 - \log_2 x$$

[4]

(i) is the value of the ratio $\frac{V_1}{V_2}$?

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 2\frac{\mathrm{d}x}{\mathrm{d}t} + 5x = 4 - 5t^2$$

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.

[4]

25 masses of the bags of rice made by a company are normally distributed with mean μkg and standard deviation 0.14 kg . The probability that the mass of a randomly chosen bag of this rice is less than 1.48 kg is 0.22 .

(a) (ii) relationship is used in the derivation of the equation shown?

28 33 55 38 42 39 27 48 51 37 57 49 33

[4]

(iii) Find the tension in the string in terms of W.

diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.

[2]

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

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.

[8]

(iv) researcher records the time, T seconds, taken by adults to complete a questionnaire.

State what is meant by the internal energy of a system.

[4]

(c) (iv) Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

$$x = \frac{2}{5}t^{\frac{5}{2}} - 2t^{\frac{1}{2}}, \quad y = \frac{4}{3}t^{\frac{3}{2}}, \quad \text{for } 1 \leqslant t \leqslant 4.$$

[6]

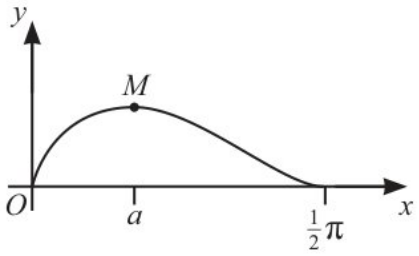
(i) ABC is a uniform triangular lamina of weight 19 N , with $AB = 0.22$ m and $AC = BC = 0.61$ m. The plane of the lamina is vertical. A rests on a rough horizontal surface, and AB is vertical. The equilibrium of the lamina is maintained by a light elastic string of natural length 0.7 m which passes over a small smooth peg P and is attached to B and C. The portion of the string attached to B is horizontal, and the portion of the string attached to C is vertical (see diagram).

Calculate the speed of the star relative to the Earth.

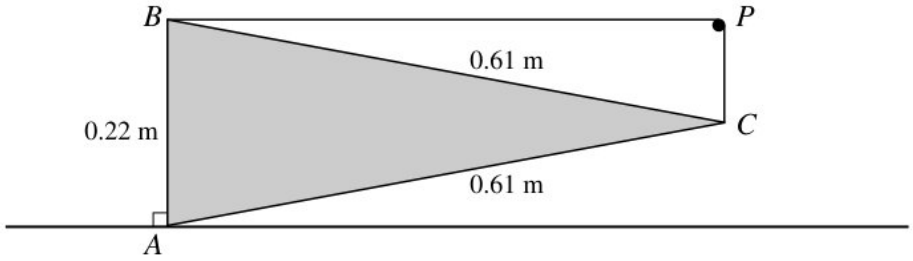
student determines the ratio $\frac{\text{upthrust acting on the object}}{\text{weight of the object}}$.

[6]

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



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



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

(a) (v) 100 nm to 400 nm

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

[12]

(ii) State what happens to the electron and to the positron.

$$x_1 = 1, \quad x_{n+1} = \frac{1}{2}\sqrt[3]{\left(x_n^2 + 6\right)}$$

[6]

(b) (iii) quantities would be measured in order to determine E ?

statement is correct when S is changed from open to closed?

[12]

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

that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[6]

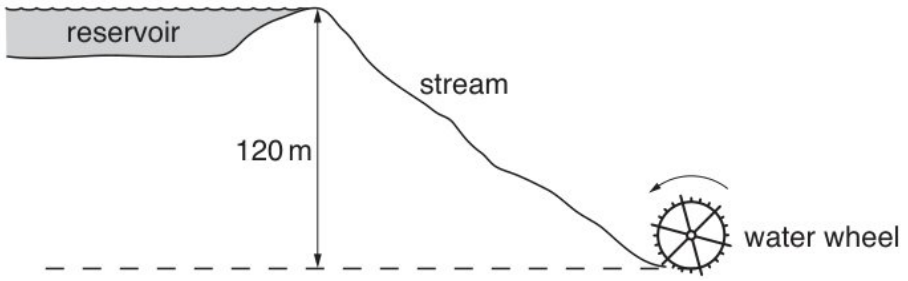
7 tension in the string of the pendulum is T. The weight of the pendulum bob is W. The string is held at an angle of 30° to the vertical.

(b) (i) Find the coordinates of the turning points of C.

curve C has equation $y = \frac{x^2+px+1}{x-2}$, where p is a constant. Given that C has two asymptotes, find the equation of each asymptote.

[6]

(iv)



wire of unstretched length 0.81 m is made of a metal with Young modulus 95 GPa . The wire obeys Hooke's law and has a constant cross-sectional area. Fig. 5.1 shows the force-extension graph for the wire.

[8]

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

the inequality $|x| < |5 + 2x|$.

$n \geqslant 0$. Use the fact that $\tan^2 x = \sec^2 x - 1$ to show that, for $n \geqslant 2$,

[6]

(a) (i) Find the probability that the die lands on 3 and the number of times the coin shows heads is 3 .

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

[3]

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

Explain how an electric field can be used with the magnetic field to ensure that the Explain how an electric field can be used with the magnetic field to ensure that the particle in (b) now passes through point Z. particle in (b) now passes through point Z.

[6]

(vi) Find the tension in the string.

object is free to rotate about the axis l. The object is held so that CA makes an angle α with the downward vertical and is released from rest.

that the mean of these 40 values is 124.0 , find the value of k.

[8]

(iv) sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

circle is divided into 6 sectors in such a way that the angles of the sectors are in arithmetic progression. The angle of the largest sector is 4 times the angle of the smallest sector. Given that the radius of the circle is 5 cm , find the perimeter of the smallest sector.

[5]

(c) (i) diagram shows part of the curve

Show that $m = 0.9$.

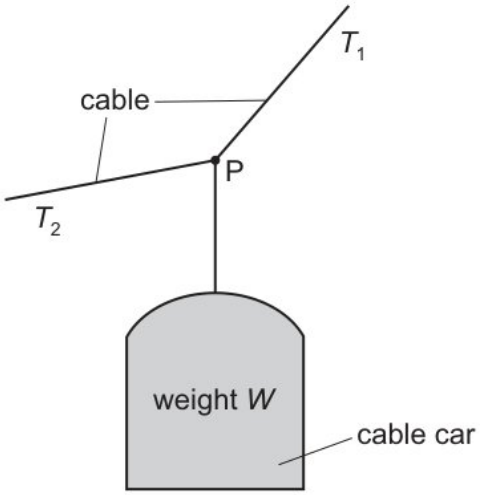
[4]

(iii) to the value α.

row describes the momentum and kinetic energy of the two bodies after the collision?

[6]

(iv)



logarithms to solve the equation $4^{x+1} = 5^{2x-3}$, giving your answer correct to 3 significant figures.

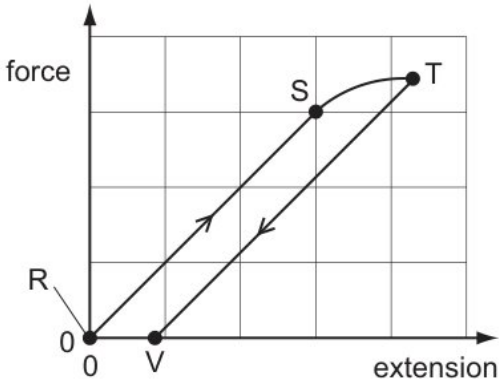
[6]

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

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

[1]

(v) the sum to infinity of the progression.



[8]

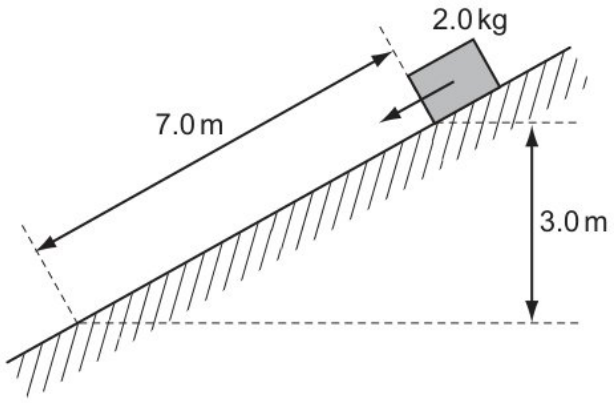
9 electron moving at a speed of 4.9×10^7 ms^{-1} collides with a positron that is travelling at the same speed in the opposite direction. As a result of the collision, two gamma-ray photons are produced.

(a) (iii) the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

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

[3]

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



[5]

(iv) $\frac{\text{force}}{\text{length} \times \text{speed}}$

Find the proportions of large, small and medium pineapples.

find corresponding eigenvectors.

[5]

(i) Find the terms in x^2 and x^3 in the expansion of $\left(1 - \frac{3}{2}x\right)^6$.

a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.

[3]

(b) (i) Density is mass per cubic metre.

Find angle ABC.

$$6\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 3\frac{\mathrm{d}x}{\mathrm{d}t} + 6x = \mathrm{e}^{-t}$$

[20]

(iii) Show that the cartesian equation of C is

control of variables,

[6]

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

(a) (i) is given that $\mu = 0.15$ and $X = 20$.

the gradient of the curve

[6]

(iii) Find the direction of motion of the particle 0.4 s after the instant of projection.

position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where

[4]

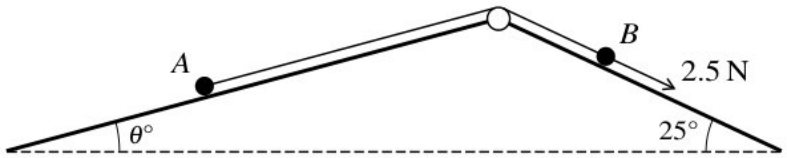
(b) (i) linear transformation T: $\mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M}$, where

cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm \sin \frac{1}{5}\pi$ and $x = \pm \sin \frac{2}{5}\pi$.

points = ... *pa* **[12]**

(v)



Find the values of a and b.

[8]

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

1,2 and 3

[6]

(iii) radius of the circle in which P moves and the radius of the circle in which Q moves,

the time taken for the ball to reach its maximum height

[10]

10 considering the binomial expansion of $\left(z - \frac{1}{z}\right)^5$, where $z = \cos\theta + \mathrm{i}\sin\theta$, use de Moivre's theorem to show that

A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

aircraft, initially stationary on a runway, takes off with a speed of 85 km h^{-1} in a distance of no more than 1.20 km .

Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

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

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).

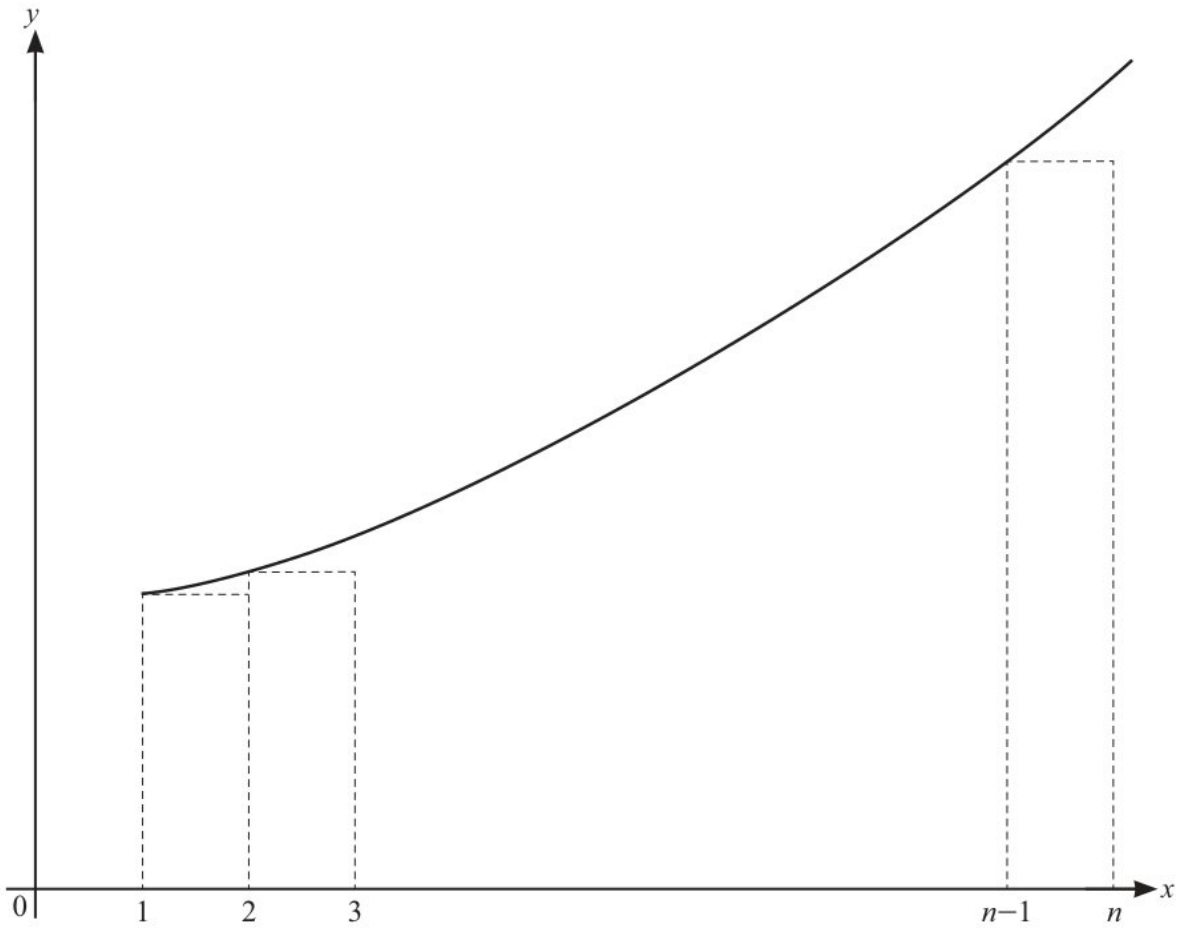
[5]

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

block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N , acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion.

[4]

(f) (ii)



gas is enclosed inside a cylinder which is fitted with a frictionless piston.

There will always be 9.0 V across the battery terminals.

[3]

(i) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant.

what is meant by work done.

[6]

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

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

[4]

(b) (i) potential difference (p.d.) between P and Q is V.

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

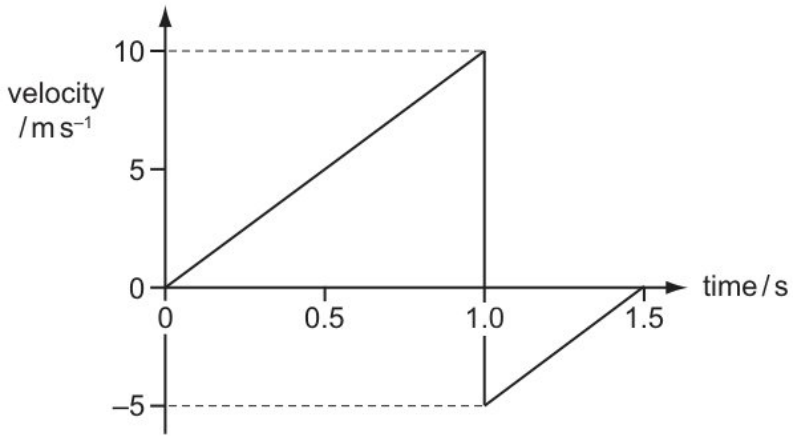
[6]

(v) diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

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

[3]

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



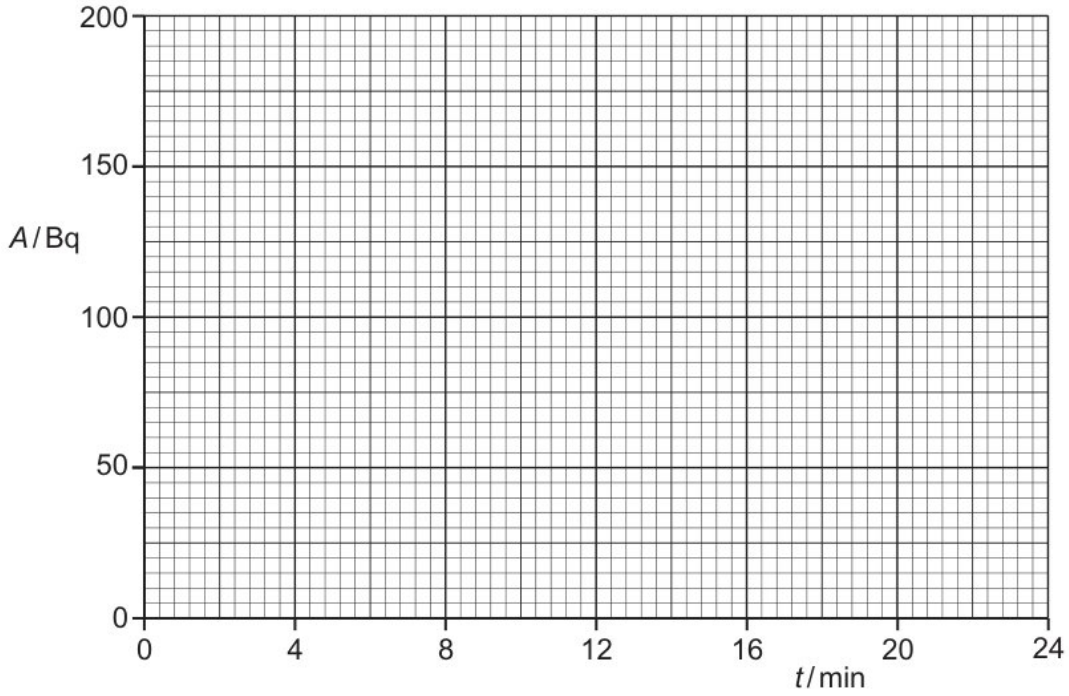
[5]

(iv) exactly at point S

believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p, is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $H_0 : p = 0.2$, against the alternative hypothesis, $H_1 : p < 0.2$.

[4]

(ii)



in terms of a, the distance that P moves down the plane before coming to rest.

[8]

(iii) matrix **M** represents a sequence of two geometrical transformations in the $x - y$ plane

random sample of 3 customers who each bought a computer from this store is chosen.

Find the terms in x^2 and x^3 in the expansion of $\left(1 - \frac{3}{2}x\right)^6$.

[5]

6 Use the trapezium rule with three intervals to estimate the value of

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 **AB**, and state corresponding eigenvectors.

(b) (i) 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).

a suitable approximation to find the probability that more than 50 of these competitors had times less than 36.0 minutes.

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.

[5]

(ii) Show that $u^3 + 8 = 0$.

Density is mass per cubic metre.

[2]

(iv) amplitude $\propto$ intensity

	direction of acceleration	separation of the plates
A	downwards	decrease
B	downwards	increase
C	upwards	decrease
D	upwards	increase

[4]

(a) (ii) 1 Which quantity is a scalar quantity?

t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

Find the speed of P when it passes through L.

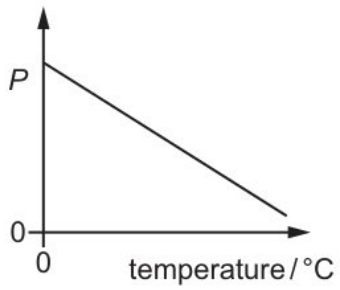
[8]

(iii) is given that $\sum x^2 = 1823.0$.

the term isotope.

[5]

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



[2]

(d) (i) that $v = y^3$, show that

Find the magnitude and direction of the force exerted by the surface on the lamina at A.

$$\int_2^5 (x - 2\ln x)\mathrm{d}x$$

[10]

(ii) Speed is distance travelled per second.

Calculate the acute angle between the planes p and q.

[5]

(c) (ii) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant.

are the amplitude and period of the wave?

[3]

(i) the polar coordinates of the points of intersection of C and l.

the probability of a Type I error.

[8]

(iv) planes have equations $x + 2y - 2z = 7$ and $2x + y + 3z = 5$.

linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$

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

[10]

(g) (iv) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .

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

[4]

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

How many possible arrangements are there of seating Mary, Ahmad, Wayne, Elsie and John if Mary and Ahmad sit together in the front row and the other three sit together in one of the other rows?

passing = ... ga **[8]**

10 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.

(c) (iii) diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

$$\sin\frac{1}{5}\pi \sin\frac{2}{5}\pi \sin\frac{3}{5}\pi \sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right) + \sin^2\left(\frac{2}{5}\pi\right)$$

[5]

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

obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

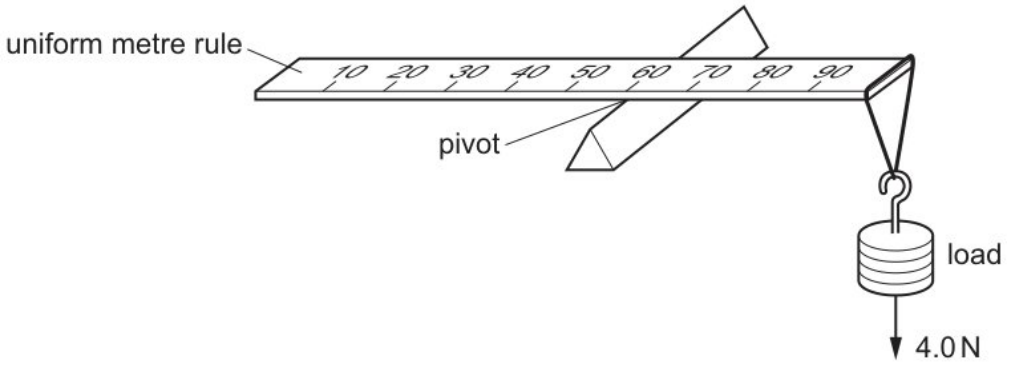
[6]

(b) (i) p and q are given real numbers, then

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

[5]

(ii)



the Maclaurin s series for $e^{\left(\frac{1}{x+2}\right)}$ up to and including the term in x^2

[6]

(v) bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

ripple tank is used to demonstrate interference between water waves.

with = ... aq **[12]**

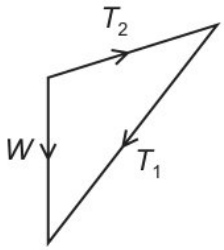
(a) (iv) particles P and Q are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of P and Q are 12 m s^{-1} and 7 m s^{-1} respectively and the heights of P and Q above the ground, t seconds after projection, are h_P m and h_Q m respectively. Each particle comes to rest on returning to the ground.

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 θ with the upward vertical.

Gulls	7.9	8.2	8.3	8.6	8.6	8.8	9.2	9.7	9.8	10.0	10.4
Herons	9.5	9.9	8.5	8.1	9.2	10.8	8.3	9.7	9.3	9.9	8.7

[5]

(iii)



random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

[2]

(d) (iii) Find the greatest height that P reaches above the level of O.

$$\mathrm{f}(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{2} & 1 \leqslant x \leqslant 3 \\ 0 & x > 3 \end{cases}$$

the form $\sec(q\pi)$ where q is rational

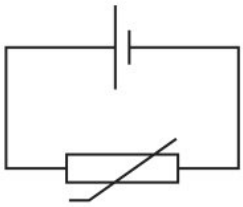
[10]

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

are the frequencies of the next two higher notes for this air column?

[6]

(ii) Show that the mass of Mars is 6.4×10^{23} kg.



[6]

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

body travelling with a speed of 10 ms^{-1} has kinetic energy 1500 J .

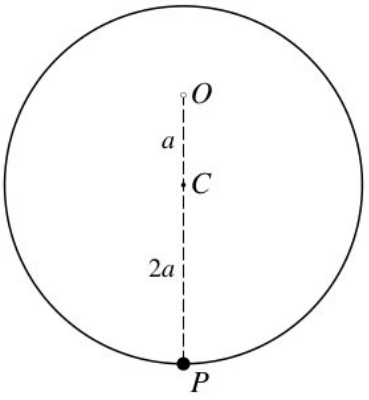
line L_1 passes through the points $A(2, 5)$ and $B(10, 9)$. The line L_2 is parallel to L_1 and passes through the origin. The point C lies on L_2 such that AC is perpendicular to L_2. Find

[8]

8 Find the mean and standard deviation of the weights of boys aged 16 years in Brigville.

is given that $\text{f}(n) = 3^{3n} + 6^{n-1}$.

(b) (ii) 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° and α 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.



[5]

(i) Find the product moment correlation coefficient for the data.

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.

[8]

(iii) diagram shows two waves R and S.

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

$I_n = \int_0^1 x^n(1-x)^{\frac{1}{2}}\,\mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

[6]

(c) (ii) how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

Find the terms in x^2 and x^3 in the expansion of $\left(1 - \frac{3}{2}x\right)^6$.

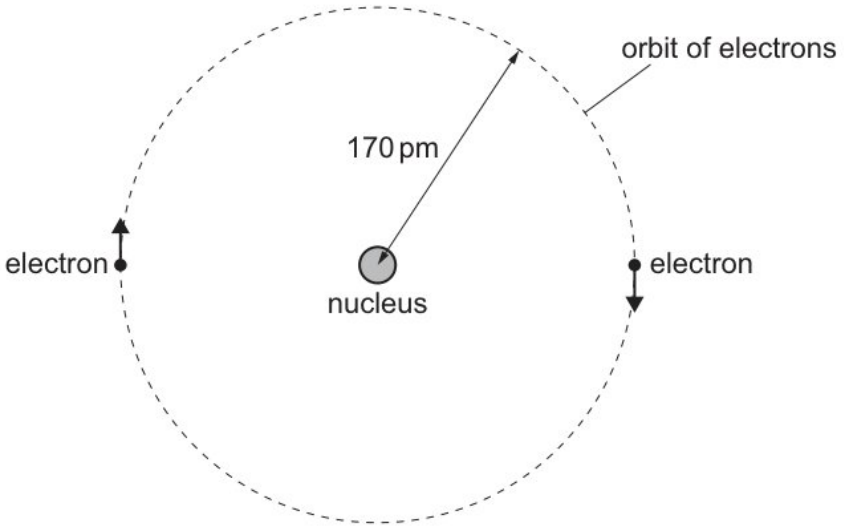
[15]

(i) of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

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

[12]

(iii) x is in radians, has only one root for $0 < x \leqslant \frac{1}{2}\pi$.



[6]

(iv) equation of a curve is $xy + y^2\mathrm{e}^{-x} = 4$.

how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

[20]

(e) (iv) Find angle ABC.

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.

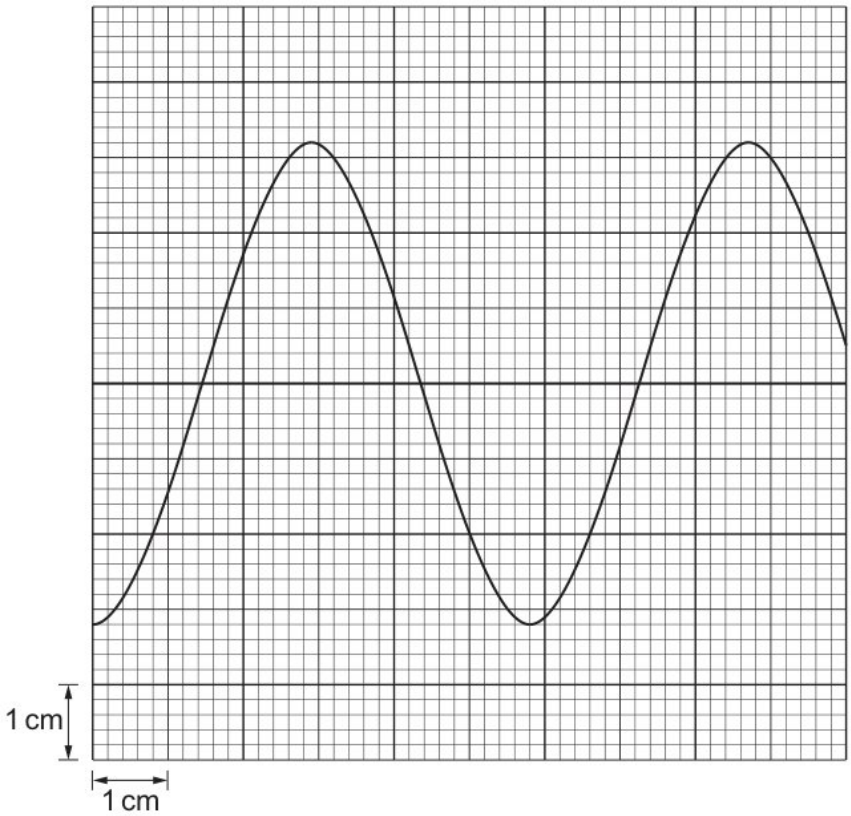
[10]

(vi) stationary nucleus has nucleon number A.

the probability of a Type I error.

[5]

(v)

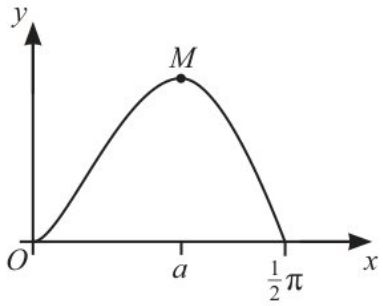


amplitude $\propto \sqrt{\text{intensity}}$

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.

[2]

(ii)



Write down matrices $\mathbf{P}$ and $\mathbf{D}$ such that $\mathbf{P}^{-1}\mathbf{AP} = \mathbf{D}$, 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.

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

[8]

10 polynomial $3x^3 + pax^2 + 7a^2x + qa^3$ is denoted by f(x) where p, q and a are constants and $a \neq 0$

(c) (ii) ball of mass m kg is projected vertically upwards with initial speed U m s^{-1} and moves under gravity. At time t s after projection, the ball has travelled a distance x m and its speed is v m s^{-1}. There is a resistive force of magnitude mkv^2 N, where k is a positive constant.

the average power of the aeroplane's engines.

[10]

(iii) (amplitude)$^2 \propto \sqrt{\text{intensity}}$

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

[6]

(d) (iii)

X and Y are connected in series to a cell.

[5]

(i) particle P starts from rest at a point O and travels in a straight line. The acceleration of P is $(15 - 6x)\text{ms}^{-2}$, where x m is the displacement of P from O.

the exact volume of the solid generated

[12]

(iv) analysis of the data,

Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

[6]

21 that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.

(a) (iii) state an eigenvector of the matrix **CD** and give the corresponding eigenvalue.

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.

[15]

(ii) height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

the speed of Q after the collision.

[4]

(c) (i) For some nuclei, the nucleon number can be less than the proton number.

rod in (b) is removed from the pin and supported by ropes A and B , as shown in Fig. 2.2.

[4]

(iii) Given that the total number of cars sold during the 5 days is 5 , carry out the test.

supermarket is open 7 days a week.

[5]

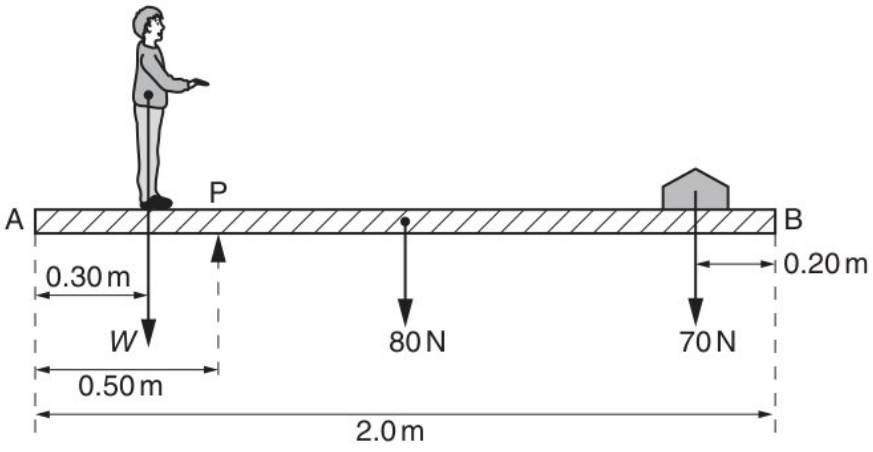
(d) (v) mass of peaches sold per day in a supermarket is normally distributed with mean 65.8 kg and standard deviation 9.6 kg

x is in radians, has only one root for $0 < x \leqslant \frac{1}{2}\pi$.

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 2\frac{\mathrm{d}x}{\mathrm{d}t} + 5x = 4 - 5t^2$$

[5]

(i) Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.



[5]

12 1.1 shows the measurements for cube A.

(a) (v) For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

Find the equation of the tangent to the curve at the point where $x = 0$.

[6]

(ii) Saturday, a particular community holds a 'Puzzle' event to raise money for a new Leisure Centre. Competitors attempt to solve a puzzle as quickly as possible.

expression calculates the fractional uncertainty in the value of this speed?

[5]

(iii) bag contains 10 marbles, of which 4 are red and 6 are blue. Four marbles are selected from the bag at random, without replacement. The random variable X denotes the number of blue marbles selected.

aircraft, initially stationary on a runway, takes off with a speed of 85kmh^{-1} in a distance of no more than 1.20 km .

The total momentum and the total kinetic energy are always conserved.

[5]

(iv) is the horizontal distance of the van's centre of gravity from the front of the van?

three quantities that are conserved during the decay.

State the work W done by F.

[2]

(d) (vi) State the equation of the other asymptote.

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

skateboarder and her skateboard have a total mass of 70 kg . She pushes on the ground with her foot to create a forward force F of 25 N on herself and the skateboard, as shown in the diagram.

[6]

(iii) diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

Show that the mean number of rooms that are occupied each night is 3.25 .

[10]

(i) Find the values of p and q such that

curve C has equation $\tan y = x$, for $x > 0$.

[6]

(iv) village hall has seats for 40 people, consisting of 8 rows with 5 seats in each row. Mary, Ahmad, Wayne, Elsie and John are the first to arrive in the village hall and no seats are taken before they arrive.

P and Q collide and stick together.

Let $z = \cos\theta + \mathrm{i}\sin\theta$. Show that $z - \frac{1}{z} = 2\mathrm{i}\sin\theta$ 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.

[2]

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

(d) (ii) van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

Use de Moivre's theorem to prove that

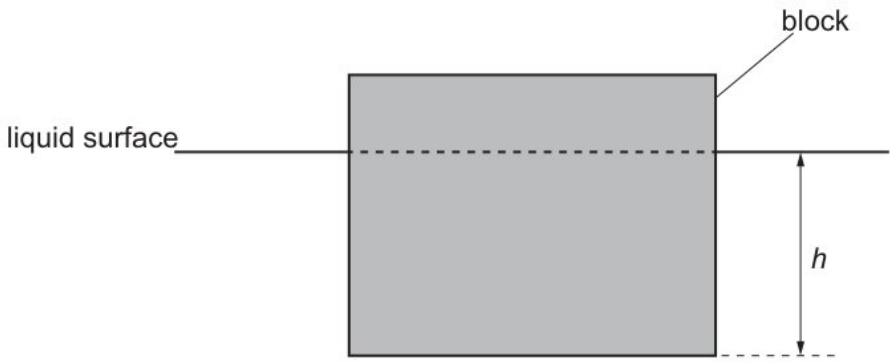
[6]

(iv) 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.

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

[4]

(iii)



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

[6]

(c) (ii) Derive an expression for v in terms of B and the electric field strength E.

Use implicit differentiation to show that

[12]

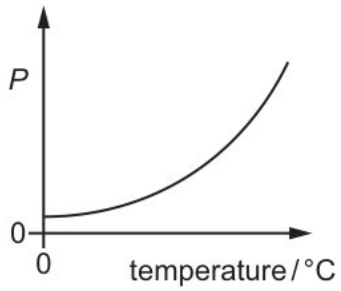
(iv) has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.

car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

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

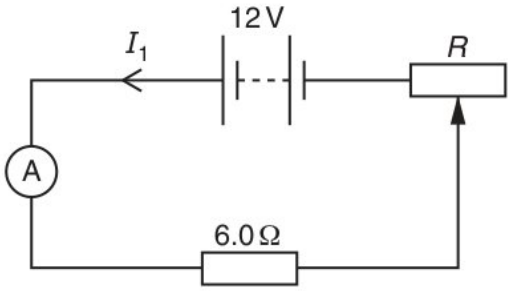
frame = ... *xl* **[10]**

(iii) gravitational potential at a point.



[10]

(a) (i) control of variables,



[2]

(iii) block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N , acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion.

is the current in the load resistor?

bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

[12]

(iv) Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm \sin \frac{1}{5}\pi$ and $x = \pm \sin \frac{2}{5}\pi$.

Prove by mathematical induction that, for all positive integers n,

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

[8]

(b) (iv) Hence show that the differential equation

Find the equation of the tangent to the curve at the point where $\theta = \frac{1}{4}\pi$, giving your answer in the form $y = mx + c$.

[6]

(v) row compares the number of charge carriers per unit time passing through X and through Y and compares the average drift speed of the charge carriers in X and in Y ?

exactly at point S

[4]

(ii) Find the coordinates of the turning points of C.

the geometric effects of multiplying z_1 and z_2 by ω

[5]

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

curve with equation $y = \frac{2-\sin x}{\cos x}$ has one stationary point in the interval $-\frac{1}{2}\pi < x < \frac{1}{2}\pi$.

diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.

sample of an ideal gas at thermodynamic temperature T has internal energy U.

(a) (iii) statement describes the speed of the object after it is fired until immediately before it reaches the ground again?

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 .

[3]

(ii)

	A	n	v	q
A	area of cross-section	number of free electrons	voltage	charge of each molecule
B	area of cross-section	number of free electrons per unit volume	average drift speed of electrons	charge of each electron
C	current	number of free electrons	average drift speed of electrons	charge of each molecule
D	current	number of free electrons per unit volume	voltage	charge of each electron

there are no restrictions,

[12]

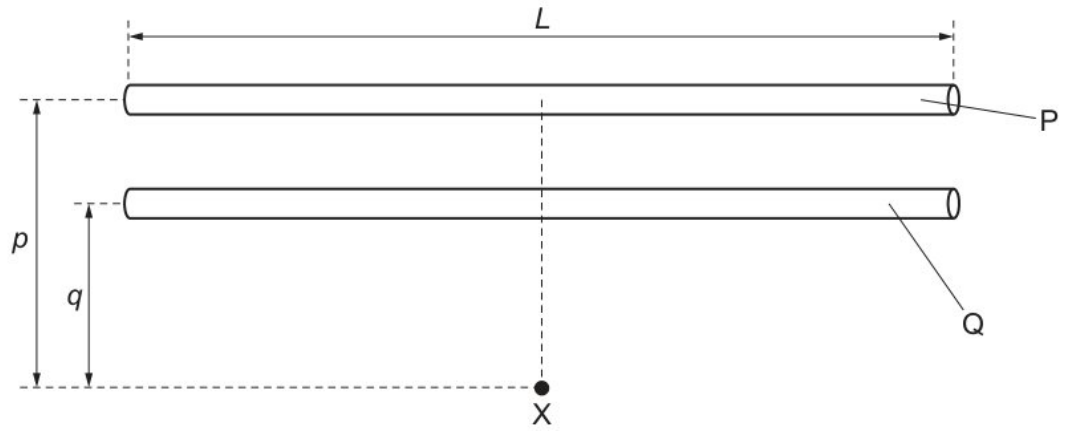
(d) (iii) particle moves in a straight line. The velocity v ms^{-1} of the particle t s after leaving a fixed point O is given by $v = k\left(20 + pt - 6t^2\right)$, where k and p are constants. The acceleration of the particle at $t = 1$ is 42 ms^{-2}, and the displacement of the particle from O at $t = 1$ is 93 m .

$$\sum(x-k) = 836.0, \quad \sum(x-k)^2 = 25410.8$$

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 $0 < \theta < 2\pi$.

[5]

(iv)



the probability that Ali, Ben and Charlie are all in the same group.

[5]

(b) (ii) variables x and y satisfy the differential equation

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

[5]

(iii) Show that $\frac{\mathrm{d}^{n+1}}{\mathrm{d}x^{n+1}}\left(x^{n+1}\ln x\right) = \frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n + (n+1)x^n \ln x\right)$.

the acute angle between the planes ABC and ABD.

[4]

18 potential difference across a resistor is 12 V . The current in the resistor is 2.0 A .

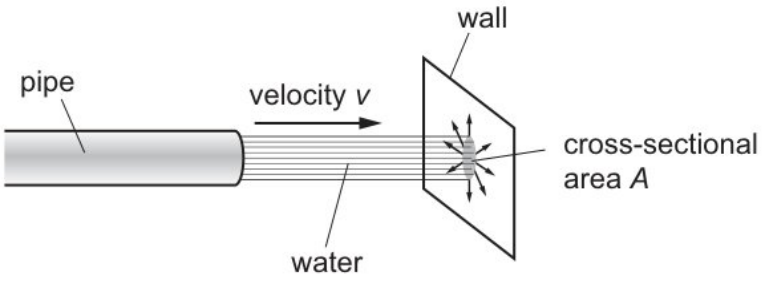
(a) (i) is suggested that these results are consistent with a distribution having probability density function f given by

what time will some portion of the wavefront GH reach point P ?

[2]

(iii) Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

light is passed through a narrow slit and the grating is placed so that its lines are parallel to the slit. Light passes through the slit and then the grating.



[5]

(iv) 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.

that, at the point of C furthest from the initial line,

procedure to be followed,

[6]

(v) the probability density function of Y,

It is given that the determinant of $\mathbf{A}$ is equal to the product of the eigenvalues of $\mathbf{A}$. Use this result to find the third eigenvalue of $\mathbf{A}$, and find also a corresponding eigenvector.

[5]

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

Find the equation of the tangent to the curve at the point where $x = 0$.

[5]

(i) State what happens to the electron and to the positron.

this compression, work W is done on the gas.

eigenvalues $1, -1$ and -2 .

[6]

(g) (i) Its speed decreases to zero, then increases to 20 m s^{-1}.

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 3\left(2^n - 1\right) \\ 0 & 1 \end{pmatrix}$$

Show that the mean number of rooms that are occupied each night is 3.25 .

[5]

(vi) uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

diagram shows four forces applied to a circular object.

etween time $t = 0$ and time $t = 5.8$ s the work done against resistive forces is 4.7×10^4 J

[5]

(iii) the probability that fewer than 6 rolls of this dice are required to obtain an A .

an electron and an antineutrino

line L_1 passes through the points $A(2, 5)$ and $B(10, 9)$. The line L_2 is parallel to L_1 and passes through the origin. The point C lies on L_2 such that AC is perpendicular to L_2. Find

[3]

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

the probability that a 3 is obtained for the second time before the 6th throw.

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

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 $90°$ and α 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.

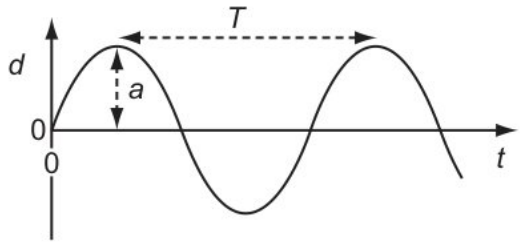
[10]

(iii) three coplanar forces shown in the diagram act at a point P and are in equilibrium.

Nucleus X undergoes β^-decay to form nucleus Z.

[5]

(f) (i)



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

Find the probability that the die lands on 3 and the number of times the coin shows heads is 3 .

[10]

(iii) row best specifies the correct $I - V$ graphs for the lamp and the diode?

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

is the force exerted on the wall by the water?

[5]

(d) (iii) Find the rate of working of the tension at this instant.

Fig. 7.1, complete the charge and mass of α-particles, β-particles and γ-radiation. Give example speeds of α-particles and γ-radiation emitted by a laboratory source.

[6]

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

diagram shows the graph of the probability density function, f , of a random variable X. The graph is a straight line from $(0, a)$ to $(2, b)$, where a and b are positive constants. Elsewhere, $\mathrm{f}(x) = 0$.

Calculate the length AG.

[6]

(iv) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{\sin\theta\cos^3\theta}$.

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

Find the modulus and argument of u.

[15]

(c) (v) an instant during the motion the velocity of the load is 1.5 m s^{-1}.

$\mathrm{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

Find the mean and standard deviation of the weights of boys aged 16 years in Brigville.

[2]

(ii)

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

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

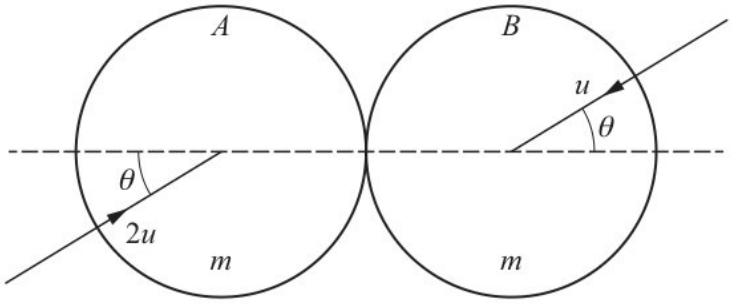
[10]

22 the other root and hence find the values of b and c.

$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

line l_1 passes through the point with position vector $8\mathbf{i} + 8\mathbf{j} - 7\mathbf{k}$ and is parallel to the vector $4\mathbf{i} + 3\mathbf{j}$. The line l_2 passes through the point with position vector $7\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$ and is parallel to the vector $4\mathbf{i} - \mathbf{k}$. The point P on l_1 and the point Q on l_2 are such that PQ is perpendicular to both l_1 and l_2. In either order,

(a) (ii) The extension of the wire is not proportional to the tensile force.



Find the area of one loop of C.

[10]

(iii) specific heat capacity of water is 4.18 J $g^{-1}°C^{-1}$.

a set of 40 values of x, it is found that

[6]

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

Find the values of a and b.

[5]

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

Show that the mean number of rooms that are occupied each night is 3.25 .

[4]

(i) that l_1 and l_2 do not intersect.

the gas has a volume V_1 and is in equilibrium with the external pressure p. The gas is then heated slowly so that it expands at constant pressure, pushing the piston back until the volume of the gas has increased to V_2.

[6]

(iv) Find the area of one loop of C.

the time from release until OP makes an angle $\frac{1}{2}\alpha$ with the downward vertical for the first time.

cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ

[2]

18 are no resistive forces acting on the block.

(a) (iii) Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{3x^2y - 3y^3}{9xy^2 - x^3}$.

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

[5]

(vi) 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.

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

the Young modulus.

[4]

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

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

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

[3]

(i) The weight of the plank equals the force on the plank from the pivot.

P hears a sound of increasing frequency.

[6]

(v) 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.

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

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

[5]

(iii) amplitude $\propto$ intensity

$$\sum_{r=1}^{n}(2 - 3r)(5 - 3r) = an^3 + bn^2 + cn$$

state an eigenvector of the matrix **CD** and give the corresponding eigenvalue.

[8]

(b) (iii) Calculate the speed of the star relative to the Earth.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - \left(8x + \frac{1}{x}\right)\frac{\mathrm{d}y}{\mathrm{d}x} + 12x^2y = 4x^2\mathrm{e}^{-x^2}$$

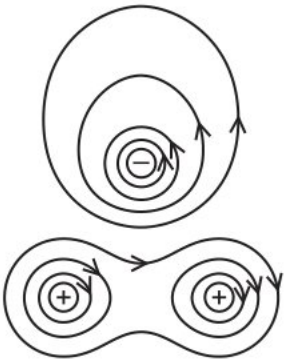
[5]

(i) Use de Moivre's theorem to prove that

$z = 3\mathrm{e}^{\frac{1}{4}\pi\mathrm{i}}$ is a root of the equation $z^2 + bz + c = 0$, where b and c are real.

[4]

(iv)



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.

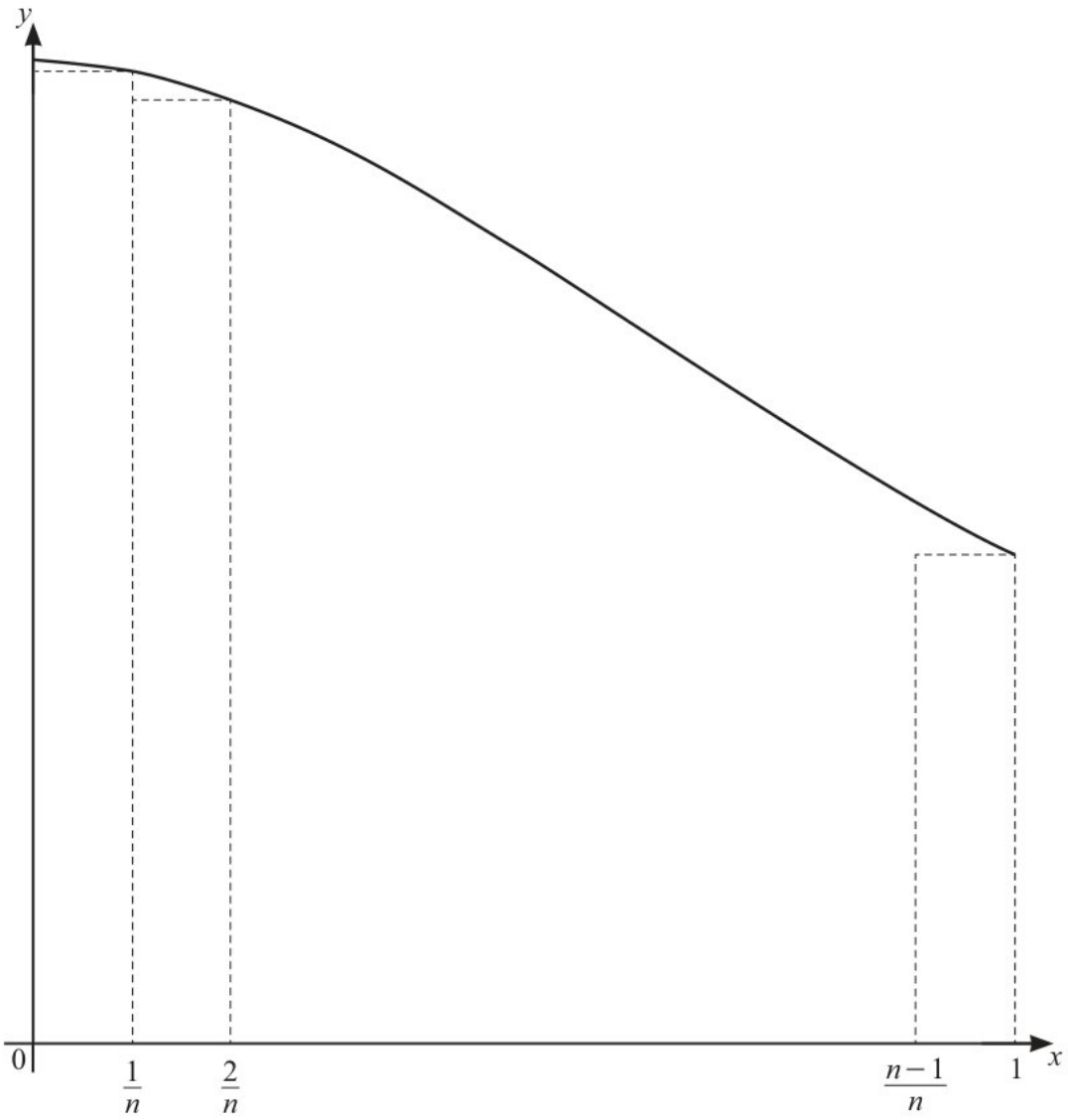
[2]

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

statement is correct?

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

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



[5]

(d) 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.

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

the values of a for which the system of equations

[8]

(b) sample of an ideal gas at thermodynamic temperature T has internal energy U.

plane Π_2 contains the lines

[4]

(iii) (c) Show that the mean number of rooms that are occupied each night is 3.25 .

Find the rank of **A** and a basis for the null space of T .

[1]

(b) as shown in Fig. 2.1.

the value of θ.

[6]

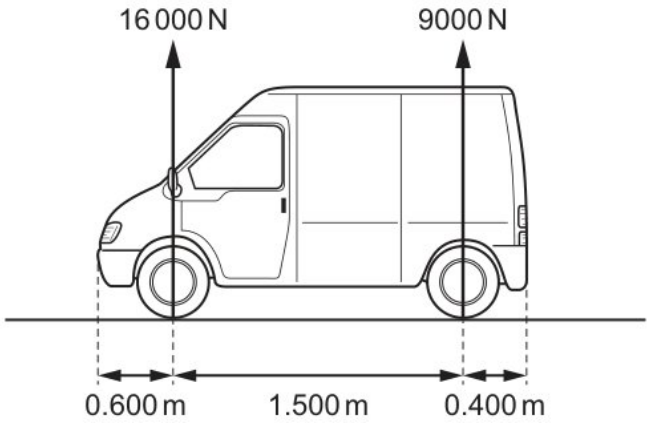
(d) for $0° \leqslant \theta \leqslant 180°$ the equation $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) = 3$,

The curve C has equation $y = \sec^3 x$ for $0 \leqslant x \leqslant \frac{1}{4}\pi$. The region R is bounded by C, the x-axis, the y-axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x-axis.

ice cube of mass 37.0 g at temperature 0.0°C is placed in a beaker containing water of mass 208 g at temperature 26.4°C.

[3]

(a) parametric equations of a curve are



Hence factorise p(x) completely.

[12]

(vi) (a)

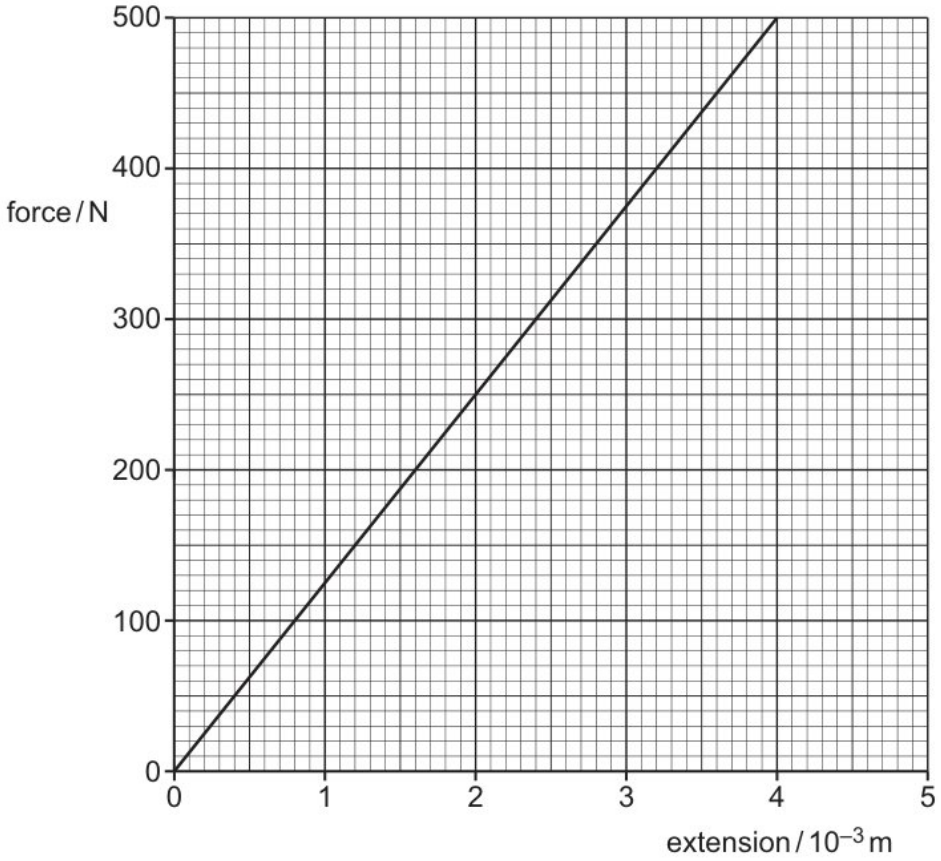
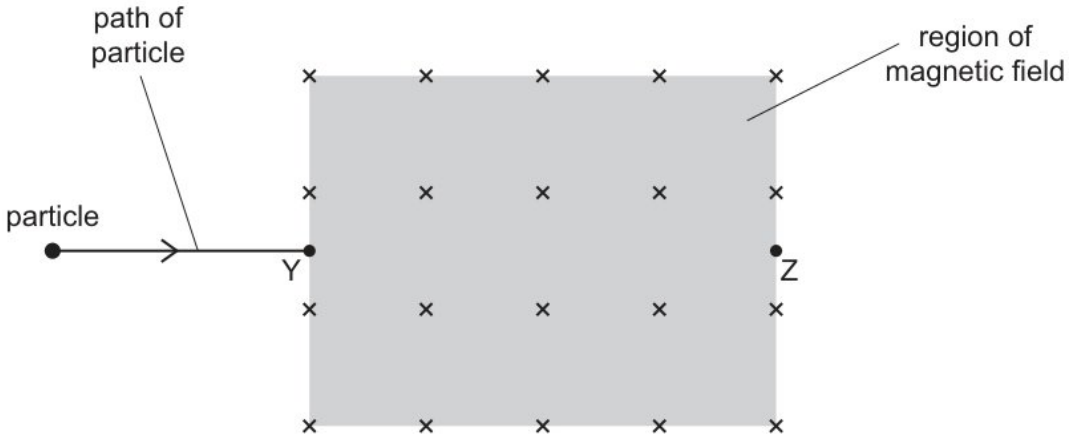


diagram shows the curve $y = x^2 e^{-x}$.

[10]

(b) 1 and 2 only



[12]

(c) Find the product moment correlation coefficient for the data.

is the average useful power at which he is working?

[6]

(iv) (c) is the efficiency of the process?

the values of ωz_1 and ωz_2 Give your answers in the form $re^{i\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

[4]

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

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 .

[6]

24 safety precautions to be taken.

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

the exact value of a.

[8]

(ii) Find $\frac{dy}{dx}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

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

[6]

(b) (iii) magnetic flux density.

that the area of the region bounded by the initial line, the arc of C_1 from $\theta = 0$ to $\theta = \beta$, and the arc of C_2 from $\theta = \beta$ to $\theta = \frac{1}{4}\pi$ is

[5]

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

t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

[3]

(i) electromagnetic wave phenomenon is needed to explain the spectrum produced when white light falls on a diffraction grating?

Hence find the value of $\frac{d^2y}{dx^2}$ at the point $\left(1, \frac{1}{4}\pi\right)$ on C.

[5]

(d) (iii) Find the frictional and normal components of the contact force acting on B.

Draw up the probability distribution table for X.

[15]

(ii) point D is such that $ABCD$ is a parallelogram.

the type of each transformation and make clear the order in which they are applied

[2]

(i) Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

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

equation $x^3 + px + q = 0$ has a repeated root. Prove that $4p^3 + 27q^2 = 0$.

[6]

19 Find the probability that a randomly chosen letter weighs more than 13 g .

(c) (i) an instant during the motion the velocity of the load is 1.5 m s^{-1}.

State the work W done by F.

in terms of m and g, the magnitude of the frictional force in this position.

[5]

(iii) cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

the circuit shown, XY is a length L of uniform resistance wire. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a small signal lamp S .

[5]

(b) (ii) the matrix **A**,

The waves must have equal amplitudes.

[5]

(iii) sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

tension in the string when the particle is at Q is twice the tension in the string when the particle is at P.

[3]

(i) uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

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

[6]

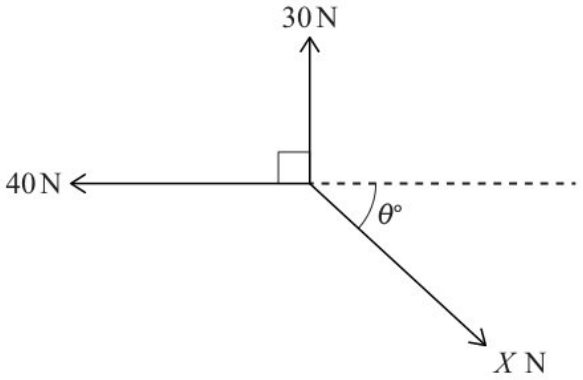
(d) (ii) is suggested that these results are consistent with a distribution having probability density function f given by

the exact value of I_2

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

[4]

(i) - falling freely with the parachute closed,



[3]

(iii) the values of p and q

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

a diagram, on page 3, showing the arrangement of your equipment. In your account

[6]

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

(a) (i) is given that $y = 2$ when $x = 2$.

V increases because there is a p.d. across R.

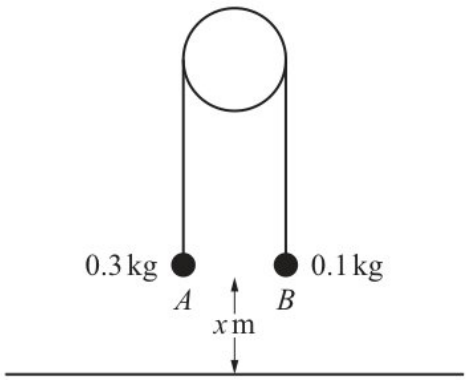
[15]

(v) roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

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

[6]

(iv) 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° to the vertical.



variation with extension x of the force F for a spring A is shown in Fig. 6.1.

[8]

(c) (v) the exact value of $\int_{\frac{1}{5}\pi}^{\frac{1}{4}\pi} 3\cos^2 5x \, \mathrm{d}x$

is given instead that $\mu \neq 0.15$ and that when $X = 10$, the block is on the point of moving down the plane.

[8]

(vi) only one of the following two alternatives.

curve C with equation

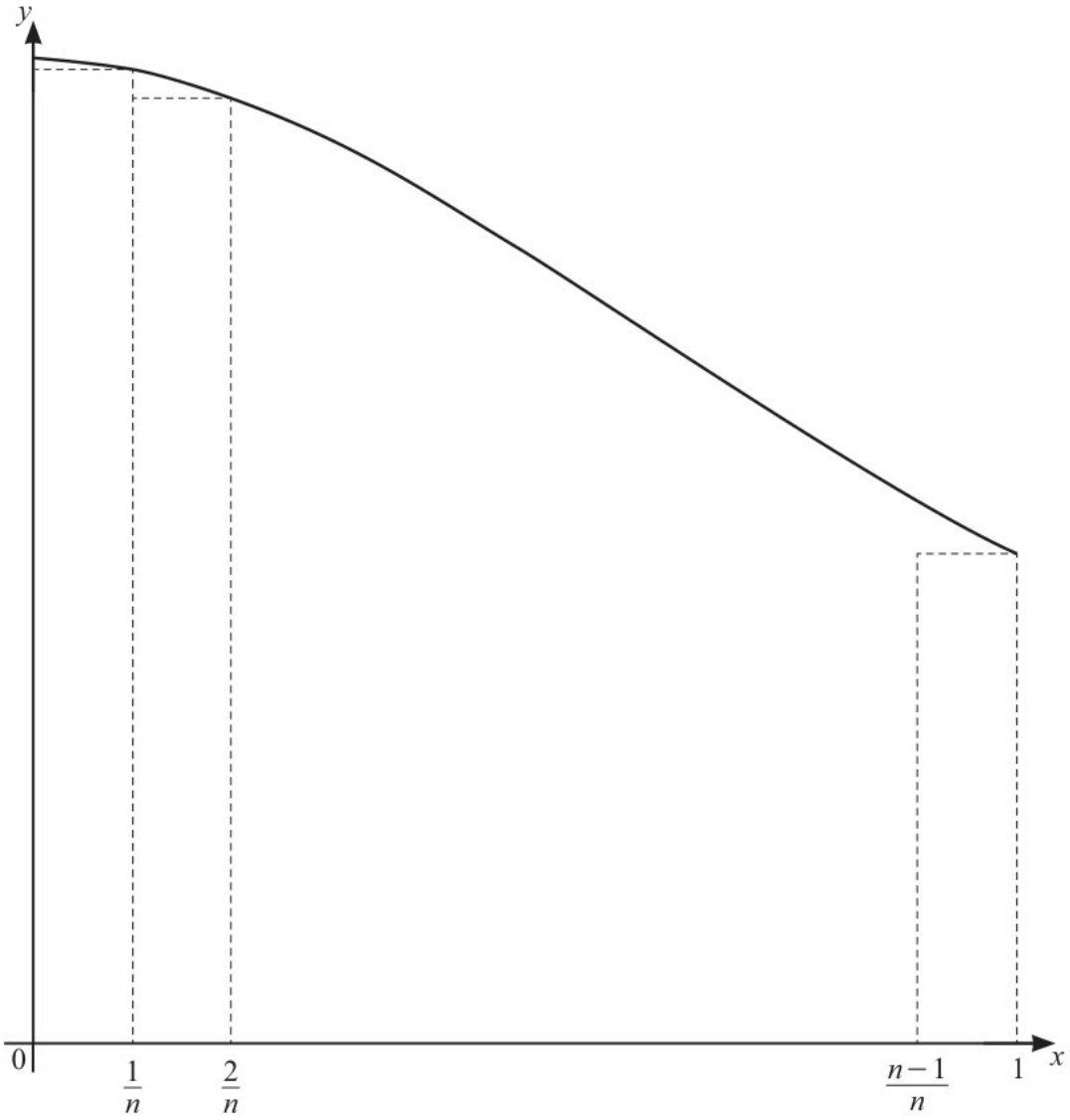
[2]

(i) Find the greatest height that P reaches above the level of O.

is given that $\sum x^2 = 1823.0$.

[3]

(b) (i)



the general solution of the differential equation

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[5]

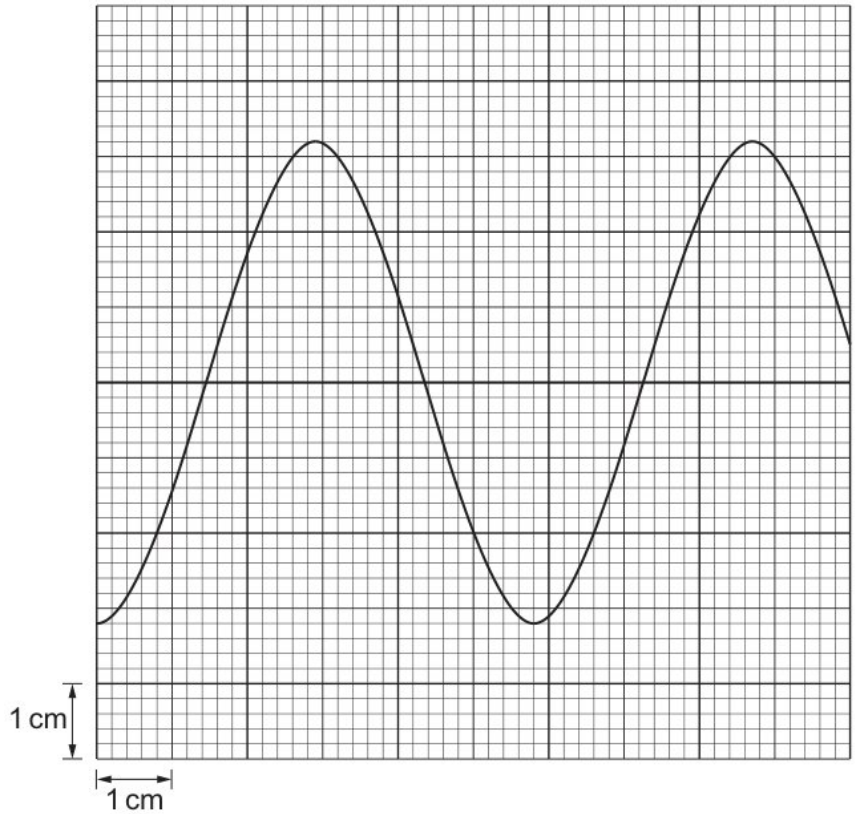
(ii) the value of θ for which the transformation represented by **M** has a line of invariant points 7

The waves must be coherent.

[10]

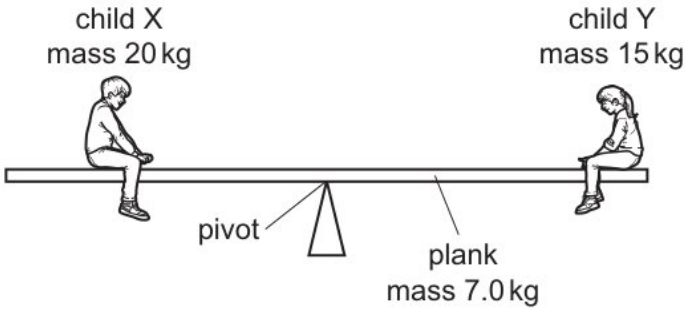
(iii) the subsequent motion, B does not reach the pulley. When A reaches the ground, it comes to rest.

Find a vector equation for the line of intersection of the planes.



order than = ... hh **[6]**

(e) (iv) Show that $b = 1 - a$.



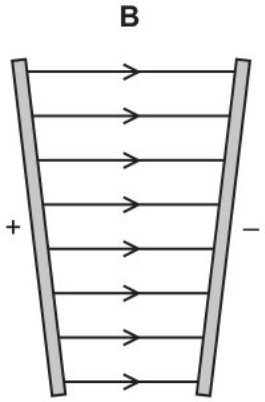
[8]

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

suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

[6]

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



[15]

(iv) cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ.

the circuit shown, XY is a length L of uniform resistance wire. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a small signal lamp S .

[5]

15 body travelling with a speed of 10 ms^{-1} has kinetic energy 1500 J .

(b) (iv) Show that $\frac{\mathrm{d}^{n+1}}{\mathrm{d}x^{n+1}}\left(x^{n+1}\ln x\right) = \frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n + (n+1)x^n \ln x\right)$.

Find the rank of **M**.

was the by-product of this reaction?

[3]

(ii) polynomial $3x^3+pax^2+7a^2x+qa^3$ is denoted by f(x) where p, q and a are constants and $a \neq 0$

Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{3x^2y-3y^3}{9xy^2-x^3}$.

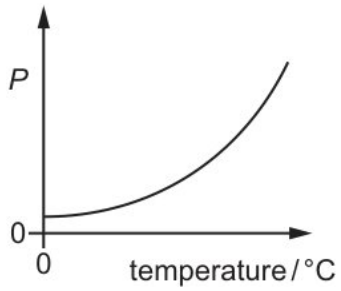
[4]

(iii) Find the standard deviation of the weights of the letters.

a, b and c are integers to be determined.

[6]

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



[10]

(d) (vi) is the average useful power at which he is working?

student wishes to investigate the effect of adding various thicknesses of glass in front of

[10]

(i) Hence show that $\sum_{r=1}^{n} \frac{2r+1}{r(r+1)(r+2)} = \frac{1}{2}\left\{\frac{(2n+1)(2n+3)}{(n+1)(n+2)} - \frac{3}{2}\right\}$.

the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

[6]

(iv) the term interference.

diagram shows a junction in a circuit where three wires, P, Q and R, meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.

The total momentum is conserved only in elastic collisions.

[3]

(c) (ii) 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° 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 $\frac{11}{30}mg$.

where α is a positive integer. It is given that the shortest distance between the line AB and the line CD is equal to $2\sqrt{2}$.

[5]

(iii) labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.

When a and b have these values, factorise p(x) completely.

[5]

12 a tree diagram to represent this information, giving the probability on each branch.

(a) (ii) Find the equations of the asymptotes of C.

$$\sqrt{3}x^5 - 10x^4 + 40x^2 - 32 = 0$$

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.

[5]

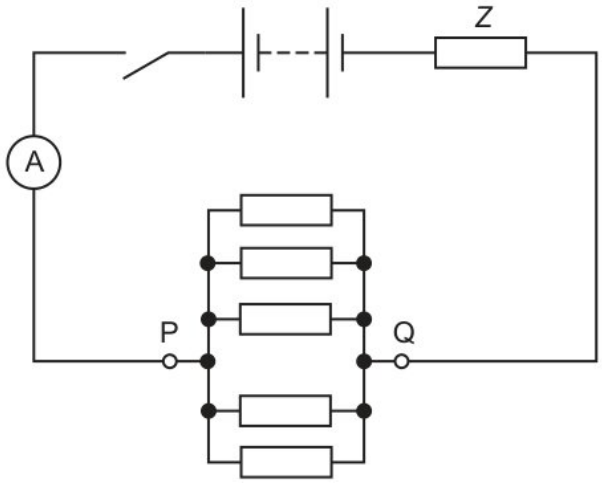
(vi) the team contains more boys than girls.

a positron and a neutrino

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

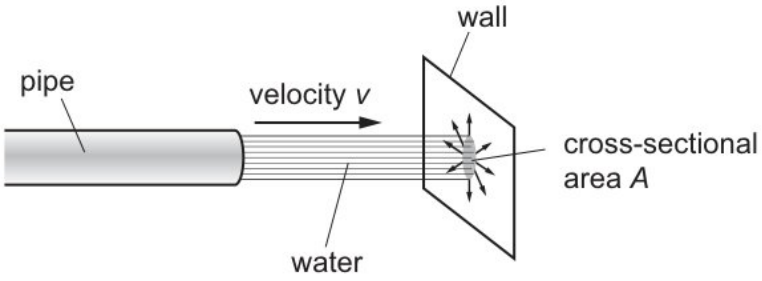
[5]

(i) the probability that fewer than 6 rolls of this dice are required to obtain an A .



[2]

(b) (ii)



Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

[6]

(i) the term interference.

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

[4]

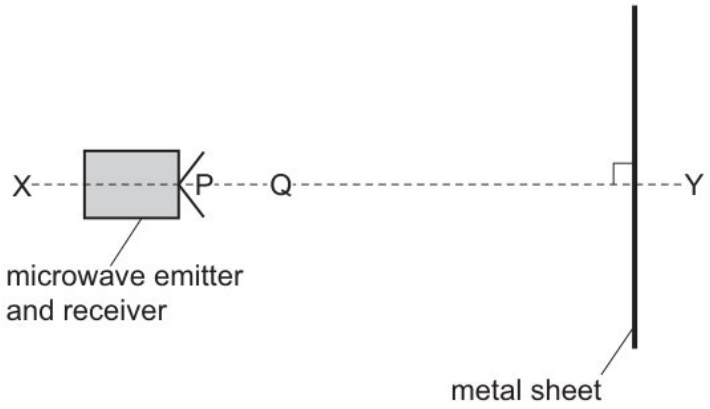
(iii)

that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\mathrm{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

[3]

(v) is the work done by F on the skateboarder and skateboard?

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



[5]

29 ice cube of mass 37.0 g at temperature 0.0°C is placed in a beaker containing water of mass 208 g at temperature 26.4°C.

(g) (ii) Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

Find the set of values of k for which the line $y = k$ does not intersect C.

the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

[3]

(i) temperature θ_{R} of the laboratory is measured using a thermometer.

Find the deceleration of the tractor at the instant it begins to climb the hill.

[10]

(b) (i) are selected from these 20 to perform at a concert.

V increases because there is a p.d. across R.

[6]

(iii) polarised beam of light with intensity I is incident normally on a polarising filter.

$$E_{\mathrm{K}} = \frac{1}{2}mv^2.$$

is given that $z_1 = r_1 \mathrm{e}^{\mathrm{i}\theta_1}$ and $z_2 = r_2 \mathrm{e}^{\mathrm{i}\theta_2}$.

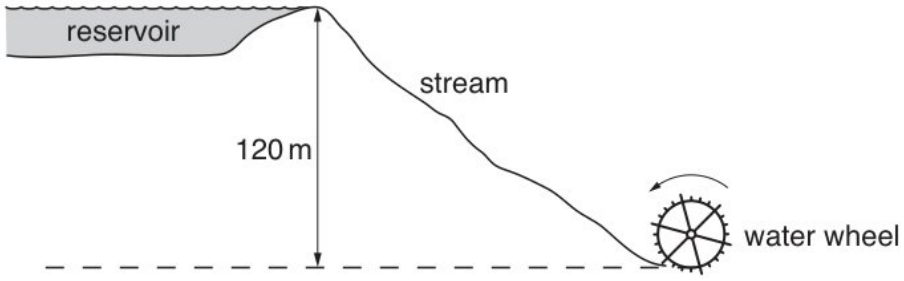
[3]

(vi) - falling with constant speed with the parachute open,

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

[8]

(e) (ii)



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

[8]

(iii) the team contains more boys than girls.

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

[5]

23 the time taken for the ball to reach its maximum height

(c) (ii) the speed of the aeroplane.

projectile is launched at 45° to the horizontal with initial kinetic energy E.

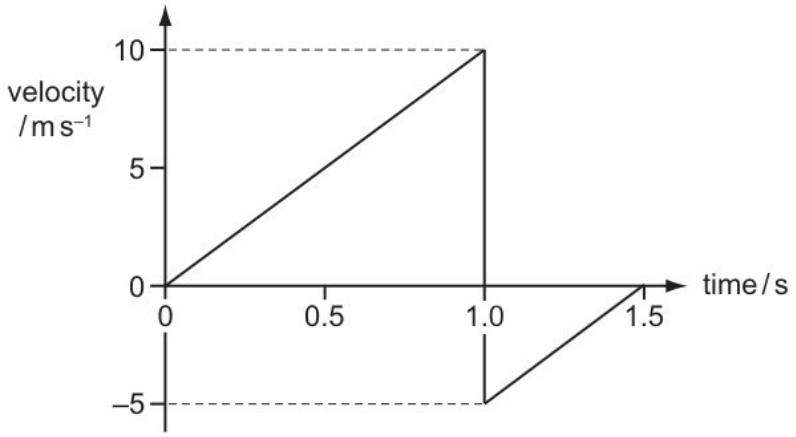
[1]

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

Show that $2\cos 2x \cos\left(2x + \frac{1}{6}\pi\right)$ can be expressed in the form

[5]

(vii) Find the eigenvalues and corresponding eigenvectors of the matrix **A**, where



[6]

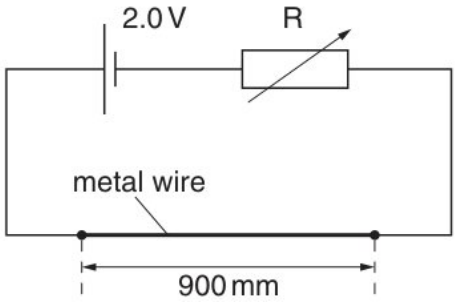
(d) (v) **a** and **b** are vectors and t is a scalar.

safety precautions to be taken.

points A, B and C have position vectors $2\mathbf{i} - \mathbf{j} + \mathbf{k}, 3\mathbf{i} + 4\mathbf{j} - \mathbf{k}$ and $-\mathbf{i} + 2\mathbf{j} + 4\mathbf{k}$ respectively.

[3]

(ii) diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.



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

[4]

17 how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

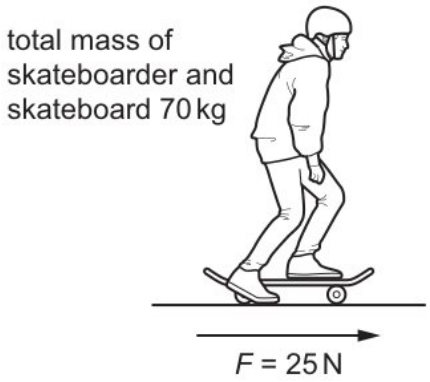
(a) (iii) a value, to three significant figures, for the specific latent heat of fusion of water.

is the useful power output of the power station?

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

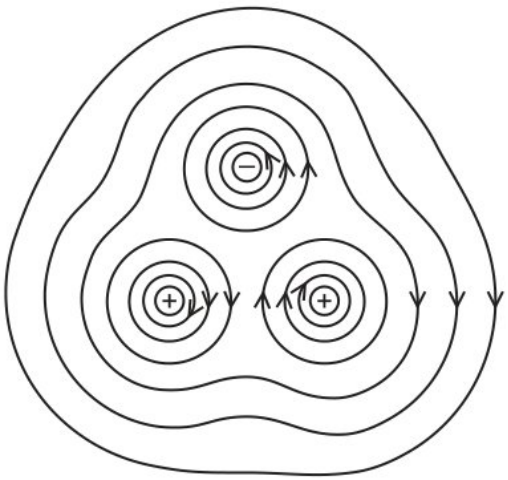
[5]

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



[5]

(c) (i) Find the period of the motion.



[5]

(ii) the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution 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.

the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

[3]

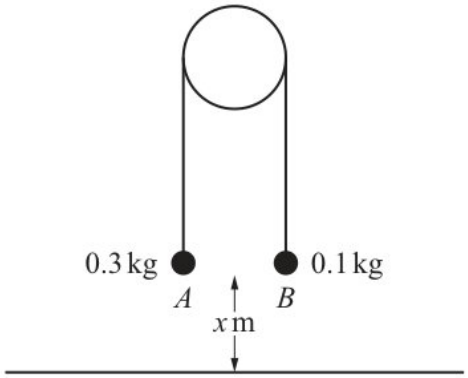
(b) (vi) shaded region is bounded by the curve and the two axes.

device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

$$I_n = \frac{1}{n-1} - I_{n-2}$$

[6]

(ii) Prove that, for $n \geqslant 2$,



[6]

8 selects 4 books from her 10 different books from the series Squares and Circles.

(i) (a) the term elastic limit.

measurements to be taken,

[5]

(c) statement about the weight of the plank is correct?

$$\sin\frac{1}{5}\pi \sin\frac{2}{5}\pi \sin\frac{3}{5}\pi \sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right) + \sin^2\left(\frac{2}{5}\pi\right)$$

[2]

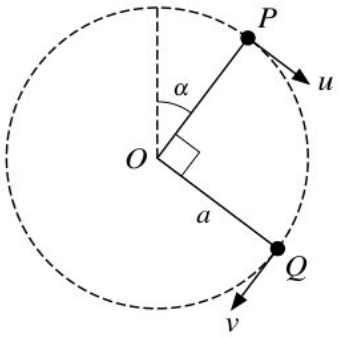
(b) helium atom may be modelled as a nucleus surrounded by two electrons in diametrically opposite circular orbits, each of radius 170 pm, as shown in Fig. 2.1.

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 $3 : 4$.

$$\sin\frac{1}{5}\pi \sin\frac{2}{5}\pi \sin\frac{3}{5}\pi \sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right) + \sin^2\left(\frac{2}{5}\pi\right)$$

[10]

(iv) (f)



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

[5]

(c) Find a set of corresponding eigenvectors.

row of the table gives an angle θ of $90°$?

[4]

(ii) (c) statement about the weight of the plank is correct?

the moment of a force about a point.

$$x + 3y + kz = 4$$
$$4x - 2y - 10z = -5$$
$$x + y + 2z = 1$$

[4]

(b) Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

Express $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of t.

curve C has equation

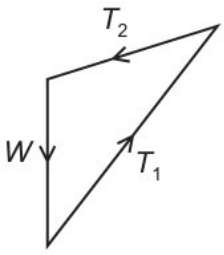
[3]

(vi) (d) Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

tension in the string when the particle is at Q is twice the tension in the string when the particle is at P.

[4]

(f)



the time that it takes from when P is initially projected until the instant at which P collides with the combined particle

[6]

(b) 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 **AB**, and state corresponding eigenvectors.

is the change to the quark composition of a nucleus that takes place during β^+decay?

[3]

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

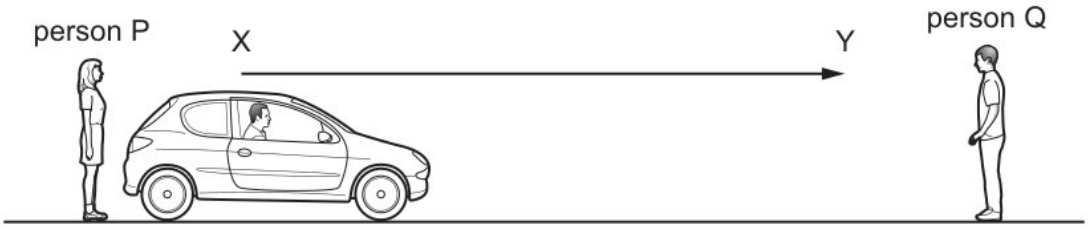
device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

(d) (iii) for a wire,

analysis of the data,

[5]

(ii) 1,2 and 3



row gives the sub-multiples or multiples represented by pico (p) and giga(G)?

[4]

(a) (iii) region R is enclosed by C and l, and contains the pole. Find the area of R.

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

[6]

(ii) a back-to-back stem-and-leaf diagram to represent this information, with Gulls on the left-hand side.

$$\operatorname{cosec}^5\theta = \frac{a}{\sin 5\theta + b\sin 3\theta + c\sin\theta}$$

[5]

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

It limits the range of values obtained in repeated measurements.

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

that = ... *pk* **[6]**

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

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

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

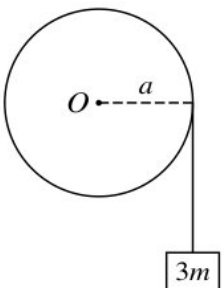
[1]

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

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

[15]

(ii) position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where



[4]

(e) (i) truck R of mass 9400 kg moves with constant acceleration in a straight line down a slope, as illustrated in Fig. 3.1.

a digit can be repeated and the number made is even.

[6]

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

the values of ωz_1 and ωz_2 Give your answers in the form $re^{i\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

[4]

8 Find the standard deviation of the weights of the letters.

Hence solve the equation

turbine at a hydroelectric power station is situated at a vertical distance of 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

(e) (ii) gas is then cooled at constant volume so that its temperature decreases to $2T$.

Calculate the length AG.

system is released from rest with OP making a small angle α with the downward vertical. Find

[8]

(i) is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

copper wire of cross-sectional area 2.0 mm^2 carries a current of 10 A .

[8]

(iii) gravitational potential at a point.

the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

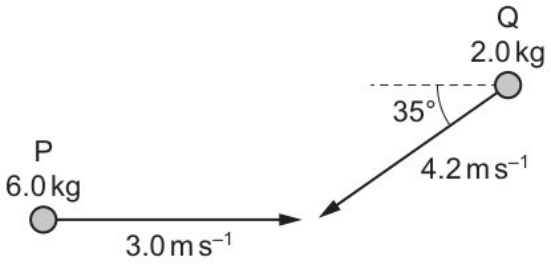
[5]

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

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

[6]

(iii)



block of mass 12 kg is placed on a rough plane inclined at an angle of α 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 μ.

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.

[2]

(b) (ii) rigid body is made from uniform wire of negligible thickness and is in the form of a square $ABCD$ of mass M enclosed within a circular ring of radius a and mass $2M$. The centres of the square and the circle coincide at O and the corners of the square are joined to the circle (see diagram). Show that the moment of inertia of the body about an axis through O, perpendicular to the plane of the body, is $\frac{8}{3}Ma^2$.

curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.

[3]

(iii) 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.

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

progressive wave of frequency 300 Hz is travelling with a speed of 600 m s^{-1}.

[2]

(c) (i) the value of $\left(\alpha^3 - 1\right)^3 + \left(\beta^3 - 1\right)^3 + \left(\gamma^3 - 1\right)^3$

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

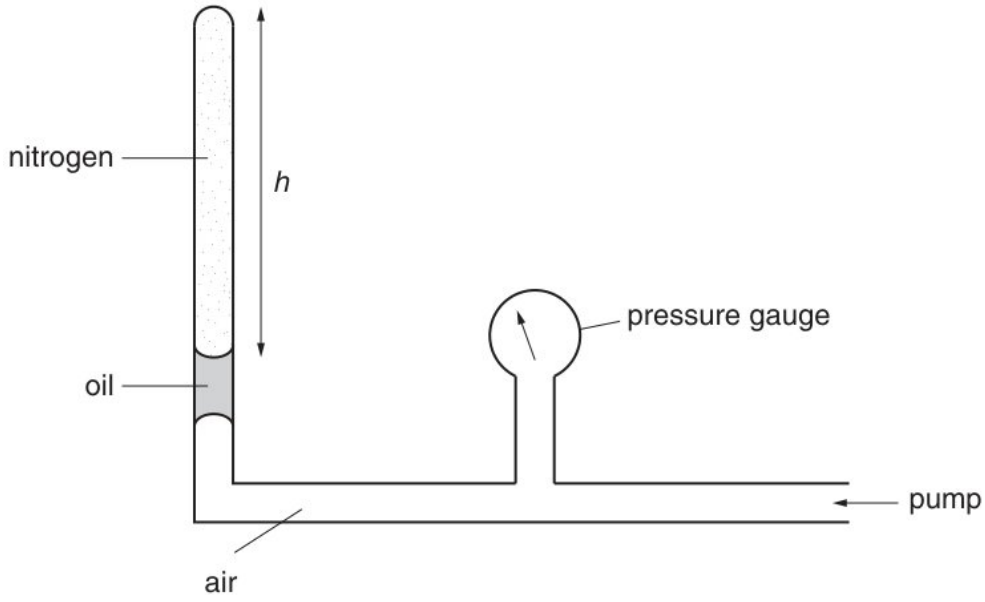
[12]

(ii) Find the rate of working of the tension at this instant.

transmitted light has intensity $0.75I$.

[5]

(v) identical uniform smooth spheres A and B, each with mass m, are moving on a horizontal surface with speeds $2u$ and u respectively when they collide. Immediately before the collision, the spheres are moving parallel to each other in opposite directions such that their directions of motion each make an angle θ with the line of centres (see diagram). As a result of the collision, B moves in a direction which is perpendicular to its initial direction of motion. The coefficient of restitution between the spheres is e.



[5]

(d) (i) is suggested that these results are consistent with a distribution having probability density function f given by

sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

Without using a calculator, find the exact values of

[3]

(iii) the exact value of $\lim_{n\to\infty} \sum_{r=1}^{n} \frac{n}{n^2+r^2}$.

Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

[8]

15 your answers in the form $\tan k\pi$, where k is a rational number.

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.

(b) (vi) Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

Use the equation of a suitable regression line to estimate the number of hours of sunshine on a day when the mid-day temperature is 2°C.

[6]

(iii) Explain, with reference to the diagram, why the trapezium rule may be expected to give a good approximation to the true value of the integral in this case.

the instant when the rule is horizontal, what is the resultant moment about the pivot?

is the value of R ?

[2]

(c) (i) only one of the following two alternatives.

point $P(2, 1)$ lies on the curve with equation

[15]

(ii) how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

find the variance of the number of 4 s obtained in 30 throws,

[5]

(e) (ii) activity of a radioactive sample.

diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.

[5]

(vi) students are selected at random from the students who study Science.

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

[2]

(i) State what is meant by the internal energy of a system.

volume of oil. Pressure is applied by a pump. The applied pressure is measured on a

[6]

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

is given that

(b) (iii) first, second and third terms of a geometric progression are $2k + 3, k + 6$ and k, respectively. Given that all the terms of the geometric progression are positive, calculate

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

student is investigating a non-inverting operational amplifier (op-amp) circuit.

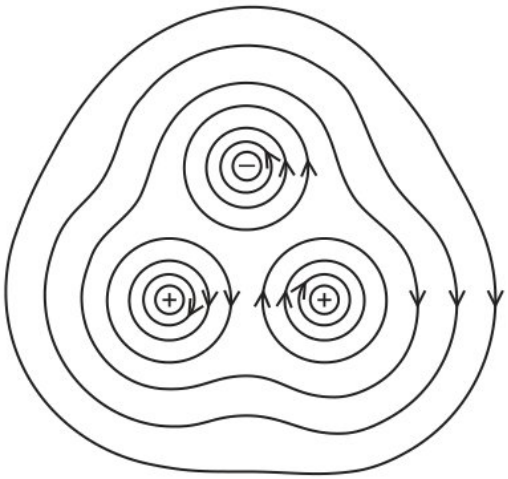
[12]

(v) The weight of the plank equals the force on the plank from the pivot.

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.

[5]

(ii)



is the average velocity of the toy car for the journey shown by the graph?

Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

[12]

(vi) object is free to rotate about the axis l. The object is held so that CA makes an angle α with the downward vertical and is released from rest.

The curve C has equation $y = \sec^3 x$ for $0 \leqslant x \leqslant \frac{1}{4}\pi$. The region R is bounded by C, the x-axis, the y-axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x-axis.

[3]

(a) (iii) three coplanar forces shown in the diagram act at a point P and are in equilibrium.

Find the product moment correlation coefficient for the data.

[12]

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

student wishes to investigate the effect of adding various thicknesses of glass in front of

[5]

(ii) activity of a radioactive sample.

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.

[12]

(c) (ix) and explain whether the nuclei in the sample are undergoing α-decay, β^+decay or β^-decay.

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.

[12]

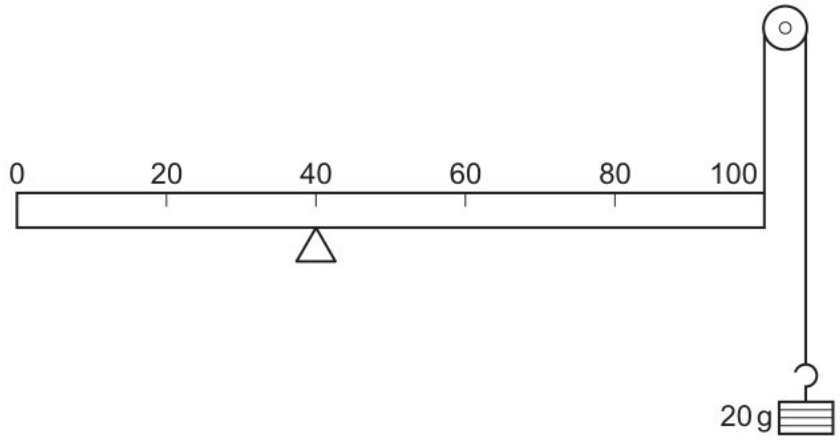
(iv) Find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

Find the equations of the asymptotes of C.

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

[12]

13 skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.



airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.

(e) (vi) $\mathbf{a}$ and $\mathbf{b}$ are vectors and t is a scalar.

plane Π_1 passes through the points $(1, 2, 1)$ and $(5, -2, 9)$ and is parallel to the vector $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$.

[6]

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

that if a sequence of values given by the iterative formula

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

[5]

(b) (iv) far apart are two adjacent interference fringes that are formed on the laboratory wall?

variables x and y satisfy the differential equation

[10]

(iii) the rank of the matrix

that $\tan 2a = -4a$

Show that $v^2 = u^2 + \frac{14}{5}ag$.

[2]

(ii)

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

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

[4]

9 (b) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

(vi) what is meant by the de Broglie wavelength.

[6]

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

[8]

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

variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

[10]

(a) a sketch of an Argand diagram with origin O show the points A, B, C and D representing the complex numbers $z_1, z_2, \omega z_1$ and ωz_2 respectively

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

[5]

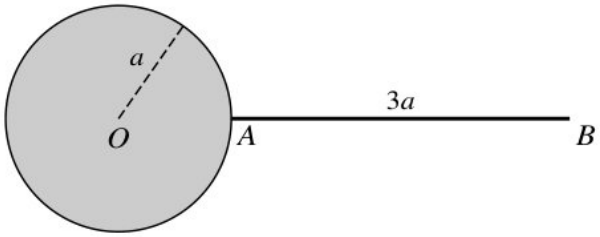
(i) by calculation that a lies between 2 and 2.1.

[3]

(d) the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

support at end X exerts a force F vertically upwards on the plank.

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



[5]

(ii) that, when $t = 0, x = 3$ and $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

Find the total work done against the resistance force as the car ascends the first ramp and descends the second ramp.

The matrix $\mathbf{B}$ is given by $\mathbf{B} = \mathbf{A} - 2\mathbf{I}$, where $\mathbf{I}$ is the 3×3 identity matrix. Write down the eigenvalues of $\mathbf{B}$, and state a set of corresponding eigenvectors.

[10]

(e) diagram shows the graph of the probability density function, f , of a random variable X. The graph is a straight line from $(0, a)$ to $(2, b)$, where a and b are positive constants. Elsewhere, $\mathrm{f}(x) = 0$.

(iv) many different colour arrangements are there of the 10 books with exactly 4 books between the 2 yellow books?

beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

data give a pooled estimate of 10 for σ^2. Find N.

[12]

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

ages of a group of 12 people at an Art class have mean 48.7 years and standard deviation 7.65 years. The ages of a group of 7 people at another Art class have mean 38.1 years and standard deviation 4.2 years.

[1]

(f) frequency of the signal is 50 kHz .

Show that the cartesian equation of C is

Hence, or otherwise, prove by mathematical induction that $\mathrm{f}(n)$ is divisible by 7 for every positive integer n.

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

[8]

(ii) procedure to be followed,

curve $y = 4x^2 \ln x$ has one stationary point.

[4]

(i) a, b and c are integers to be determined.

[5]

13 competitors who took part in this Saturday's event are selected at random.

(f) (iii) Use the result for integrating $\frac{1}{x^2+a^2}$ with respect to x, in the List of Formulae (MF10), to find the value of I_1 and deduce that

$$y = \frac{3x - 9}{(x-2)(x+1)}$$

point = ... rk **[6]**

(ii) diagram shows a semicircle ACB with centre O and radius r. The tangent at C meets AB produced at T. The angle BOC is x radians. The area of the shaded region is equal to the area of the semicircle.

variable resistor in (a) is now connected as a potential divider, as shown in Fig. 5.3.

[6]

(v) for a wire,

- coming to rest instantaneously on hitting the ground.

[6]

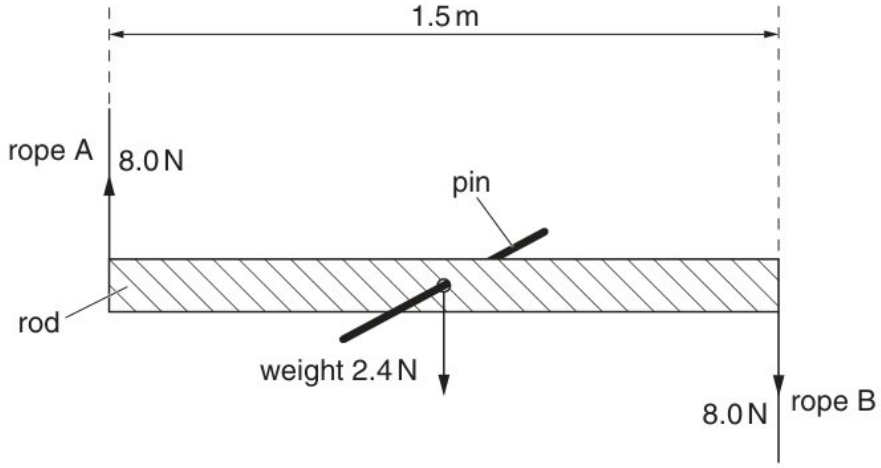
(a) (v) mass of peaches sold per day in a supermarket is normally distributed with mean 65.8 kg and standard deviation 9.6 kg

Show that the mass of P is 0.8 kg .

parametric equations of a curve are

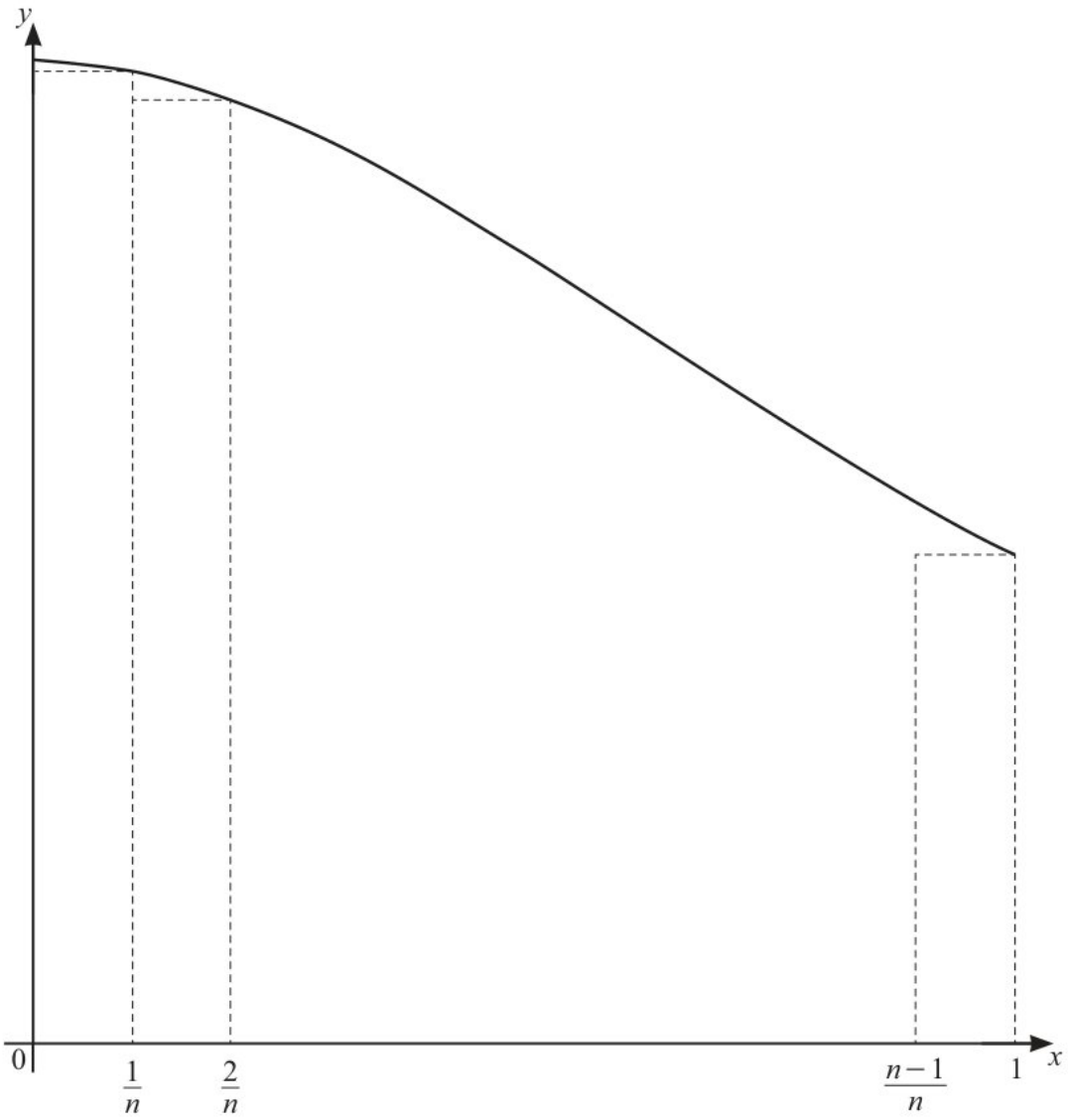
[4]

(i) 1.1 shows the measurements for cube A.



[5]

(ii)



is a general description of a baryon?

a laboratory experiment to determine the absorption coefficient of glass. You should

[6]

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

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

	wavelength	width of gap
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[4]

(iii) is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

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

weight of the parachutist is 850 N .

[3]

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

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

[3]

(b) (iii) diagram shows two waves R and S.

$$\overrightarrow{OA} = \begin{pmatrix} 2 \\ 3 \\ 5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} \quad \text{and} \quad \overrightarrow{OC} = \begin{pmatrix} 10 \\ 0 \\ 6 \end{pmatrix}.$$

that the mean of these 40 values is 124.0 , find the value of k.

[3]

(i) the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is the fifth day of the week.

bag contains 7 red balls and 3 blue balls. Kieran selects 2 balls at random, without replacement. The number of red balls selected by Kieran is denoted by X, and the number of different colours present in Kieran's selection is denoted by Y.

[8]

(ii) the speed of the combined particle after this collision.

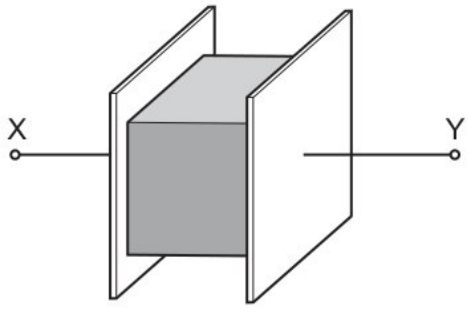
$$I_n = \int_0^{\frac{1}{2}\pi} \cos^n x \, \mathrm{d}x$$

[8]

24 suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

not have a unique solution.

student takes measurements to calculate the density of a liquid in a beaker.



(b) (iii) matrix $\mathbf{A}$ is given by

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

[5]

(iv) Saturday, a particular community holds a 'Puzzle' event to raise money for a new Leisure Centre. Competitors attempt to solve a puzzle as quickly as possible.

particle P is projected from a point O with speed U at an angle 45° above the horizontal and moves freely under gravity.

[6]

(v) Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

[8]

(d) (iv) student investigates an electrical circuit.

$$\sum_{r=1}^{n} \frac{n}{n^2 + r^2} < \frac{1}{4}\pi$$

[4]

(i) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.

Hence obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

the number of different arrangements of the 8 letters in the word KANGAROO in which the two As are together and the two Os are not together.

[3]

17 car is accelerated by a constant resultant force of 300 N for 5.0 s .

the probability of a Type I error.

masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

(c) (ii) Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

$$\mathbf{M} = \begin{pmatrix} 3 & 4 & 2 & 5 \\ 6 & 7 & 5 & 8 \\ 9 & 9 & 9 & 9 \\ 15 & 16 & 14 & 17 \end{pmatrix}.$$

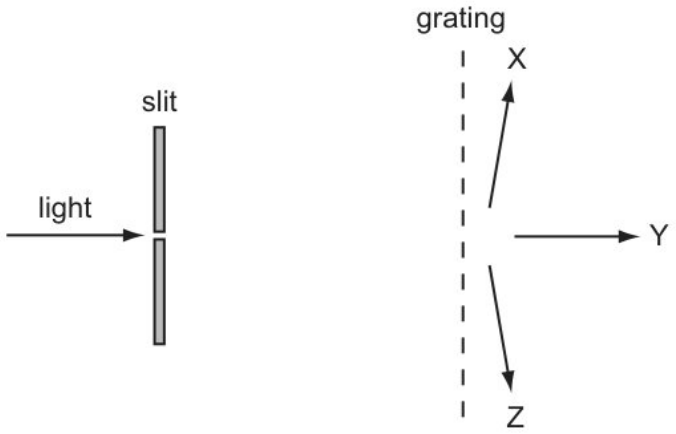
[5]

(i) company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

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.

[5]

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



[5]

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

1.26 1.24 1.17 1.23 1.18 1.25 1.19 1.20 1.21 1.18

[3]

(i) Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

$\mathbf{A}^{2n}$, where n is a positive integer.

[20]

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

verify that this equation has a root between 5 and 5.05.

[8]

(d) (iii) anywhere between point R and point S

water is added to an insulated beaker, as shown in Fig. 2.1.

Find the coordinates of the turning points of C.

[6]

(i)

a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.

[4]

(iv) car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

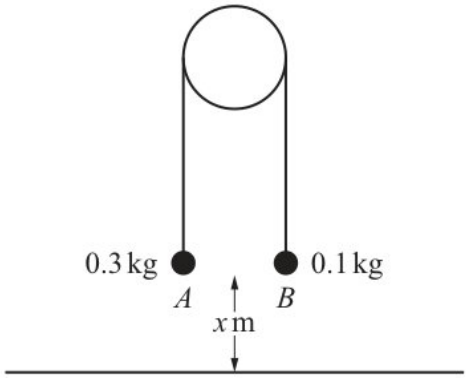
$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

[8]

(a) (iii) row describes the momentum and kinetic energy of the two bodies after the collision?

cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.



[1]

(ii) that $(z_1 z_2)^* = {z_1}^* {z_2}^*$.

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

[2]

(i) that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

Find the value of k for which the set of linear equations

[12]

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

$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

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

(a) (iii) The power to X will increase and the powers to Y and Z will remain unaltered.

X and Y are connected in series to a cell.

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

[12]

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

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

shows = ... qx **[5]**

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

row correctly identifies the properties of all electromagnetic waves?

body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is 1.64 m s^{-2}.

[10]

(c) (ii) resistors of equal value are connected as shown.

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

[5]

(iii) the acute angle between the planes ABC and ABD.

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

the equations of the asymptotes of C

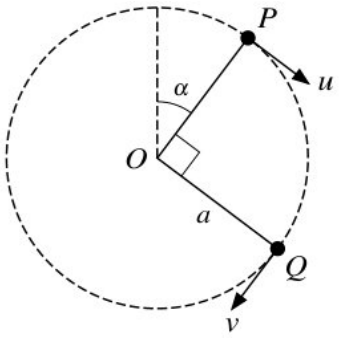
[8]

(b) (ii) Hence, or otherwise, prove by mathematical induction that f(n) is divisible by 7 for every positive integer n.

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.

[10]

(iii)



Its speed decreases to zero, then increases to 20 m s^{-1}.

Amplitude is inversely proportional to velocity.

[12]

(v) 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.

Find the x-coordinate of M.

[6]

(f) (iv) roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

show that $PQ = 13$,

light elastic string has natural length 2 m and modulus of elasticity 39 N . The ends of the string are attached to fixed points A and B which are at the same horizontal level and 2.4 m apart. A particle P of mass m kg is attached to the mid-point of the string and hangs in equilibrium at a point 0.5 m below AB (see diagram).

[8]

(iii) the length of C.

find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

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

[6]

(i) Show that the cartesian equation of C is

that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[12]

(d) (i) manufacturer claims that the machine produces rods with mean length 300 mm .

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

[4]

(v) density of the water is ρ. The water does not rebound from the wall.

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.

[6]

(ii) specific latent heat.

x is in radians, has only one root for $0 < x \leqslant \frac{1}{2}\pi$.

[6]

10 (c) curve C has equation

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

$$\mathrm{p}(x) = ax^3 + bx^2 - 17x - a$$

[10]

(iv) continuous random variable X has probability density function f given by

diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

[5]

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

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

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

[10]

(ii) value for the Hubble constant is 2.3×10^{-18} s^{-1}.

[8]

(d) body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

(iii) waves are emitted from two sources.

[20]

(v) When a and b have these values, factorise $\mathrm{p}(x)$ completely.

[15]

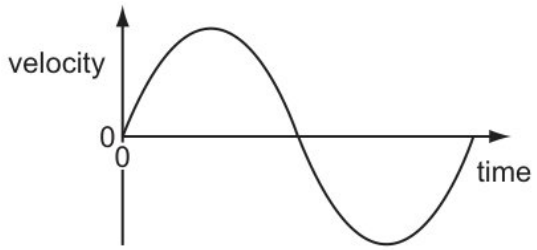
11 Event X is 'exactly two of the selected balls have the same number'. Event Y is 'the ball selected from bag A has number 2'. Showing your working, determine whether events X and Y are independent or not.

(c) (iv) by mathematical induction, that 5^n+3 is divisible by 4 for all non-negative integers n.

electromagnetic wave phenomenon is needed to explain the spectrum produced when white light falls on a diffraction grating?

[4]

(ii)



For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

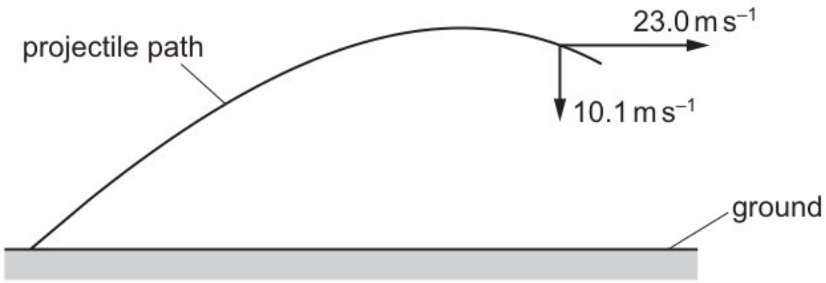
[3]

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

tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

[2]

(b) (ii)



tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

$$\sec 5\theta = \frac{\sec^5\theta}{5\sec^4\theta - 20\sec^2\theta + 16}$$

[5]

(iii) be written as a quadratic equation in x.

body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is 1.64 m s^{-2}.

[12]

(i) graph shows the variation with temperature of power, P, dissipated in the thermistor?

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

[10]

(v) values, x, in a particular set of data are summarised by

sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

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

[6]

(a) (i) C, stating the coordinates of the intersections with the axes.

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

[8]

(ii) Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

Velocity is proportional to wavelength.

[8]

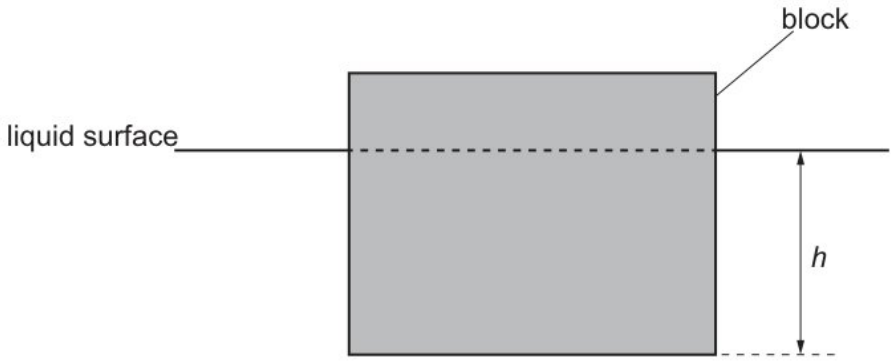
(iii) Find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

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

no digit can be repeated,

[8]

(d) (vi) Obtain another equation relating u^2, v^2, a and g, and hence find u in terms of a and g.



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

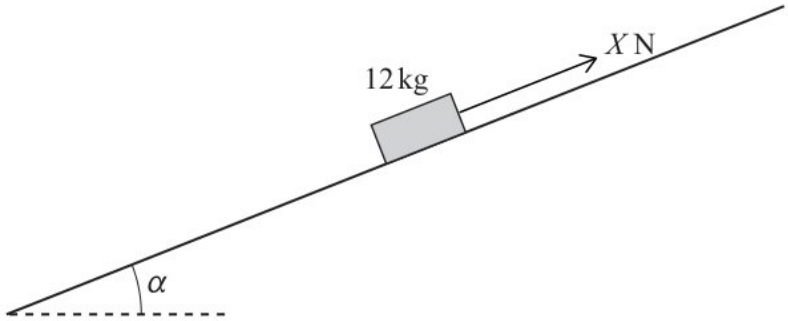
[2]

(v) 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.

variable resistor in (a) is now connected as a potential divider, as shown in Fig. 5.3.

[6]

(e) (ii) relationship is used in the derivation of the equation shown?



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

[5]

(iii) the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

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

[5]

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

is the ratio $\frac{\text{stress at } Y}{\text{stress at } X}$?

frequency of the signal is 50 kHz .

[10]

21 is given that $x = t^{\frac{1}{2}}$, where $x > 0$ and $t > 0$, and y is a function of x.

Given that $\tan 2\theta \cot \theta = 8$, show that $\tan^2 \theta = \frac{3}{4}$.

The matrix $\mathbf{B}$, where

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

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

$$\mathbf{B} = \begin{pmatrix} 3 & 6 & 1 \\ 1 & -2 & -1 \\ 6 & 6 & -2 \end{pmatrix},$$

[3]

(i) only one of the following two alternatives.

the expected value and variance of Y.

[6]

(iv) obtain the roots of the equation

P and Q collide and stick together.

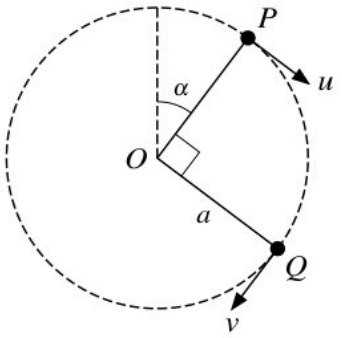
[3]

(b) (v) particle P of mass 0.4 kg is released from rest at a point O on a smooth plane inclined at 30° to the horizontal. P moves down the line of greatest slope through O. The velocity of P is v m s^{-1} when its displacement from O is x m. A retarding force of magnitude $0.2v^2$ N acts on P in the direction PO.

When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

[1]

(i)



first coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{3}$.

(amplitude)$^2 \propto \sqrt{\text{intensity}}$

[8]

10 block of mass 12 kg is placed on a rough plane inclined at an angle of α 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 μ.

Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

(b) (iii) the speed of Q after the collision.

It is given that the determinant of $\mathbf{A}$ is equal to the product of the eigenvalues of $\mathbf{A}$. Use this result to find the third eigenvalue of $\mathbf{A}$, and find also a corresponding eigenvector.

[4]

(ii) the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

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.

[5]

(i) coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.

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

many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

[8]

(c) (ii) Hence, or otherwise, obtain an expression for $\mathrm{f}^{-1}(x)$.

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 $\frac{3k+1}{3(1-k)}$.

[4]

(iii) cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

[8]

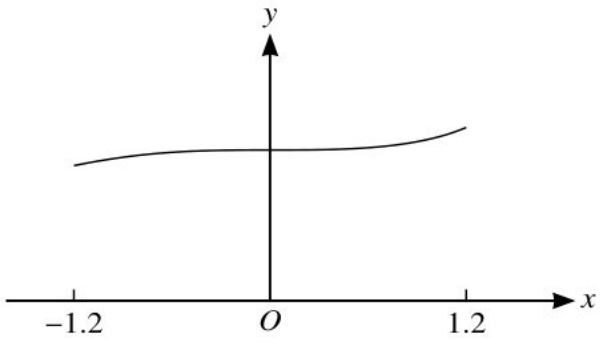
(a) (iv) Show that $\cos\theta = \frac{2}{3}$.

polarised beam of light with intensity I is incident normally on a polarising filter.

[10]

(iii) polynomial $3x^3+pax^2+7a^2x+qa^3$ is denoted by $\mathrm{f}(x)$ where p, q and a are constants and $a \neq 0$

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



[6]

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

object is fully submerged in a liquid.

Find the equations of the asymptotes of C.

[5]

11 by mathematical induction, that $\sum_{r=1}^{n} r \ln\left(\frac{r+1}{r}\right) = \ln\left(\frac{(n+1)^n}{n!}\right)$ for all positive integers n.

(b)(vii) Hence solve the equation

Calculate the distance moved by the car during this acceleration.

the process by which α-particles lose energy when they pass through air.

[6]

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

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

Find the value of the product moment correlation coefficient for this sample.

[5]

(a) (iv) progressive water waves X and Y travel along a straight line from point A to point B. The variation of displacement of the waves with distance from A at an instant in time is shown in Fig. 3.1.

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

[10]

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

the number of bags for which you would expect the mass of pasta to be more than 1.65 standard deviations above the mean.

[12]

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

(c) (ii) 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.

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

[3]

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

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[5]

(a) (vi) striking the horizontal plane, P rebounds with speed w. The coefficient of restitution between P and the plane is $\frac{2}{3}$.

The total momentum is conserved only in elastic collisions.

- decelerating at a constant rate with the parachute open,

[4]

(iii) Find the distance OM.

Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

[5]

(i) that if a sequence of values given by the iterative formula

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

[20]

(e) (i) The waves must not be polarised.

Find the values of a and b.

[8]

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

acceleration of free fall on Pluto is 0.66 m s^{-2}.

[10]

7 the gradient of the curve

positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

linear transformation T: $\mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M}$, where

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

fair tetrahedral die has faces numbered $1, 2, 3, 4$. A coin is biased so that the probability of showing a head when thrown is $\frac{1}{3}$. The die is thrown once and the number n that it lands on is noted. The biased coin is then thrown n times. So, for example, if the die lands on 3 , the coin is thrown 3 times.

[5]

(ix) Calculate the acceleration of P when it is at instantaneous rest and $x > 0$.

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

[4]

(b) (ii) student takes measurements to calculate the density of a liquid in a beaker.

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

[2]

(vii) from the definitions of tanh and sech in terms of exponentials, prove that

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

[6]

(a) (iii) particle P is projected from a point O on horizontal ground. 0.4 s after the instant of projection, P is 5 m above the ground and a horizontal distance of 12 m from O.

the probability density function of Y

[4]

(iv) the set of values of x for which the expansion in part (b) is valid.

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.

[6]

(i) the values of ωz_1 and ωz_2 Give your answers in the form $re^{i\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

is the effect of a systematic error on the measurement of a physical quantity?

[6]

13 what is meant by work done.

(d) (iv) numbers of barrels of oil, in millions, extracted per day in two oil fields A and B are modelled by the independent random variables X and Y respectively, where $X \sim \mathrm{N}\left(3.2, 0.4^2\right)$ and $Y \sim \mathrm{N}\left(4.3, 0.6^2\right)$. The income generated by the oil from the two fields is \$90 per barrel for A and \$95 per barrel for B.

not have a unique solution.

that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

[10]

(iii)

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

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[3]

(i) the exact value of I_2.

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

[12]

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

uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

[6]

(b) (iii) logarithms to solve the equation $4^{x+1} = 5^{2x-3}$, giving your answer correct to 3 significant figures.

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 $\frac{3k+1}{3(1-k)}$.

[2]

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

Show that $\cos\theta = \frac{2}{3}$.

[2]

19 planes p and q have equations $x + y + 3z = 8$ and $2x - 2y + z = 3$ respectively.

(a) (ii) the exact value of I_2

magnetic flux density.

[8]

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

$$I_n = \int_0^{\frac{1}{4}\pi} \tan^n x \, \mathrm{d}x$$

[6]

(iii) total energy input E_{in} in a process is partly transferred to useful energy output U and partly transfered to energy that is wasted W.

light is incident on the front of a photocell, an e.m.f. is generated in the photocell.

diagram shows a junction in a circuit where three wires, P, Q and R, meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.

[6]

(d) (iii) is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

Calculate the density, in kgm^{-3}, of the material from which the paving slab is made.

a, b and c are integers to be determined.

[1]

(iv) the moment of a force about a point.

obtain the roots of the equation

[5]

(i) the solution of the differential equation

tension in the string when the particle is at Q is twice the tension in the string when the particle is at P.

the solution of the differential equation

[8]

(b) (iv) a sketch of an Argand diagram with origin O show the points A, B, C and D representing the complex numbers $z_1, z_2, \omega z_1$ and ωz_2 respectively

ice cube of mass 37.0 g at temperature 0.0°C is placed in a beaker containing water of mass 208 g at temperature 26.4°C.

Its speed decreases to a value greater than zero, then increases to a value greater than 20 ms^{-1}.

[10]

(i) Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

$$f(x) = \begin{cases} kx & 0 \leqslant x < 1 \\ k(8-x) & 1 \leqslant x \leqslant 8 \\ 0 & \text{otherwise} \end{cases}$$

[5]

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

(b) (ii) Find the direction of motion of the particle 0.4 s after the instant of projection.

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

[5]

(iii) Hence, or otherwise, obtain an expression for $\text{f}^{-1}(x)$.

sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.

system is released from rest with OP making a small angle α with the downward vertical. Find

[5]

(vi)

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

system is released from rest with OP making a small angle α with the downward vertical. Find

expression gives the value of $\frac{v}{u}$?

[12]

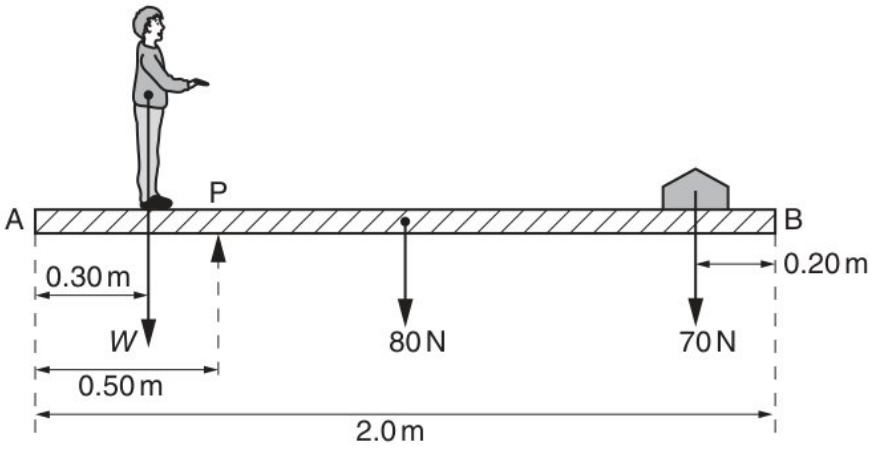
(a) (iv) as shown in Fig. 2.1.

$n \geqslant 0$. Use the fact that $\tan^2 x = \sec^2 x - 1$ to show that, for $n \geqslant 2$,

what is meant by a fundamental particle.

[6]

(i)



that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\mathrm{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

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

[6]

12 bag contains 10 marbles, of which 4 are red and 6 are blue. Four marbles are selected from the bag at random, without replacement. The random variable X denotes the number of blue marbles selected.

(a) (iv) Show that x satisfies the equation

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.

[8]

(i) specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.

particle P is projected from a point O with speed U at an angle 45° above the horizontal and moves freely under gravity.

rest = ... *sb* **[8]**

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

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

[10]

(e) (iii) Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

curve C has parametric equations

Find the magnitude and direction of the force exerted by the surface on the lamina at A.

[2]

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

matrix **A** is given by

[15]

(ii) graph is correctly labelled?

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

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

[6]

(c) (iv) rigid body is made from uniform wire of negligible thickness and is in the form of a square $ABCD$ of mass M enclosed within a circular ring of radius a and mass $2M$. The centres of the square and the circle coincide at O and the corners of the square are joined to the circle (see diagram). Show that the moment of inertia of the body about an axis through O, perpendicular to the plane of the body, is $\frac{8}{3}Ma^2$.

$$\sum_{r=1}^{n} \frac{1}{\sqrt{r}}\mathrm{e}^{\sqrt{r}} < \left(2 + \frac{1}{\sqrt{n}}\right)\mathrm{e}^{\sqrt{n}} - 2\mathrm{e}.$$

[6]

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

curve C has equation $y = \frac{x^2-3x+6}{1-x}$.

[8]

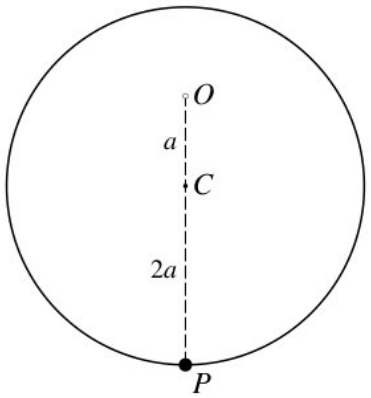
23 skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

(b) (i) believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p, is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $H_0 : p = 0.2$, against the alternative hypothesis, $H_1 : p < 0.2$.

continuous random variable X has probability density function f given by

[5]

(iv) the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.



the ratio $H : D$.

[6]

(ii) the value of x.

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

[5]

(c) (v) Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

statements about what person P and person Q hear during the motion of the car are correct?

[3]

(i) 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.

basic principle of note production in a horn is to set up a stationary wave in an air column.

the value of α.

[6]

(iv) row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

$$x^2 + y^2 = a\left(x + \sqrt{}\left(x^2 + y^2\right)\right).$$

the experimental observations that show radioactive decay is

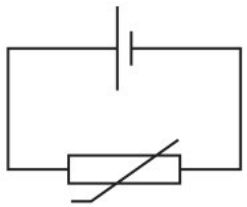
[5]

(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.

frequency of the signal is 50 kHz .

[5]

(e) (iii) considering the sum of the areas of these rectangles, show that



[2]

(ii) data give a pooled estimate of 10 for σ^2. Find N.

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

the distribution function of X.

charge = ... kt **[6]**

13 cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ

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

(a) (v) car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

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.

[6]

(ii) 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.

Carry out the test.

[4]

(c) (ii) by induction that $u_n = 6^n - 1$ for all positive integers n.

Find also the value of $\frac{1}{\alpha^2\beta^2} + \frac{1}{\beta^2\gamma^2} + \frac{1}{\gamma^2\alpha^2}$.

[6]

(i) Hence solve the equation $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4$, for $0° \leqslant \theta \leqslant 360°$.

Fig. 7.1, complete the charge and mass of α-particles, β-particles and γ-radiation. Give example speeds of α-particles and γ-radiation emitted by a laboratory source.

[4]

(iii) a value, to three significant figures, for the specific latent heat of fusion of water.

Find the equations of the asymptotes of C.

[3]

(b) (ii) 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.

Find the work done by the tension.

[4]

(iii) row best specifies the correct $I - V$ graphs for the lamp and the diode?

Find the area of the triangle ABC.

the instant when the rule is horizontal, what is the resultant moment about the pivot?

[6]

(v) Show that x satisfies the equation

a and **b** are vectors and t is a scalar.

particle = ... *lb* **[12]**

(f) (ii) an estimate for the mean length of these 250 leaves.

random sample of 12 customers who each bought a computer from this store is chosen.

[10]

(iii) obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

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

[3]

18 that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.

electric potential difference across a component.

(b) (iii) the principle of superposition.

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° 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 $\frac{11}{30}mg$.

how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

[5]

(i) the probability that both marbles chosen are the same colour.

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

[4]

(a) (iii) Show that the tension in the string is 10 N .

your answers in the form $\tan k\pi$, where k is a rational number.

[10]

(ii) circle is divided into 6 sectors in such a way that the angles of the sectors are in arithmetic progression. The angle of the largest sector is 4 times the angle of the smallest sector. Given that the radius of the circle is 5 cm , find the perimeter of the smallest sector.

$$\sin\frac{1}{5}\pi\sin\frac{2}{5}\pi\sin\frac{3}{5}\pi\sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right) + \sin^2\left(\frac{2}{5}\pi\right)$$

[8]

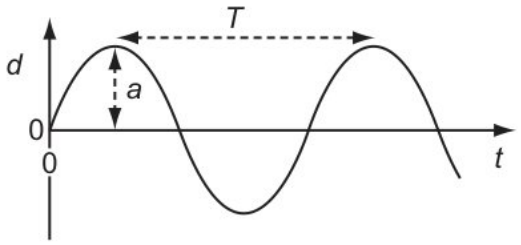
(i) the probability of a Type I error.

Find the arc length of C between the point where $\theta = 0$ and the point where $\theta = \frac{1}{3}\pi$.

variation with time t of the velocity v of the car is shown.

[4]

(iv)



that $\tan 2a = -4a$

The total momentum and the total kinetic energy are always conserved.

[20]

(d) (vi) λ 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.

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

[8]

(iii) (amplitude $)^2 \propto \sqrt{\text{intensity}}$

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]

(c) (iii) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$

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.

[8]

(ii) and explain whether the nuclei in the sample are undergoing α-decay, β^+decay or β^-decay.

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

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

[3]

(vi) diagram illustrates successive wavefronts.

the general solution of the differential equation

row describes the momentum and kinetic energy of the two bodies after the collision?

[10]

24 system is released from rest with OP making a small angle α with the downward vertical. Find

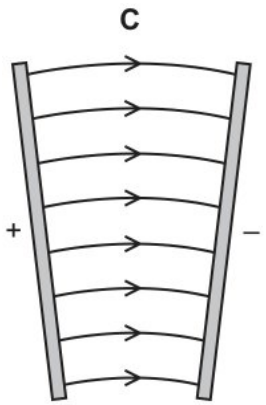
(b) (i)

wavelength of light is 550 nm .

consists = ... *sq* **[8]**

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

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



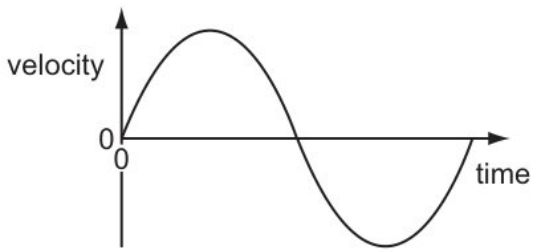
[8]

(c)(vii) the term interference.

acceleration of free fall on Pluto is 0.66 m s^{-2}.

[3]

(iii) are the amplitude and period of the wave?



[6]

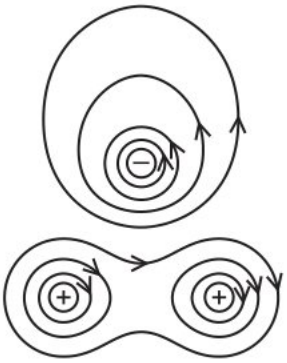
(iv) Given also that -1 is an eigenvalue of **A**, find a corresponding eigenvector.

Find the value of x.

the average power of the aeroplane's engines.

[10]

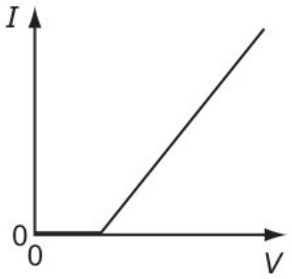
(a) (i)



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

[10]

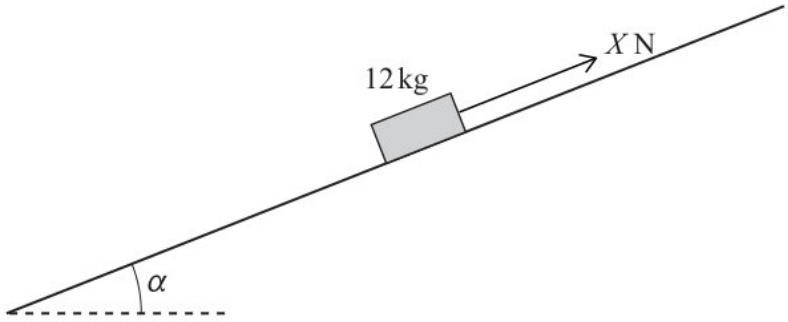
(ii) The potential difference across any component connected to the battery will be 9.0 V .



[6]

13 the graph of $y = |2x - 3|$.

(c) (iv)



four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x.

state an eigenvector of the matrix **CD** and give the corresponding eigenvalue.

[6]

(ii) The weight of the plank is causing a clockwise moment.

one similarity and one difference between an electron and positron.

[5]

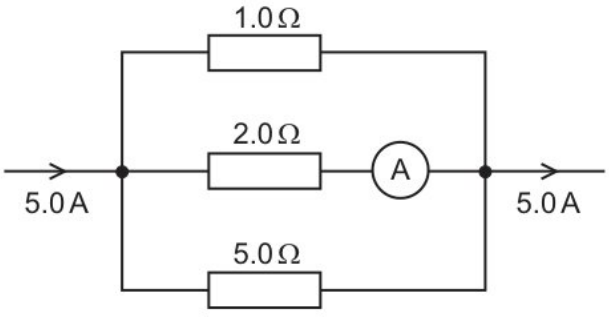
(a) (iii) curve C has equation $y = \frac{x^2+px+1}{x-2}$, where p is a constant. Given that C has two asymptotes, find the equation of each asymptote.

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

process does not require energy to be supplied?

[2]

(ii)



Amplitude is inversely proportional to velocity.

[5]

(f) (iii) linear transformation T: $\mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix **M**, where

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

the value of x.

[5]

(i) Saturday, 600 competitors took part. The times taken to complete the puzzle were normally distributed with mean 32.4 minutes and standard deviation 2.5 minutes.

ages of a group of 12 people at an Art class have mean 48.7 years and standard deviation 7.65 years. The ages of a group of 7 people at another Art class have mean 38.1 years and standard deviation 4.2 years.

[6]

(ii) 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.

is the work done by F on the skateboarder and skateboard?

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

[4]

10 is the ratio $\frac{\text{stress at } Y}{\text{stress at } X}$?

(c) (v) - falling freely with the parachute closed,

your answer correct to 2 decimal places.

Find the weight of the lamina.

[3]

(iii) the complex numbers z for which $\frac{z+5\mathrm{i}}{z-5}$ is real and $|z| = \sqrt{17}$ Give your answers in the form $z = x + \mathrm{i}y$ where x and y are real

sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

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

[4]

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

Express f(x) in partial fractions.

[6]

(a) (i) number of cars sold per day at another showroom has the independent distribution Po(0.6). Assume that the distribution for the first showroom is still Po(0.7).

considering the binomial expansion of $\left(z - \frac{1}{z}\right)^5$, where $z = \cos\theta + \mathrm{i}\sin\theta$, use de Moivre's theorem to show that

[10]

(iv) stationary nucleus has nucleon number A.

$$\int_0^k e^{4x}dx = \int_0^{2k} e^{x}dx$$

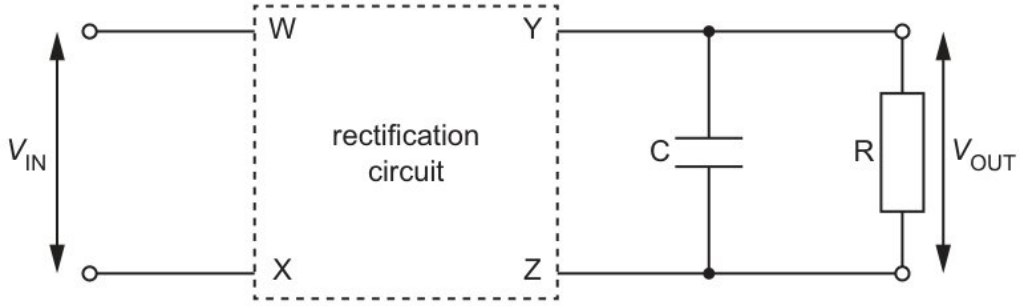
[6]

(iii) the rank of **M** and a basis for the range space of T ,

Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

[5]

(b) (ii) 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]

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

the probability that the marble chosen from bag A is blue, given that the marble chosen from bag B is blue.

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

[8]

(iv) 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.

Find the cartesian equation of the plane through A, B and C.

[4]

(d) (iii) Its speed decreases to zero, then increases to a value less than 20 ms^{-1}.

sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $P(T > 330) = 0.0391$, correct to 3 significant figures.

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

[6]

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

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

is given that $k = 0.025$ and that $U = 20$

[5]

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

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

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

(d) (i) variables x and y satisfy the differential equation

chooses an appropriate random sample of 60 students. She finds that 45 of these students think that the sports facilities are good.

[10]

(iii) the position vector of P.

the complex numbers z for which $\frac{z+5\mathrm{i}}{z-5}$ is real and $|z| = \sqrt{17}$ Give your answers in the form $z = x + \mathrm{i}y$ where x and y are real

[2]

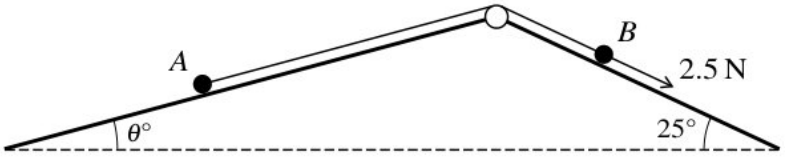
(iv) Find the equations of the asymptotes of C.

$I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

Show that the equation

[6]

(b) (iii) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = 2t^{\frac{1}{2}} \frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 2\frac{\mathrm{d}y}{\mathrm{d}t} + 4t\frac{\mathrm{d}^2y}{\mathrm{d}t^2}$.



[5]

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

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

[6]

(a) (iii) that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\operatorname{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

object of mass 8 kg slides down a line of greatest slope of an inclined plane. Its initial speed at the top of the plane is 3 m s^{-1} and its speed at the bottom of the plane is 8 m s^{-1}. The work done against the resistance to motion of the object is 120 J . Find the height of the top of the plane above the level of the bottom.

[6]

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

the type of each transformation, and make clear the order in which they are applied.

[6]

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

what time will some portion of the wavefront GH reach point P ?

moment of a force.

[8]

(c) (i) C, stating the coordinates of the intersections with the axes.

sheets between a light source and the front of the photocell.

the values of ωz_1 and ωz_2 Give your answers in the form $r\mathrm{e}^{\mathrm{i}\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

[6]

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

curve C has parametric equations

[8]

(g) (ii) For this value of k, find the set of possible solutions, giving your answer in the form

star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

eigenvalues = ... xp **[10]**

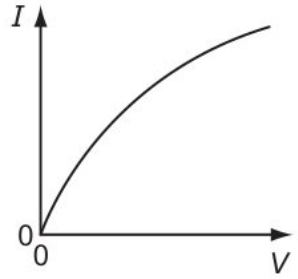
(i) the number of different ways in which these three bands can be selected.

copper wire of cross-sectional area 2.0 mm^2 carries a current of 10 A .

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

[3]

21 are the frequencies of the next two higher notes for this air column?



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

(b) (iii) 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.

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 3\left(2^n - 1\right) \\ 0 & 1 \end{pmatrix}$$

a sketch of an Argand diagram with origin O show the points A, B, C and D representing the complex numbers $z_1, z_2, \omega z_1$ and ωz_2 respectively

[4]

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

Show that the tension in the string is 10 N .

[5]

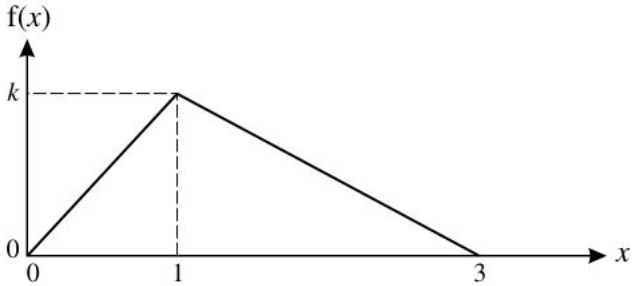
(c) (ii) the probability that at least 1 of these students studies Drama.

For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

[6]

(iv) that u_{2n} is divisible by u_n for $n \geqslant 1$.

statement is correct?



[4]

(a) (iii) Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is -10 m s^{-2}.

Find the coordinates of any intersections with the coordinate axes.

[5]

(ii) plane Π_2 contains the lines

$$\frac{3}{2}x + 3y + 8z = 1,$$
$$ax + 3y + 4z = 2,$$
$$ay - z = 3,$$

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

[6]

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

Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

region = ... xa **[6]**

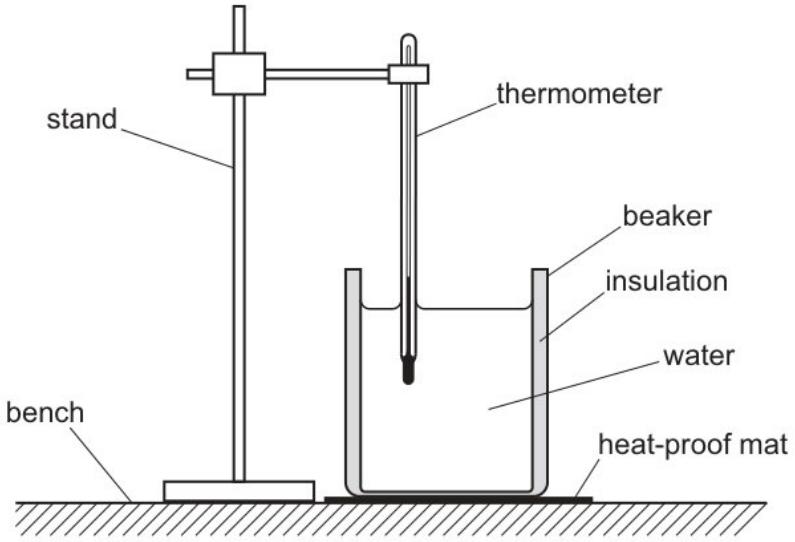
(iv) graph shows the variation with temperature of power, P, dissipated in the thermistor?

progressive wave of frequency 300 Hz is travelling with a speed of 600 m s^{-1}.

[8]

18 the instant when the rule is horizontal, what is the resultant moment about the pivot?

the values of the constants k_1 and k_2 are to be determined.



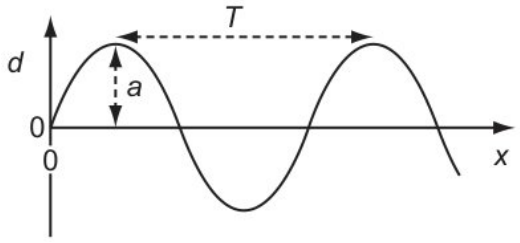
$\frac{\text{mass}}{\text{length} \times (\text{ time })^2}$

(g) (iii) diagram shows part of the curve $y = 4\sqrt{x} - x$. The curve has a maximum point at M and meets the x-axis at O and A.

neutron decays to form a proton.

[10]

(i)



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

[5]

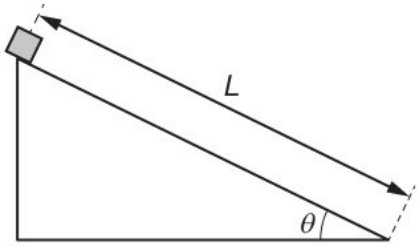
(iv) diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

no digit can be repeated,

[6]

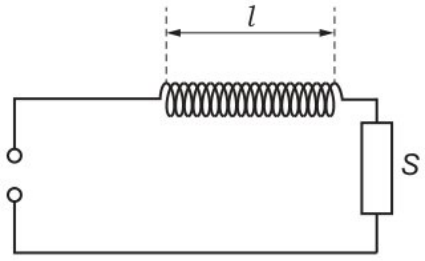
(c) (ii) Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.



up to antidown

[20]

(iii)



position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where

Find the period of the motion.

[6]

12 Find the value of a for which $\arg(u^*) = \frac{3}{4}\pi$, where u^* denotes the complex conjugate of u.

(c) (ii) s friend says,"This survey is about sports facilities, so you should choose a sample of students from the school sports teams."

Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

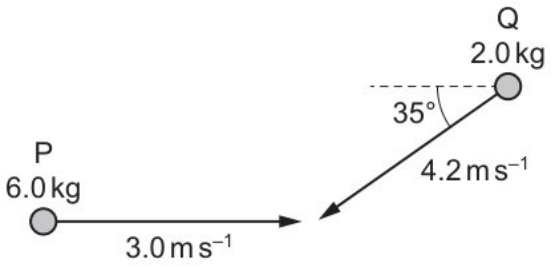
[6]

(iii) Find the angle that the force acting on the rod at A makes with the horizontal.

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

[6]

(e) (iii)



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

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° and α 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.

[4]

(v) find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

[4]

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

$z = 3e^{\frac{1}{4}\pi i}$ is a root of the equation $z^2 + bz + c = 0$, where b and c are real.

(c) (i) 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 ms^{-1}. After P and Q collide, P continues to move in the same direction with speed 1.5 m s^{-1}.

row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

[8]

(iv) identical uniform smooth spheres A and B, each with mass m, are moving on a horizontal surface with speeds $2u$ and u respectively when they collide. Immediately before the collision, the spheres are moving parallel to each other in opposite directions such that their directions of motion each make an angle θ with the line of centres (see diagram). As a result of the collision, B moves in a direction which is perpendicular to its initial direction of motion. The coefficient of restitution between the spheres is e.

potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) $V_{\text{in.}}$ The p.d. across R_1 is V_{out} .

[5]

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

diagram shows four forces applied to a circular object.

State what is meant by the internal energy of a system.

[5]

(v) cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

the number of different arrangements of the 7 men in a line in which Ali and Ben do not stand next to each other.

this Saturday's event, 60% of the competitors had times less than 36.0 minutes.

[3]

(ii) Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

one similarity and one difference between an electron and positron.

[4]

22 diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm .

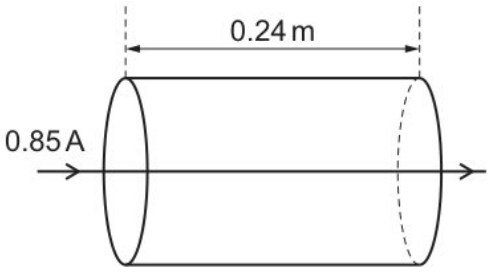
(a) (ii)

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

is the current in the load resistor?

hypothesis, = ... yr **[5]**

(v) The curve C has equation $y = \sec^3 x$ for $0 \leqslant x \leqslant \frac{1}{4}\pi$. The region R is bounded by C, the x-axis, the y-axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x-axis.



$I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

[6]

(i) the solution of the differential equation

graph shows the variation with time of the velocity of the object?

[3]

(c) (i) x is in radians, has only one root for $0 < x \leqslant \frac{1}{2}\pi$.

acceleration of free fall on Pluto is 0.66 m s^{-2}.

[5]

(ii) the Young modulus.

variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

[6]

(iii) that the forces are in equilibrium, find the values of θ and X.

$\mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - 2\mathbf{j} - \mathbf{k})$ and $\mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \mu(2\mathbf{i} + 3\mathbf{j} - \mathbf{k})$.

particles A and B have masses 0.3 kg and 0.1 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley, and the particles hang vertically below the pulley. Both particles are initially at a height of x m above horizontal ground (see diagram). The system is released from rest.

[4]

(d) (iii) graph is correctly labelled?

Find the equations of the asymptotes of C.

[4]

(i) the exact solutions of the equation $\mathrm{f}(x) = 1$.

control of variables,

fixed = ... qr **[6]**

(iv) Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

object of mass 8 kg slides down a line of greatest slope of an inclined plane. Its initial speed at the top of the plane is 3 m s^{-1} and its speed at the bottom of the plane is 8 m s^{-1}. The work done against the resistance to motion of the object is 120 J . Find the height of the top of the plane above the level of the bottom.

[4]

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

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

[5]

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

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

[4]

(ii) the values of ωz_1 and ωz_2 Give your answers in the form $re^{i\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

this Saturday's event, 60% of the competitors had times less than 36.0 minutes.

Find the equation of the tangent to the curve at P.

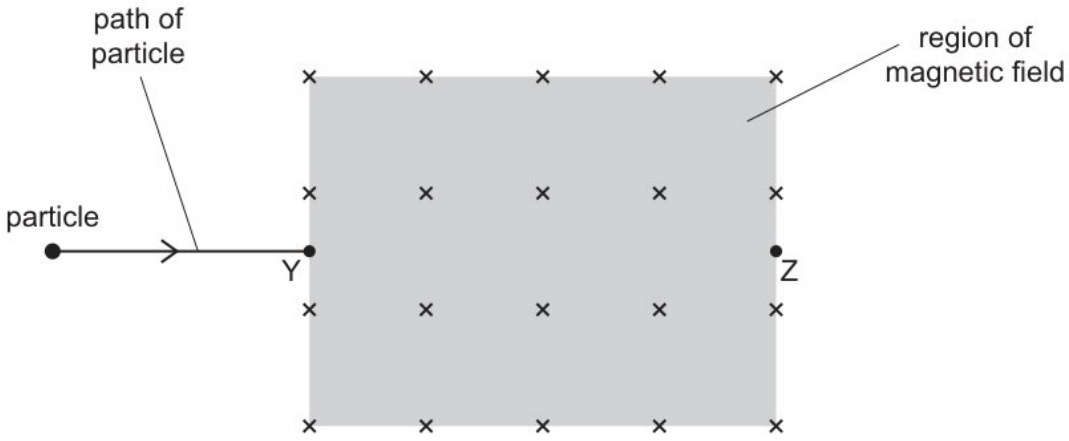
[12]

(h) (ii) 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.

Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

[20]

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



[4]

(i) Draw a sketch of C for the case $\lambda > 3$.

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

[15]

9 is a statement of the principle of conservation of momentum for a system?

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

solve the equation $\cot^2 x - \tan^2 x = 5\sec 2x$ for $0° < x < 90°$.

Velocity is proportional to wavelength.

[6]

(ii) curves C_1 and C_2 intersect at the point with polar coordinates (a, β). State the value of β.

Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

the distribution function of X.

[12]

(c) (v) k is a positive constant. The relevant expected frequencies are given in the following table.

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

statement is correct when S is changed from open to closed?

[12]

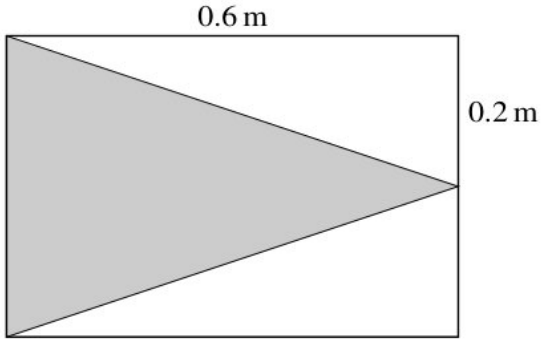
(i) The power to X will decrease and the powers to Y and Z will increase.

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

[4]

7 three coplanar forces shown in the diagram act at a point P and are in equilibrium.

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 **AB**, and state corresponding eigenvectors.



(b) (i) the equation representing this decay.

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.

[5]

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

The weight of the plank is causing an anticlockwise moment.

[6]

(d) (vi) λ 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.

moment of a force.

[10]

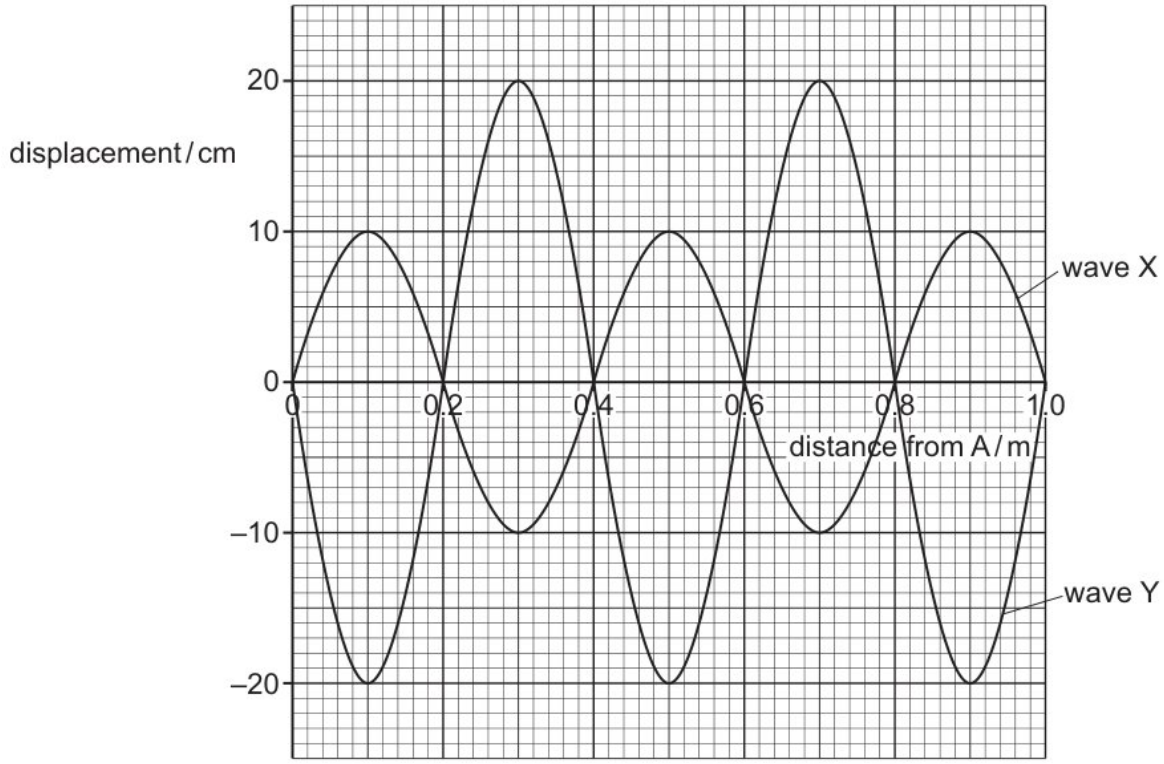
(ii) that, at the point $\left(4, \frac{1}{3}\right)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{2}$.

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

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

[8]

(v)



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

[5]

(a) (iv) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

The individual ages in years of people in the first Art class are denoted by x and those in the second Art class by y. By first finding $\sum x^2$ and $\sum y^2$, find the standard deviation of the ages of all 19 people.

taken = ... *ja* **[12]**

(i) safety precautions to be taken.

Draw box-and-whisker plots in a single diagram on graph paper to illustrate the marks for History and Physics.

[12]

(v) State one other feature of this orbit.

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

[6]

17 (c) State one other feature of this orbit.

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

(iv) 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.

linear transformation T: $\mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M}$, where

Calculate the distance of the centre of mass of the lamina from A.

[12]

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

many different colour arrangements are there of the 10 books with exactly 4 books between the 2 yellow books?

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

[6]

(i) 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.

[5]

(a) a, b and c are integers to be determined.

(vi) Stating suitable hypotheses and assuming a normal distribution, test the coach's belief at the 10% significance level.

[2]

(v) Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

$$y = \frac{3x - 9}{(x - 2)(x + 1)}$$

It results in the measured value being different from the correct value.

angle shows angle = ... fw **[3]**

(iii) Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

[8]

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

student is investigating a non-inverting operational amplifier (op-amp) circuit.

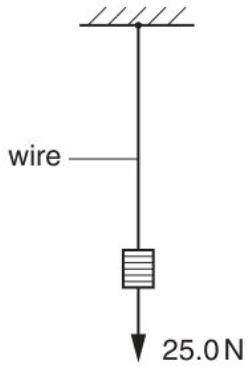
(i) is suggested that these results are consistent with a distribution having probability density function f given by

$$\theta\cos\theta + \left(\frac{1}{8}\theta + 1\right)\sin\theta = 0$$

[10]

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

village hall has seats for 40 people, consisting of 8 rows with 5 seats in each row. Mary, Ahmad, Wayne, Elsie and John are the first to arrive in the village hall and no seats are taken before they arrive.



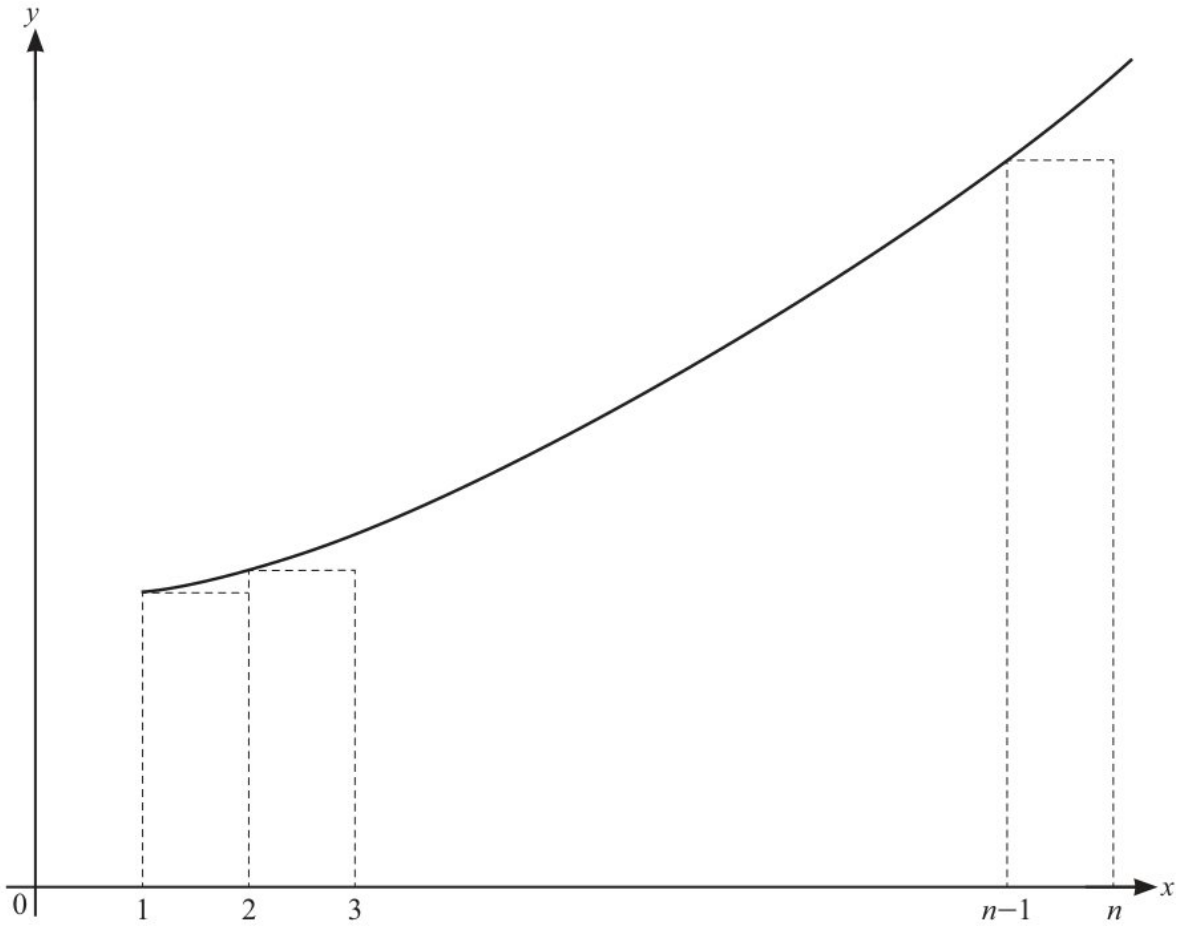
[10]

(ii) a similar method to find a lower bound for $\sum_{r=1}^{n} \frac{n}{n^2+r^2}$. Give your answer in terms of n and π.

[4]

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

(c) (i)



masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

The extension of the wire is not proportional to the tensile force.

[4]

(iii) Find the cartesian equation of the plane through A, B and C.

Find the median of X.

[5]

(vii)

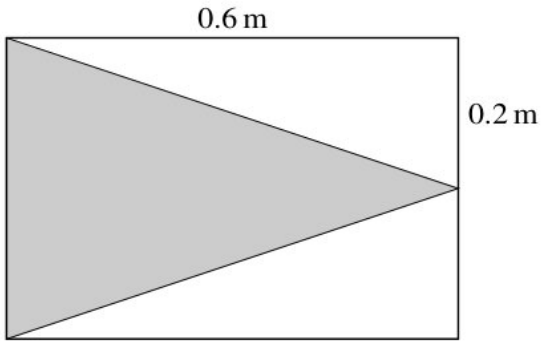
Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

The total momentum and the total kinetic energy are always conserved.

[4]

(a) (iii) Find the values of a and b.

the set of values of x for which the expansion in part (b) is valid.



[6]

(v) 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.

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.

[6]

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

random variable Y is defined by $Y = X^3$. Find

[8]

(b) (i) 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.

uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

[10]

(iii) is the horizontal force exerted by the wall on r r Y ?

sample has an activity of 180 Bq at time $t = 0$.

charge of 4.0 C passes through the resistor.

[4]

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

(i) 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.

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

[5]

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

sample has an activity of 180 Bq at time $t = 0$.

[6]

(c) the period of small oscillations,

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

[12]

(ii) Find the exact area of the shaded region.

[4]

(i) the standard deviation of these 40 values of x.

[6]

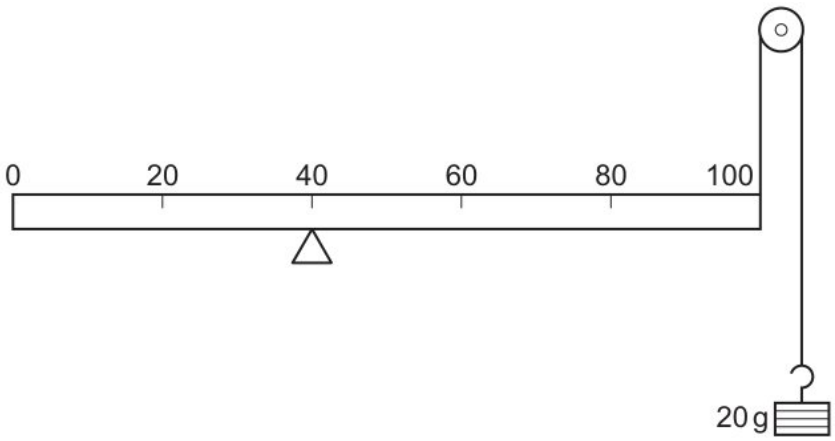
7 that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

(c) (ii) tension in the string when the particle is at Q is twice the tension in the string when the particle is at P.

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

[6]

(i)



Sunday, teams of runners took part in a charity event. The time taken, in seconds, to run 50 m was recorded, correct to 1 decimal place, for each runner. The times recorded for 11 runners from each of the Gulls and the Herons are shown in the table.

[2]

(vi) a basis for the null space of T .

car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

[8]

(b) (iii) rigid body is made from uniform wire of negligible thickness and is in the form of a square $ABCD$ of mass M enclosed within a circular ring of radius a and mass $2M$. The centres of the square and the circle coincide at O and the corners of the square are joined to the circle (see diagram). Show that the moment of inertia of the body about an axis through O, perpendicular to the plane of the body, is $\frac{8}{3}Ma^2$.

probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

[10]

(ii) flows out of a pipe and hits a wall.

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

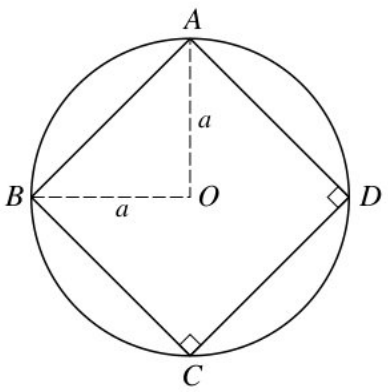
[10]

28 what is meant by work done.

There will always be 9.0 V across the battery terminals.

(a) (iv) van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

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.



[3]

(i) 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?

curve C has equation

[2]

(ii) matrix $\mathbf{A}$ is given by

object is free to rotate about the axis l. The object is held so that CA makes an angle α with the downward vertical and is released from rest.

region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

[8]

(c) (ii) Find the probability density function of Y.

Find the coordinates of the point A on C at which $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and $x \neq 0$.

times taken to run 200 metres at the beginning of the year and at the end of the year are recorded for each member of a large athletics club. The time taken, in seconds, at the beginning of the year is denoted by x and the time taken, in seconds, at the end of the year is denoted by y. For a random sample of 8 members, the results are shown in the following table.

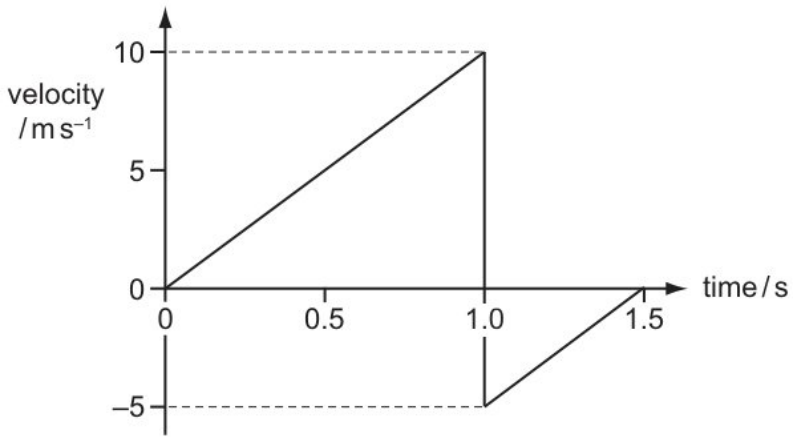
[5]

(iii) is given that $\sum_{r=1}^{n} u_r = n^2(2n+3)$, where n is a positive integer.

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

[6]

(i)



particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle moves in a horizontal circle with constant angular speed ω and with the string inclined at an angle of θ to the downward vertical.

[6]

18 (b) height of the liquid in the beaker is 0.20 m ± 2%.

Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

(iii) the particular solution of the differential equation

[6]

(ii) The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

[6]

(iv) Find the equation of the tangent to the curve at P.

Using these values of p and q, find the value of the constant r for which the equation $x^2 + px + q + r = 0$ has equal roots.

[12]

(c) the exact value of $\lim_{n\to\infty} \sum_{r=1}^{n} \frac{n}{n^2+r^2}$.

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

[6]

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

[10]

(iii) the time from release until OP makes an angle $\frac{1}{2}\alpha$ with the downward vertical for the first time.

[5]

(a) cube has volume V and is made of a material with resistivity ρ. The connections to the cube have negligible resistance.

(iv) obtain the roots of the equation

the value of α.

Find the coordinates of the turning points of C.

[5]

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

[4]

(i) student is investigating a non-inverting operational amplifier (op-amp) circuit.

which mark on the rule must a 50 g mass be suspended so that the rule balances?

[8]

10 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 $AC = a$.

(c) (ii) wave pattern produced in (b) is shown in Fig. 7.1.

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

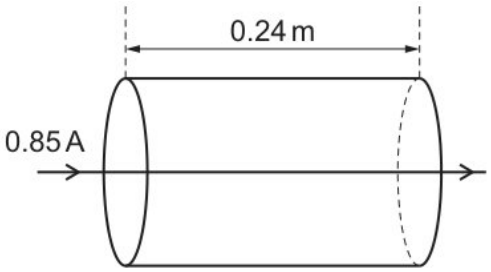
[8]

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

$$\tan x = x + \pi.$$

[3]

(a) (iv)



places the books in a row on her shelf. She is only interested in the arrangement of the colours.

[4]

(iii) considering the binomial expansion of $\left(z - \frac{1}{z}\right)^5$, where $z = \cos\theta + \mathrm{i}\sin\theta$, use de Moivre's theorem to show that

steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u, leaves it at a speed v, and rebounds vertically to half of its original height.

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 3\,(2^n - 1) \\ 0 & 1 \end{pmatrix}$$

[6]

(ii) the average output power of the car during this time

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 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.

based = ... mb **[8]**

15 complex number $1 - (\sqrt{3})\mathrm{i}$ is denoted by u.

(d) (iii) A contains 6 red marbles, 5 blue marbles and 1 green marble.

a, b and c are integers to be determined.

$$\mathbf{C} = \begin{pmatrix} -1 & -1 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 2 \end{pmatrix},$$

[10]

(iv) matrix $\mathbf{A}$ is given by

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 $0 < \theta < 2\pi$

[12]

(i) neutron decays to form a proton.

Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

[2]

(a) (iv) graph shows the variation with temperature of power, P, dissipated in the thermistor?

the position vector of D.

[5]

(iii) Draw up the probability distribution table for X.

between gravitational potential energy and electric potential energy.

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

[6]

25 (c) random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

the exact value of I_2

(iii) Over 50 198 212 217 229 235 242

[8]

(ii) an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

[4]

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

[6]

(i) the average output power of the car during this time

[6]

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

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

Express u in the form $x + \mathrm{i}y$, where x and y are real.

[10]

(ii) roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

[5]

(i) what is meant by the de Broglie wavelength.

[5]

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

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

[4]

(ii) magnetic flux density.

[2]

(i) curves C_1 and C_2 intersect at the point with polar coordinates (a, β). State the value of β.

the equation $2\ln(2x + 3) - \ln(2x + 5) = \ln(3x)$.

[12]

31 Calculate the modulus of elasticity of the string.

(e) (ii)

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

to the origin O, the position vectors of the points A, B and C are given by

[8]

(i) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

the equation representing this decay.

a similar method to find a lower bound for $\sum_{r=1}^{n} \frac{n}{n^2+r^2}$. Give your answer in terms of n and π.

[6]

(vi) what time will some portion of the wavefront GH reach point P ?

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

[10]

(a) (i) diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.

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

[12]

(iv) the number of different ways in which these three bands can be selected.

Use the information in (d)(iv) to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.

$\mathrm{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

[8]

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

Find the values of F and θ.

[2]

(b) (i) Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

quantities would be measured in order to determine E ?

Find the equation of the tangent to the curve at the point where $x = 0$.

[8]

(ii) 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.

the solution of the differential equation

supermarket is open 7 days a week.

[4]

(iv) that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\mathrm{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

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

[5]

19 Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

diagram best represents the electric field surrounding the charges?

(a) (iii) the type of each transformation and make clear the order in which they are applied

sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

[12]

(ii) car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

x is in radians, has only one root for $0 < x \leqslant \frac{1}{2}\pi$.

Find the value of $(\alpha + 1)(\beta + 1)(\gamma + 1)$.

which = ... ra **[6]**

(i) point D is such that $ABCD$ is a parallelogram.

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

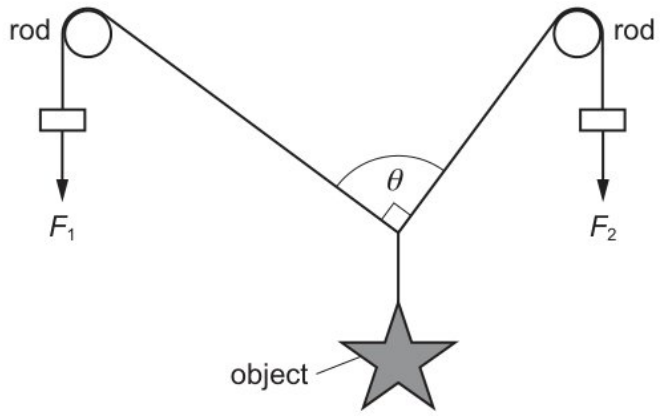
[20]

(v) the number of different ways in which the 12 letters of the word STRAWBERRIES can be arranged

$$\text{f}(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{2} & 1 \leqslant x \leqslant 3 \\ 0 & x > 3 \end{cases}$$

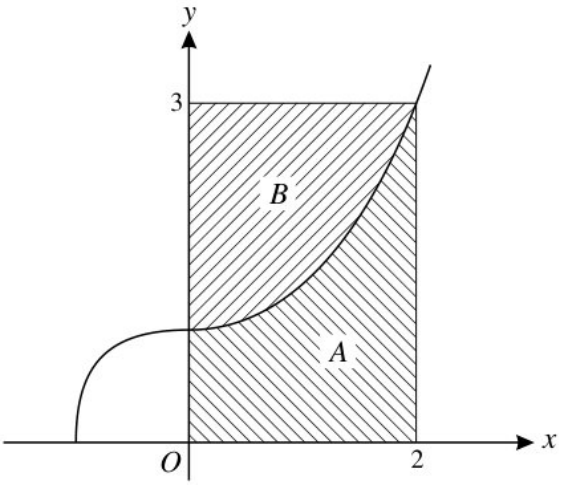
[10]

(b) (ii) that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.



[3]

(iv)



the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$

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

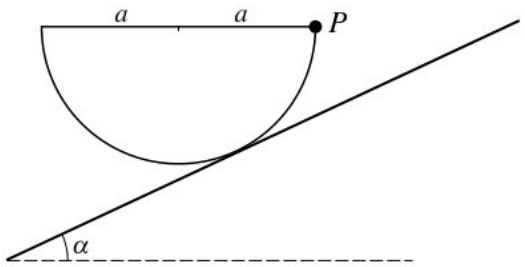
[6]

(iii) When the tensile force is removed, the wire returns to its original length.

$$\sum x = 168 \quad \sum x^2 = 720 \quad \sum y = 228 \quad \sum y^2 = 900$$

[4]

(e) (iv)



are the frequencies of the next two higher notes for this air column?

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

[8]

(i) is given that $\mu = 0.15$ and $X = 20$.

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

[4]

19 Find the area of one loop of C.

(c) (iii) Find the probability that the die lands on 3 and the number of times the coin shows heads is 3 .

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

[8]

(iv) 38% of these leaves are of length k cm or more.

rod in (b) is removed from the pin and supported by ropes A and B , as shown in Fig. 2.2.

Using these values of p and q, find the value of the constant r for which the equation $x^2 + px + q + r = 0$ has equal roots.

[8]

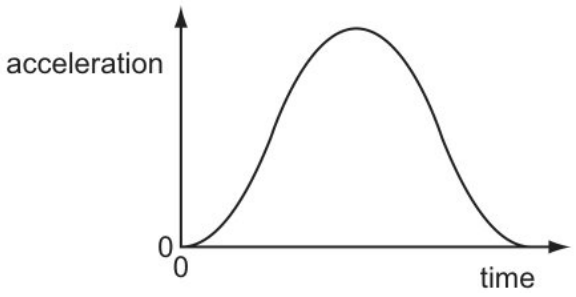
(vi) the rank of **M** and a basis for the range space of T ,

It limits the range of values obtained in repeated measurements.

cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

[4]

(a) (i)



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

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.

number'. = ... wx **[5]**

(iv) 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.

many different colour arrangements are there of the 10 books?

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

[5]

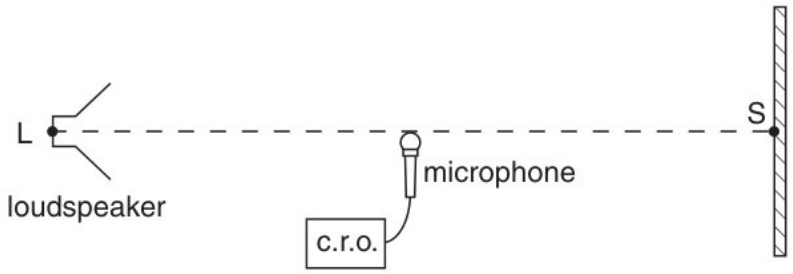
(e) (iii) object consists of a uniform lamina with a particle attached. The uniform lamina $ABCEFD$ of mass m is formed from a rectangle $ABCD$ and an isosceles triangle CEF, where F is the midpoint of CD. The rectangle has sides $AB = 2a$ and $AD = a$. The triangle CEF has base a and height $2a$. The 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).

that $\mathrm{E}(X) = 3.05$, find the values of p and q.

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

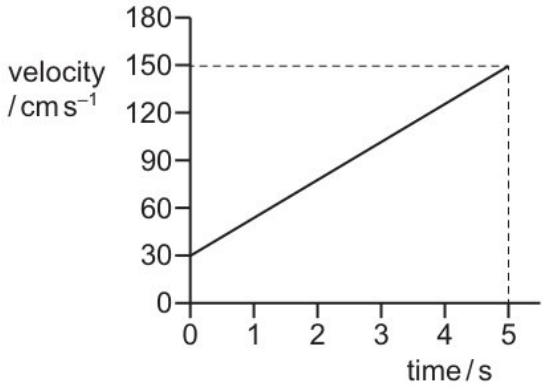
[12]

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



[5]

(ii)



Find the equations of the asymptotes of C.

[5]

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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

[5]

16 the values of a, b, x and y.

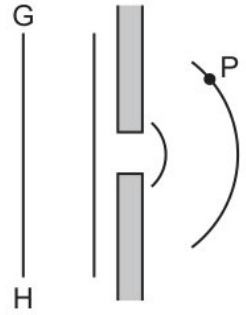
(a) (iii) C in the case $p = -1$. Your sketch should indicate the coordinates of any intersections with the axes, but need not show the coordinates of any turning points.

row compares the number of charge carriers per unit time passing through X and through Y and compares the average drift speed of the charge carriers in X and in Y ?

[5]

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

Stating suitable hypotheses and assuming a normal distribution, test the coach's belief at the 10% significance level.



[6]

(i) is the mass of the car?

Find the value of t when the particle is instantaneously at rest.

[5]

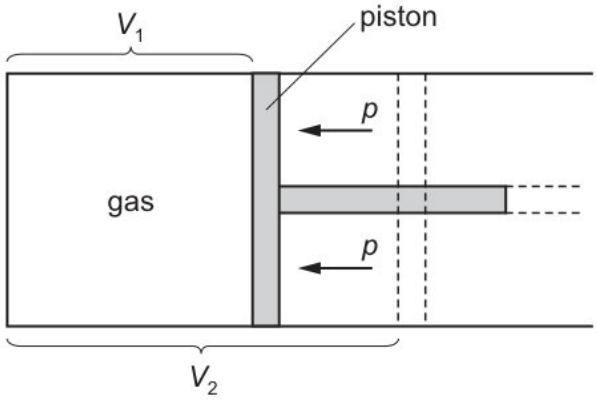
(c) (vi) a transformation from $\mathbb{R}^4$ to $\mathbb{R}^4$.

the value of μ.

[12]

(v)

continuous random variable, X, has probability density function given by



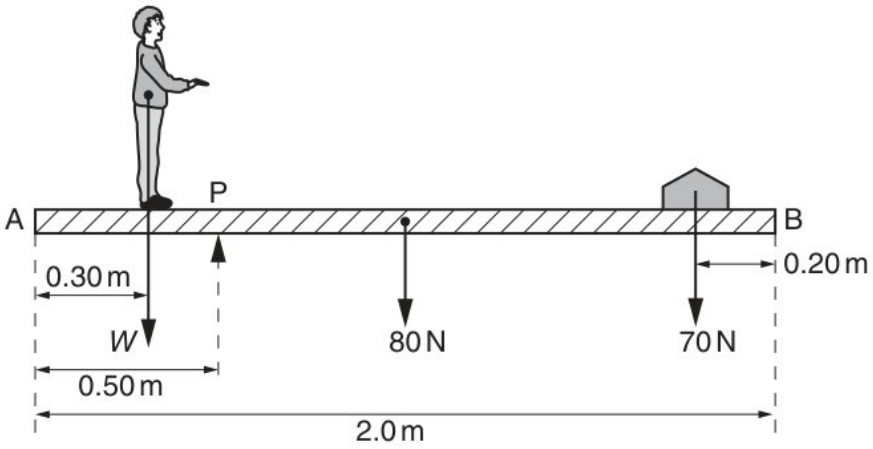
[6]

(g) (iv) The mass of the car is 920 kg . At time $t = 0$, the car is at rest. At time $t = 5.8$ s, its velocity is 17 ms^{-1}.

projectile is launched at 45° to the horizontal with initial kinetic energy E.

[5]

(ii)



coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

[6]

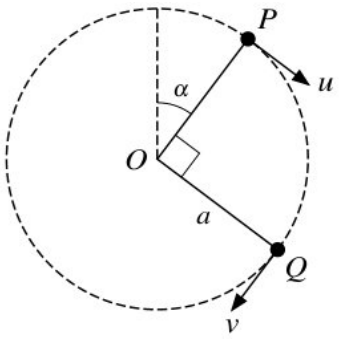
(e) (iii) your answers in the form $\tan k\pi$, where k is a rational number.

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

not have a unique solution.

[6]

(ii)



there are no restrictions,

Show that $\frac{\mathrm{d}^{n+1}}{\mathrm{d}x^{n+1}}\left(x^{n+1}\ln x\right) = \frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n + (n+1)x^n \ln x\right)$.

[1]

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

Member	A	B	C	D	E	F	G	H
x	24.2	23.8	22.8	25.1	24.5	24.0	23.8	22.8
y	23.9	23.6	22.8	24.5	24.2	23.5	23.6	22.7

[5]

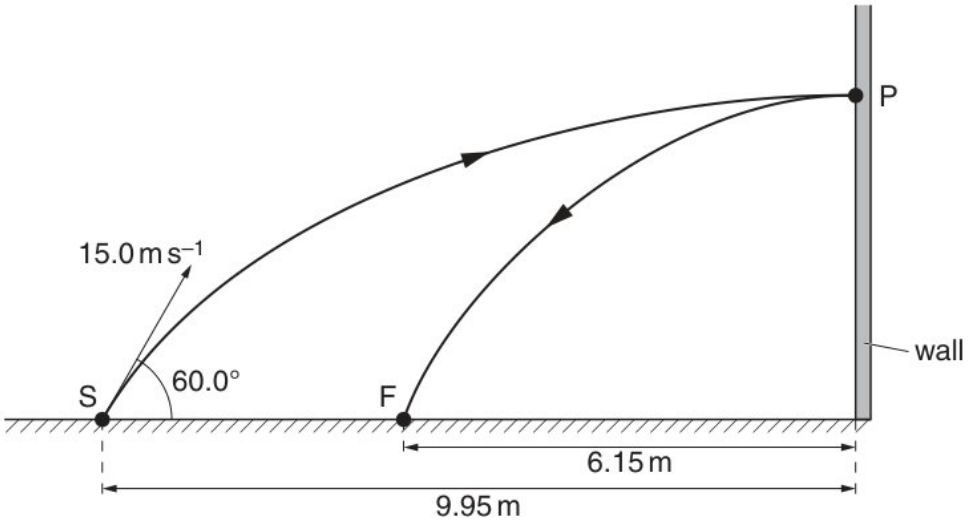
15 particle P moves on a straight line in simple harmonic motion. The centre of the motion is O, and the amplitude of the motion is 2.5 m . The points L and M are on the line, on opposite sides of O, with $OL = 1.5$ m. The magnitudes of the accelerations of P at L and at M are in the ratio $3 : 4$.

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

Given that $\begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$ is an eigenvector of $\mathbf{A}$, find the corresponding eigenvalue.

[6]

(iii) students are selected at random from the students who study Science.



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

[8]

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

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

[6]

(iv) is the minimum constant acceleration necessary for the aircraft?

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

[6]

(vii) is the minimum constant acceleration necessary for the aircraft?

is the horizontal distance of the van's centre of gravity from the front of the van?

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

[6]

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

(a) (i) the coordinates of any stationary points on C.

is given that $y = 2$ when $x = 2$.

[5]

(iv) diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

curve C has equation

student investigates the cooling of a liquid in a beaker.

[6]

(iii) a 95% confidence interval for the difference between the mean number of beech trees in regions of this size in country A and in country B.

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

[4]

(c) (vi) Find the coordinates of any intersections with the coordinate axes.

cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

[6]

(iv) find the probability that in 15 throws the number of 4 s obtained is 2 or more.

Speed is distance travelled per second.

[6]

(iii) function f is such that $\mathrm{f}(x) = 3 - 4\cos^k x$, for $0 \leqslant x \leqslant \pi$, where k is a constant.

Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m , calculate the greatest possible value of ω and the corresponding tension in the string.

the probability density function of Y,

[8]

15 marks of the pupils in a Physics examination are summarised as follows.

(d) (iv) 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.

transmitted light has intensity I.

[12]

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

specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.

rough = ... *bk* **[10]**

(e) (iii) the value of σ.

row gives the sub-multiples or multiples represented by pico (p) and giga(G)?

points A, B, C have position vectors

[3]

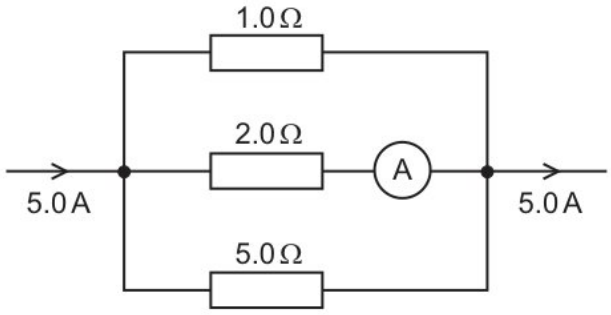
(ii) Express $5\cos\theta - 3\sin\theta$ in the form $R\cos(\theta + \alpha)$, where $R > 0$ and $0^{\circ} < \alpha < 90^{\circ}$, giving the exact value of R and the value of α correct to 2 decimal places.

ball is released from rest at time zero. After 1.0 s it bounces inelastically from a horizontal surface and rebounds, reaching the top of its first bounce after 1.5 s .

curve C has equation $y = \frac{1}{2}(e^{x} + e^{-x})$ for $0 \leqslant x \leqslant \ln 5$. Find

collision = ... *sb* **[6]**

(iv)



sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.

[10]

(a) (i) Its speed decreases to zero, then increases to 20 m s^{-1}.

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

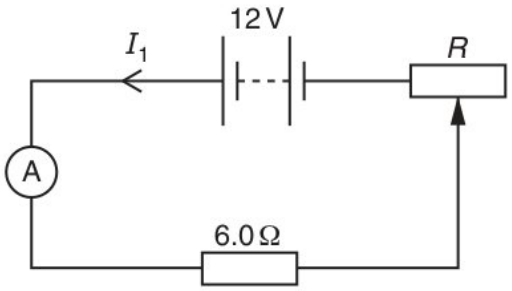
[8]

(iv) **a** and **b** are vectors and t is a scalar.

weight, in grams, of pineapples is denoted by the random variable X which has a normal distribution with mean 500 and standard deviation 91.5. Pineapples weighing over 570 grams are classified as 'large'. Those weighing under 390 grams are classified as 'small' and the rest are classified as 'medium'.

[6]

(ii) curve C has polar equation $r = 2\cos 2\theta$. Sketch the curve for $0 \leqslant \theta < 2\pi$.



curves C_1 and C_2 have polar equations

[15]

8 the number of bags for which you would expect the mass of pasta to be more than 1.65 standard deviations above the mean.

(d) (iii) Find the value of t when the particle is instantaneously at rest.

displacement = velocity × time

[6]

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

$$\frac{\mathrm{d}^2 z}{\mathrm{d}x^2} + 4\frac{\mathrm{d}z}{\mathrm{d}x} + 4z = 8x^2$$

[10]

(v) company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

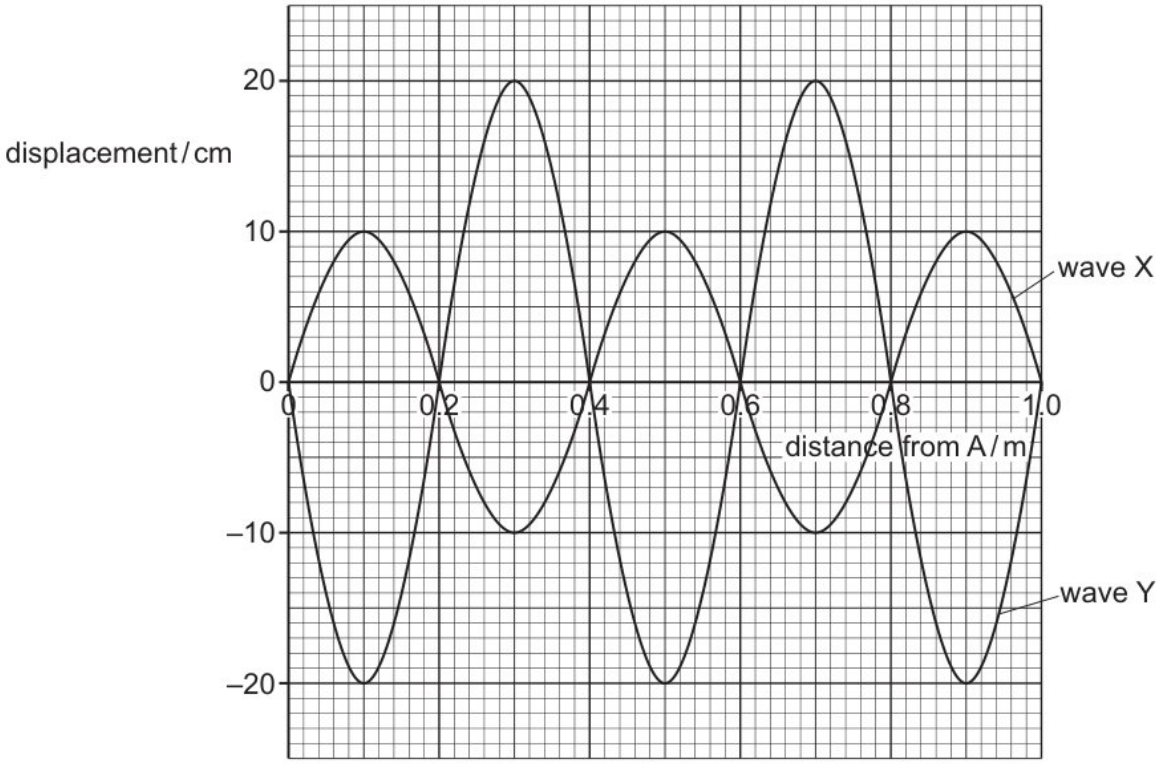
[5]

(c) (ii) by mathematical induction, that $\sum_{r=1}^{n} r \ln\left(\frac{r+1}{r}\right) = \ln\left(\frac{(n+1)^n}{n!}\right)$ for all positive integers n.

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.

[6]

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



[4]

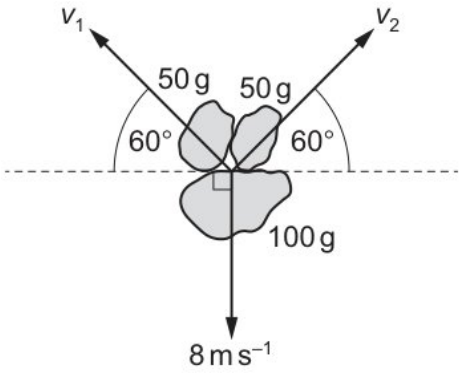
26 potential difference across a resistor is 12 V . The current in the resistor is 2.0 A .

(e) (v) 800 nm to 1000μ m

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

[2]

(i)



is now given that the true value of p is 0.05 .

[5]

(iii) $f(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

$$\sin 5\theta = 5\sin\theta - 20\sin^3\theta + 16\sin^5\theta$$

the equations of the asymptotes of C.

[4]

(a) (i) the acute angle between the planes ABC and ABD.

no unique solution.

[8]

(iii) 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°C.

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 $AC = a$.

is the percentage uncertainty in the calculated density of the liquid?

[2]

23 (ii) in terms of m and g, the magnitude of the frictional force in this position.

(b) three quantities that are conserved during the decay.

[12]

(c) Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is -10 m s^{-2}.

only one of the following two alternatives.

[15]

(a) considering the sum of the areas of these rectangles, show that

[15]

(iv) show that $PQ = 13$,

$$t^4 - 4t^3 - 6t^2 + 4t + 1 = 0,$$

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

[4]

(e) the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

[6]

(i) P and Q collide and stick together.

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

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

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

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

[6]

(d) only one of the following two alternatives.

[12]

(a) graph shows the variation with time of the velocity of the object?

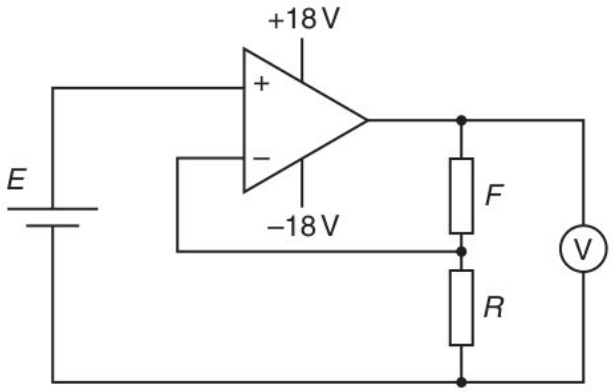
pendulum bob is held stationary by a horizontal force H. The three forces acting on the bob are shown in the diagram.

the general solution of the differential equation

[3]

20 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.

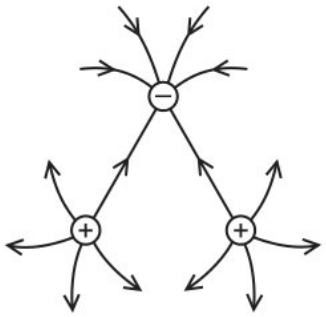
(c) (ii) third coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{5}$.



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

[3]

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



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.

[6]

(a) (i) wave pattern produced in (b) is shown in Fig. 7.1.

frequency of the signal is 50 kHz .

function f is such that $\mathrm{f}(x) = 3 - 4\cos^k x$, for $0 \leqslant x \leqslant \pi$, where k is a constant.

[15]

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

$\frac{\text{force}}{\text{length} \times \text{speed}}$

[6]

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

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

[15]

(i) tension in the string when the particle is at Q is twice the tension in the string when the particle is at P.

Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

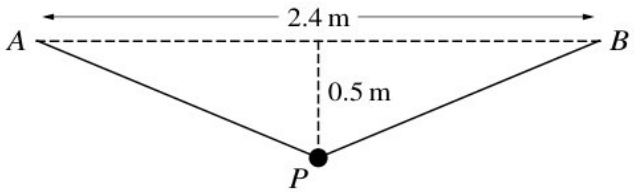
[8]

(b) (ii) is the minimum constant acceleration necessary for the aircraft?

State one difference, which can be seen from the diagram, between the marks for History and Physics.

[20]

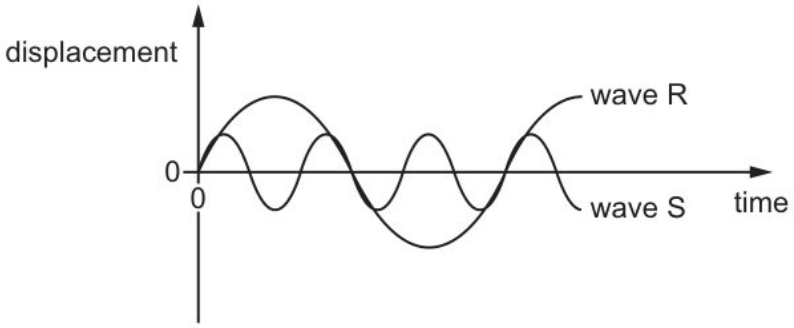
(i)



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

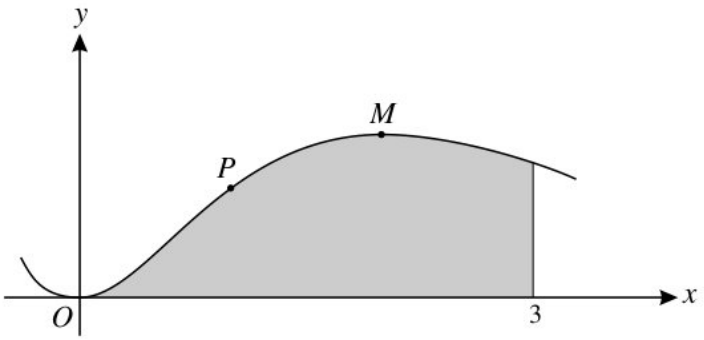
[15]

22 (b) Find the probability that the die lands on 4 and the number of times the coin shows heads is 2 .



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

(iii) determine a correct to 3 decimal places. Give the result of each iteration to 5 decimal places.



single change would double the value of this ratio?

[8]

(i) Show that the possible values of α are 3 and 5 .

[4]

(iv) considering the sum of the areas of these rectangles, show that

When a and b have these values, factorise $\text{p}(x)$ completely.

[5]

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

(vi) that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[10]

(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.

[10]

(i) Use the iterative formula $x_{n+1} = \frac{1}{\sin x_n}$ to determine this root correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

the equations of the asymptotes of C.

the nucleus of $^{238}_{92}\mathrm{U}$ absorbs a neutron, the nucleus decays, emitting an α-particle. State the proton number and nucleon number of the nucleus that is formed as a result of the emission of the α-particle.

[6]

(c) curve C has polar equation $r = a(1 + \sin\theta)$ for $-\pi < \theta \leqslant \pi$, where a is a positive constant.

many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

(i) sequence $x_1, x_2, x_3, \ldots$ defined by

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

[8]

(iv) Determine the decay constant, in min^{-1}, of the radioactive isotope.

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

[6]

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

[6]

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

(b) (iii) verify that this equation has a root between 5 and 5.05.

is a statement of the principle of conservation of momentum for a system?

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

[4]

(i) combined resistance is 66kΩ.

the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

[4]

(ii) the median value of X.

cable has tensions T_1 and T_2 as shown.

[15]

(c) (ii) marble is chosen at random from bag A and placed in bag B.

the past, the population mean time was 62.4 seconds.

[6]

(iii) Show that, for $n > 2$,

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

Calculate the speed of the star relative to the Earth.

[5]

(i) amplitude $\propto$ intensity

Use the iterative formula

[6]

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

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

the position vector of D.

(i) Calculate the speed of the star relative to the Earth.

discrete random variable X has the following probability distribution.

[5]

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

[12]

(c) many electrons pass a point in the conductor in one minute?

(iii) Find the coordinates of A and M.

[6]

(i) do each of the symbols represent for an electric current in a metal wire?

the geometric effects of multiplying z_1 and z_2 by ω

[6]

(vii) Find the constant speed that the tractor could maintain on the hill when working at this power.

resistor of resistance 240Ω is now replaced by a new resistor X of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.

linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} = \begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}$.

[5]

(b) Show that $b = 1 - a$.

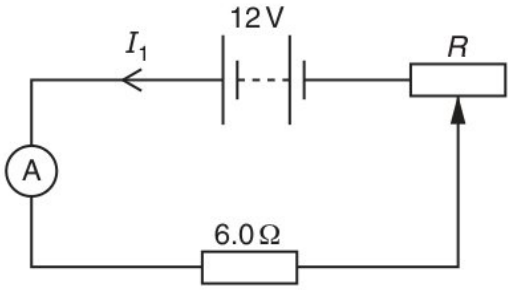
$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - \left(8x + \frac{1}{x}\right)\frac{\mathrm{d}y}{\mathrm{d}x} + 12x^2y = 4x^2\mathrm{e}^{-x^2}$$

(ii) the value of n.

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

[8]

(iii) object weighs 6.0 N on Earth.



[4]

(i) particle starts from a point O and moves in a straight line. The velocity of the particle at time t s after leaving O is v m s^{-1}, where

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

changes to R_1 and to R_2 will increase the value of V_{out} ?

[8]

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

the speed of the combined particle after this collision.

(b) (iii) curve C has polar equation $r = \theta\mathrm{e}^{\frac{1}{8}\theta}$, for $0 \leqslant \theta \leqslant 2\pi$.

variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

matrix **A** is given by

[5]

(i) Find the exact area of the shaded region.

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

[15]

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

is meant by elastic deformation?

[20]

(d) (iv) 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.

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 .

[5]

(iii) Find the greatest height that P reaches above the level of O.

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.

[6]

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

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

turbine at a hydroelectric power station is situated at a vertical distance of 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

[3]

(iii) the probability that all three cars are the same colour.

diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.

[8]

19 village hall has seats for 40 people, consisting of 8 rows with 5 seats in each row. Mary, Ahmad, Wayne, Elsie and John are the first to arrive in the village hall and no seats are taken before they arrive.

(c) (iv) Given that $\cos\alpha = \frac{1}{6}$, find the greatest speed achieved by the centre of the sphere in the subsequent motion.

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

Assume = ... yr **[10]**

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

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

[20]

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

Given that $\begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$ is an eigenvector of $\mathbf{A}$, find the corresponding eigenvalue.

Find the mean and variance of the daily income, in millions of dollars, generated by field A.

[10]

(d) (iii) variables x and y are related by the differential equation

is the reading on the ammeter?

[10]

(i) the solution of the differential equation

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{2x+6}{x^2+6x+5}y = 4,$$

[8]

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

(iii) gravitational potential at a point.

[8]

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

was the by-product of this reaction?

is given that $\mu = 0.15$ and $X = 20$.

[6]

(b) that, at the point of C furthest from the initial line,

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

[5]

(iii) Find the greatest height that P reaches above the level of O.

[3]

(e) matrix $\mathbf{A}$, given by

the polar coordinates of the points of intersection of C and l.

a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.

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

[8]

(iii) the particular solution of the differential equation

[2]

(iv) Nucleus X undergoes β^-decay to form nucleus Z.

[12]

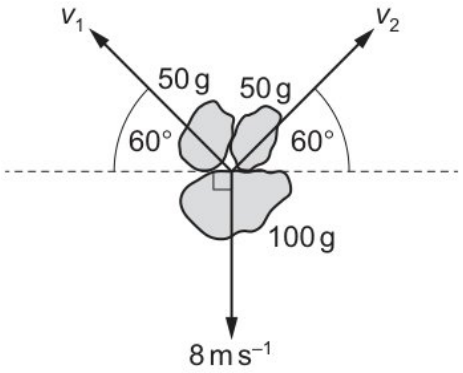
14 combination of changes must increase the amount of spreading due to diffraction?

(d)(vii) λ 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.

with a reason, whether you agree with Nikki's friend.

[12]

(ii)



Find, showing all necessary working, the equation of the regression line of y on x.

[6]

(v) sequence $x_1, x_2, x_3, \ldots$ defined by

sum of a large number, n, of values of X is denoted by T. Using a suitable approximation, it was found that $\mathrm{P}(T > 330) = 0.0391$, correct to 3 significant figures.

[8]

(b) (i) support at end X exerts a force F vertically upwards on the plank.

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

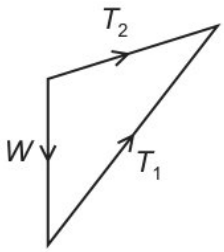
[6]

(ii) 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.

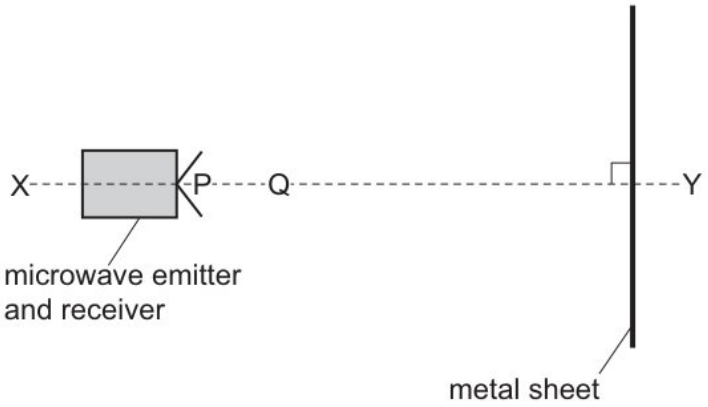
is investigating the views of students at her school about the school sports facilities. She plans to give a survey to a sample of students.

[6]

(c) (ii)



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



[2]

(iii) the speed of Q after the collision.

the solution of the differential equation

[5]

18 Show that if

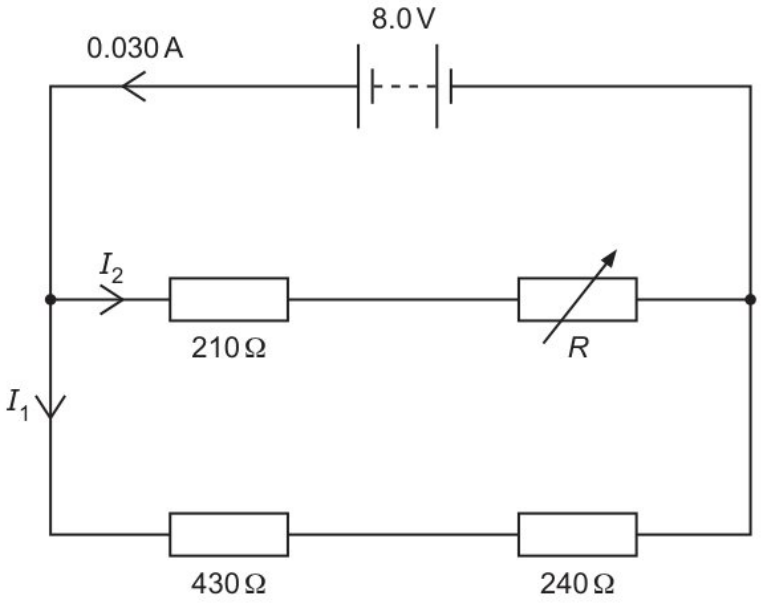
the term elastic limit.

(b) (iii) gravitational potential at a point.

Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

[4]

(ii)



sample has an activity of 180 Bq at time $t = 0$.

car sounds its horn continuously as it travels. The horn emits sound of constant frequency.

[3]

(i) procedure to be followed,

the equation $2\ln(2x) - \ln(x+3) = \ln(3x+5)$.

[8]

(a) (ii) the mean of the times taken by all 50 runners.

The individual ages in years of people in the first Art class are denoted by x and those in the second Art class by y. By first finding $\sum x^2$ and $\sum y^2$, find the standard deviation of the ages of all 19 people.

[4]

(i) curve C has parametric equations

person's eye colour may be categorised as "brown", "blue" or "other". A scientist claims that these eye colours are uniformly distributed and hence are equally likely to occur in the population. A survey of 120 people from this population found that 38 people had brown eyes, 52 people had blue eyes and 30 people had eyes which were neither brown nor blue.

[2]

15 (c) the value of θ.

does this mean?

(i) Show that $m = 0.9$.

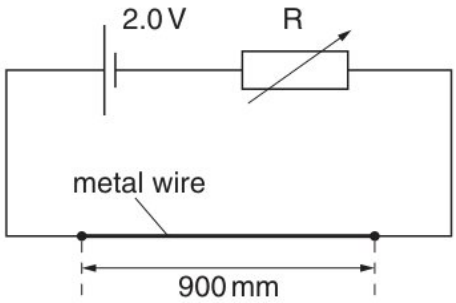
[12]

(iii) sample has an activity of 180 Bq at time $t = 0$.

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

[4]

(iv) Determine whether this point is a maximum or a minimum point.



When the tensile force is removed, the wire returns to its original length.

[10]

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

Calculate the exact value of I_1 and deduce the exact value of I_3.

Find the value of x.

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

is given that $k = 0.025$ and that $U = 20$

[3]

(i) projectile is launched at 45° to the horizontal with initial kinetic energy E.

[4]

(a) internal diameter of the beaker is 0.05 m ± 3%.

three coplanar forces shown in the diagram act at a point P and are in equilibrium.

(iii) In the case where $k = 1$,

does this mean?

[6]

(ii) a 95% confidence interval for the difference between the mean number of beech trees in regions of this size in country A and in country B.

Hence find the largest integer y satisfying the inequality $|2 \ln y - 5| < |\ln y + 3|$.

[6]

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

variables x and y satisfy the differential equation

$$I_n = \int_0^{\frac{1}{4}\pi} \tan^n x \, \mathrm{d}x$$

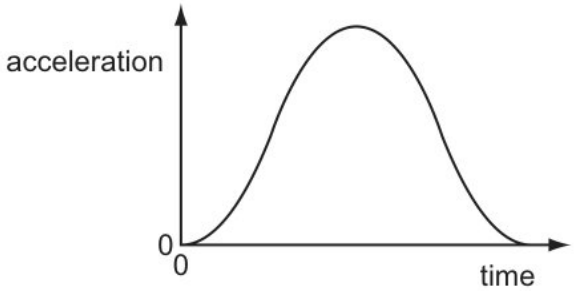
[5]

(iv) Frequency is inversely proportional to wavelength.

that u_{2n} is divisible by u_n for $n \geqslant 1$.

pivoted = ... *oh* **[10]**

(f)



- falling freely with the parachute closed,

(i) frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m . Assume that the weights of the rods are negligible.

[5]

(ii) specific latent heat.

moment of a force.

[6]

13 (c) $I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

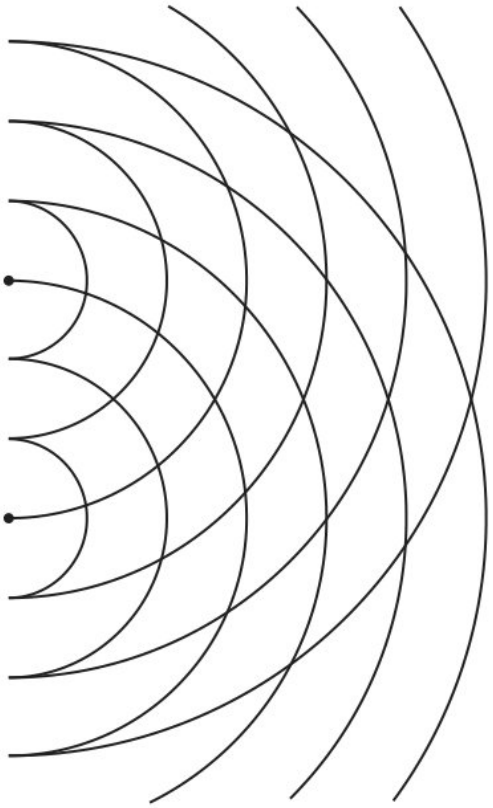
constant potential difference is applied between two horizontal metal plates. A charged oil droplet is held stationary by the electric field between the plates.

(i) Find the total distance travelled by the particle in the first 10 seconds of motion.

[6]

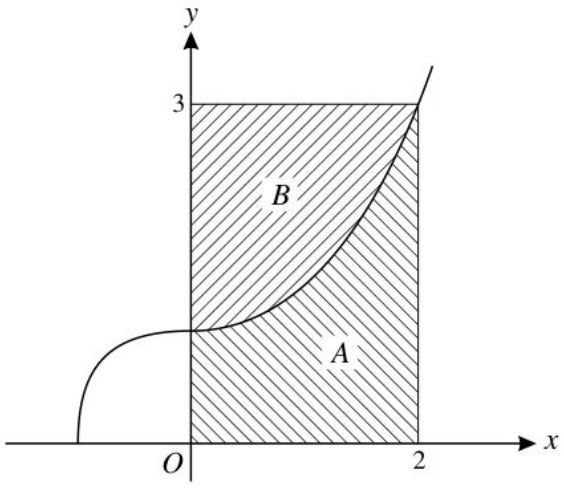
(iii) weight of the parachutist is 850 N .

that the mean of these 40 values is 124.0 , find the value of k.



[8]

(ii) that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - y\mathrm{e}^x}{x\mathrm{e}^x + 2y}$.



eigenvector = ... mn **[10]**

(iv) Show that the mean number of rooms that are occupied each night is 3.25 .

[5]

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

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

[8]

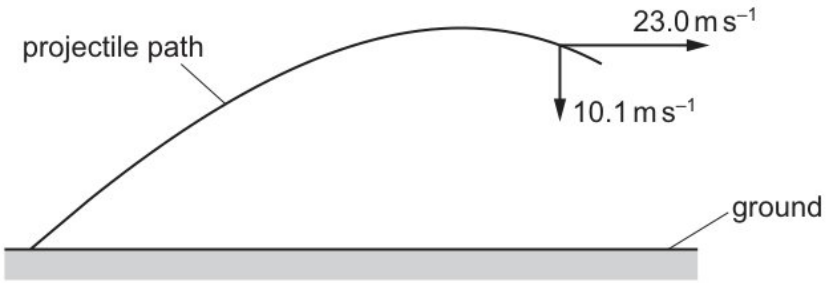
(i) point D is such that $ABCD$ is a parallelogram.

[6]

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

curves C_1 and C_2 have polar equations

(a) (iii) wire of unstretched length 0.81 m is made of a metal with Young modulus 95 GPa . The wire obeys Hooke's law and has a constant cross-sectional area. Fig. 5.1 shows the force-extension graph for the wire.



[6]

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

plank has a mass of 7.0 kg and has a pivot at its midpoint. The plank is horizontal and in equilibrium.

[6]

(c) (ii) 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.

Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

the value of μ.

[12]

(iii) diagram best represents the electric field surrounding the charges?

specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.

[6]

(i) vertical forces that the ground exerts on a stationary van are shown.

$$\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 9x = 18t^2 + 6t + 1$$

this Saturday's event, 60% of the competitors had times less than 36.0 minutes.

[6]

(iv) mass of the liquid is 0.36 kg $\pm$ 10%.

Use the confidence interval found in part (i) to comment on this claim.

the average output power of the car during this time

[12]

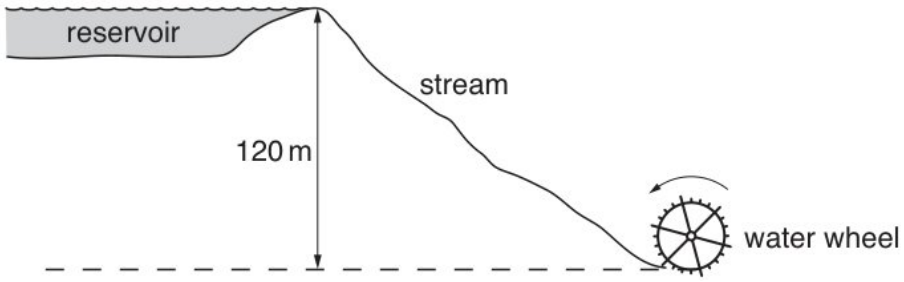
(d) (iii) stationary nucleus has nucleon number A.

which mark on the rule must a 50 g mass be suspended so that the rule balances?

$$x = \tanh^{-1} t \quad \text{and} \quad y = t\,\text{sech}^{-1} t, \quad \text{for } 0 < t < 1$$

[8]

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



analysis of the data,

[12]

(i) observer views the slit through the grating at different angles, moving his head from X parallel to the grating, through Y , opposite the slit, to Z parallel to the grating on the opposite side.

P has mass 6.0 kg and is moving at a speed of 3.0 ms^{-1}.

[6]

(v) 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.

[2]

13 student is investigating how a volume of nitrogen gas is affected by the pressure exerted

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

the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

[5]

(iii) Hence factorise p(x) completely.

the value of θ for which the transformation represented by $\mathbf{M}$ has a line of invariant points. [7]

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

[3]

(i) Find the probability that the total income produced by the two fields in a day is at least \$670 million.

radio-controlled toy car travels along a straight line for a time of 15 s .

an antinode, what could be the ratio $\frac{\text{displacement of the incident wave}}{\text{displacement of the reflected wave}}$ at any instant?

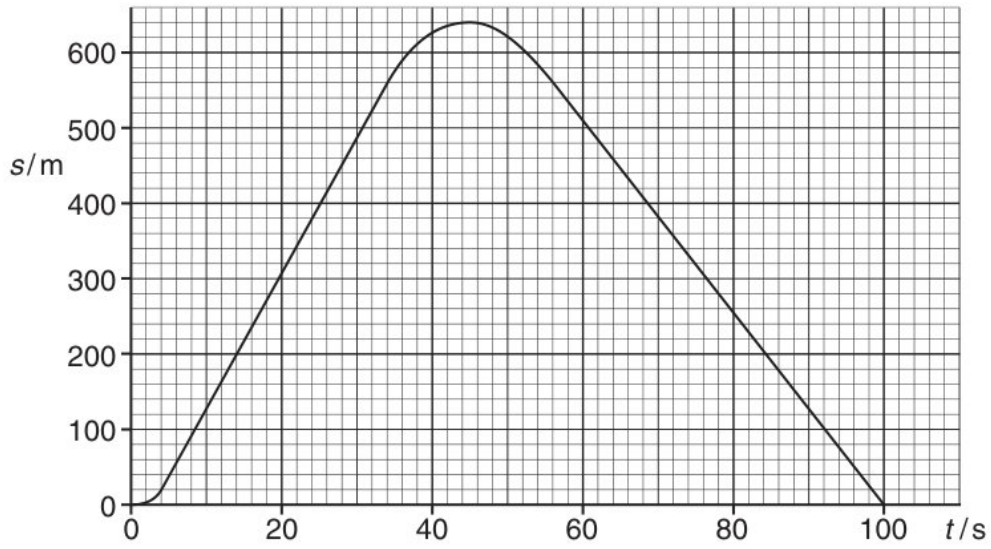
[3]

(ii) Find the exact value of the arc length of C.

the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.

decimal = ... *cc* **[6]**

(b) (iii) lengths of 250 leaves of a certain type of plant are measured, correct to the nearest centimetre. The results are summarised in the table below.



[8]

(i) Calculate the speed of projection of P.

525 520 522 524 518 520 519 525 527 516

line l_2 has equation $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 5\mathbf{k} + \mu(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$.

[12]

(c) (i) that $\tan 2a = -4a$

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

[2]

(ii) are the amplitude and the period of wave S ?

$$\Sigma x = 4, \quad \Sigma x^2 = 10, \quad \Sigma y = 8, \quad \Sigma y^2 = 102$$

[6]

(vi) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

[8]

25 one similarity and one difference between an electron and positron.

(b) (iii) the probability that a 3 is obtained for the second time before the 6th throw.

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

$$x = \tanh^{-1} t \quad \text{and} \quad y = t\,\text{sech}^{-1} t, \quad \text{for } 0 < t < 1$$

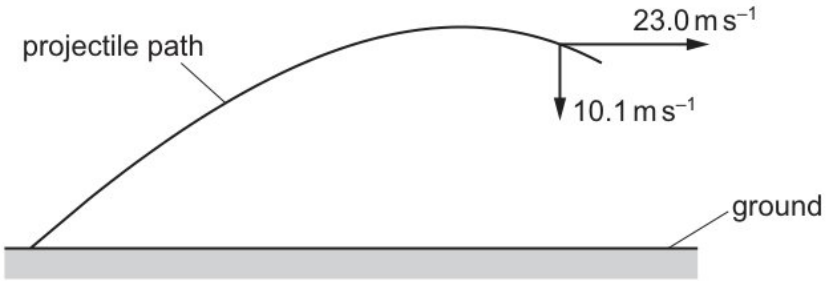
[12]

(i) In the case where $k = 2$,

Explain how an electric field can be used with the magnetic field to ensure that the Explain how an electric field can be used with the magnetic field to ensure that the particle in (b) now passes through point Z. particle in (b) now passes through point Z.

[15]

(iv)



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

[6]

(a) (i) The weight of the plank can be considered to be acting at its midpoint.

verify that this equation has a root between 5 and 5.05.

[10]

(iii) end of a light elastic string of natural length 0.4 m and modulus of elasticity 8 N is attached to a fixed point O on a smooth horizontal plane. The other end of the string is attached to a particle P of mass 0.2 kg which moves on the plane in a circular path with centre O. The speed of P is v m s^{-1} and the extension of the string is x m.

is given instead that $\mu \neq 0.15$ and that when $X = 10$, the block is on the point of moving down the plane.

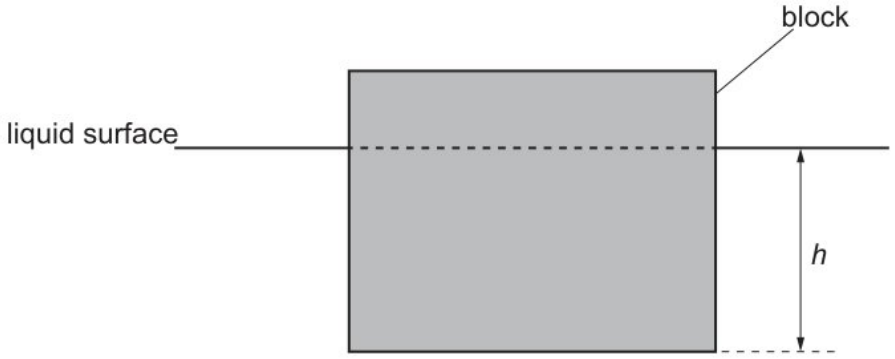
[12]

(ii) $n \geqslant 0$. Use the fact that $\tan^2 x = \sec^2 x - 1$ to show that, for $n \geqslant 2$,

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

[5]

(c) (ii) that the distance travelled by the ball when it is moving upwards is $x = \frac{1}{2k}\ln\left(\frac{g+kU^2}{g+kv^2}\right)$.



[4]

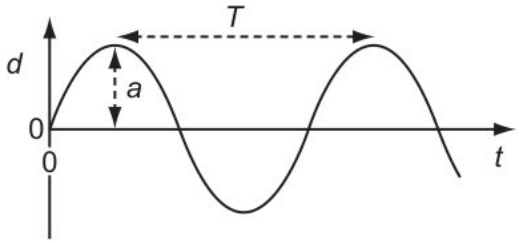
(iii) Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

$$E_K = \frac{1}{2}mv^2.$$

[3]

14 copper wire is 6.4 m long and has a resistance of 0.92Ω.

(d) (i)



is the minimum constant acceleration necessary for the aircraft?

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

[8]

(v) progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

the speed of the body is increased to 40 ms^{-1}, what is its new kinetic energy?

[6]

(vi)

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

specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.

point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

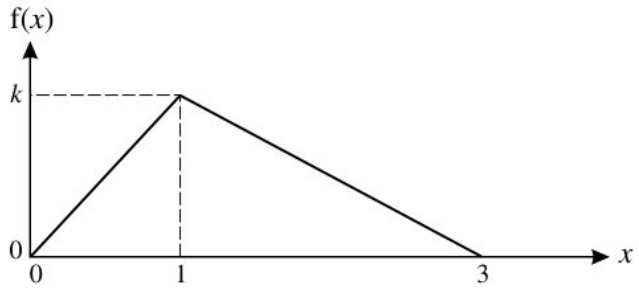
[10]

(iii) only one of the following two alternatives.

a, b and c are integers to be determined.

[5]

(c) (i)



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

line l passes through B and C.

[2]

(ii) Show that the moment of inertia of the object, consisting of rod, shell and inner sphere, about the axis l is $\frac{289}{15}ma^2$.

many competitors would you expect to have times within 1.2 minutes of the mean time?

[8]

(iv) 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.

graph shows the relationship between force acting on a compression spring and change in length of the spring.

[6]

(a) (iii) metal electrical conductor has a resistance of 5.6kΩ. A potential difference (p.d.) of 9.0 V is applied across its ends.

an electron and a neutrino

[4]

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

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.

[8]

(b) (iv) this compression, work W is done on the gas.

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

[6]

(v) coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.

Find the interquartile range of X.

[3]

(iii) the past, the population mean time was 62.4 seconds.

diagram, showing these three forces to scale, is correct?

[8]

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

Find the total work done against the resistance force as the car ascends the first ramp and descends the second ramp.

bolt is subjected to a tensile force, as shown.

[8]

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

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

the expected value and variance of Y.

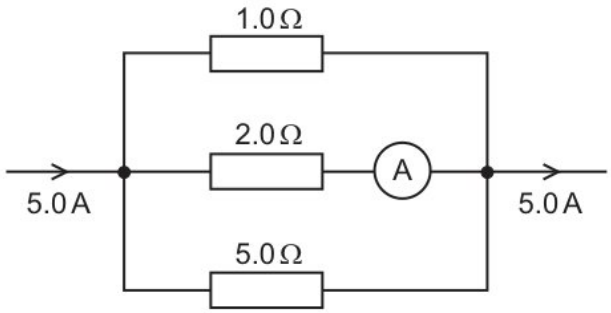
[4]

17 position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where

Find the value of k for which the set of linear equations

overall efficiency of the turbine and generator system is 90%. The density of water is 1000 kg m^{-3}.

(a) (iii) only one of the following two alternatives.



[5]

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

Show that if

points A, B, C have position vectors

[5]

(iv) the sum to infinity of the progression.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = -2x\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2$$

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

[10]

(e) (iv) the iterative formula in part (c) to calculate a correct to 4 decimal places. Give the result of each iteration to 6 decimal places.

Find the rank of **A** and a basis for the null space of T .

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

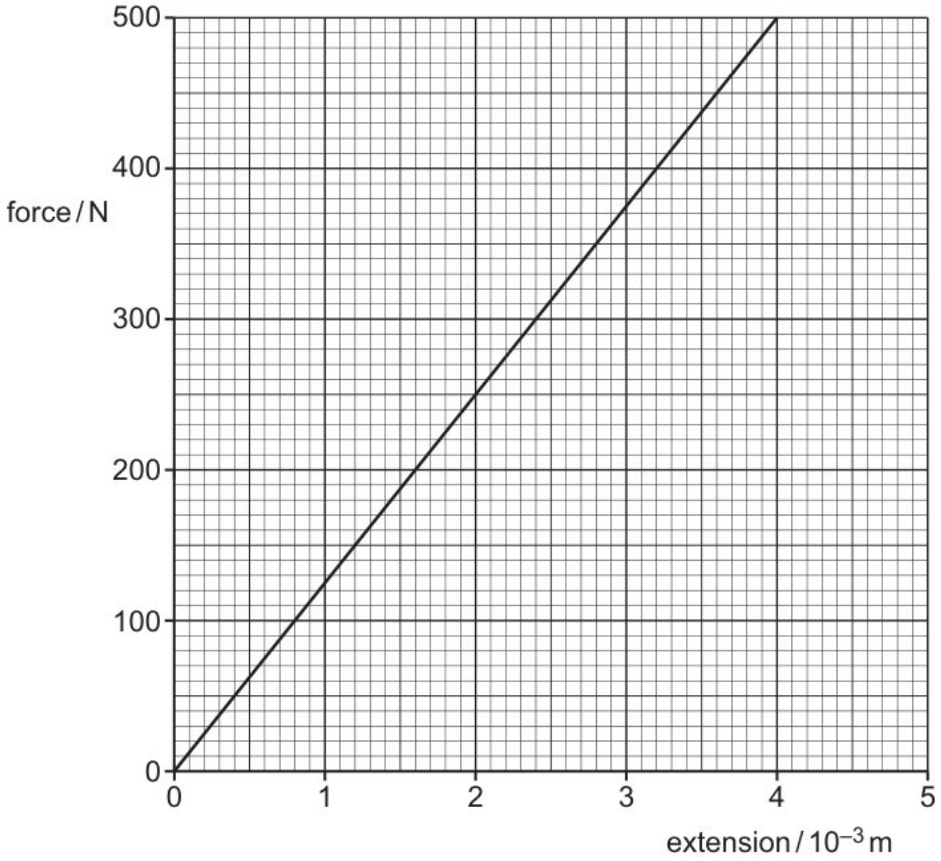
[2]

(ii) a, b and c are integers to be determined.

Find the area of the triangle ABC.

[6]

(b) (ii)



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.

[5]

(vi) State what is meant by the internal energy of a system.

The extension of the wire is not proportional to the tensile force.

[12]

(i) object is fully submerged in a liquid.

is given that $\mu = 0.15$ and $X = 20$.

[6]

18 (b) height of the liquid in the beaker is 0.20 m $\pm$ 2%.

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

(iii) In some nuclear processes, mass-energy is not conserved.

[2]

(ii) Find the equations of the asymptotes of C.

[5]

(d) The powers to X, Y and Z will all increase.

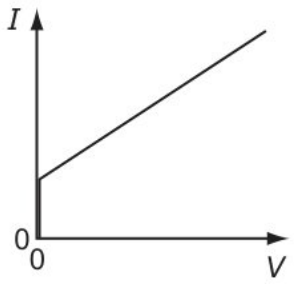
curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.

(iv) that, at the point of C furthest from the initial line,

[4]

(iii) Find the values of F and θ.

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



[4]

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

solve the equation $5\sin\left(2\theta + \frac{1}{6}\pi\right) - 4\cos 2\theta = \sqrt{7}$ for $0 \leqslant \theta \leqslant \pi$. Give your answers correct to 2 decimal places.

[10]

18 statement about light waves and sound waves is correct?

(d) (i) variables x and y satisfy the differential equation

the position vector of D.

[10]

(iv)

	first higher note /Hz	second higher note /Hz
A	113	150
B	150	225
C	150	300
D	225	375

that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - ye^x}{xe^x + 2y}$.

[5]

(a) (iv) flows out of a pipe and hits a wall.

random variable T has probability density function given by

[5]

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

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

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

[15]

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

$$\frac{\mathrm{d}^2v}{\mathrm{d}x^2} + 2\frac{\mathrm{d}v}{\mathrm{d}x} - 15v = 24\mathrm{e}^{-x}$$

[12]

(f) (iv) polynomial p(x) is defined by

variation with time t of the velocity v of the car is shown.

[8]

(ii) plane Π_1 passes through the points $(1, 2, 1)$ and $(5, -2, 9)$ and is parallel to the vector $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$.

are selected from these 20 to perform at a concert.

[4]

(i) (amplitude $)^2 \propto \sqrt{\text{ intensity }}$

was the by-product of this reaction?

[8]

(c) (iii) 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.

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

[8]

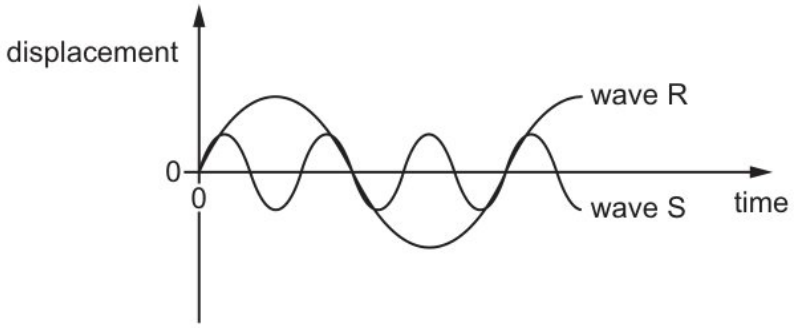
(i) Find the equation of the tangent to the curve at P.

State one other feature of this orbit.

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

[8]

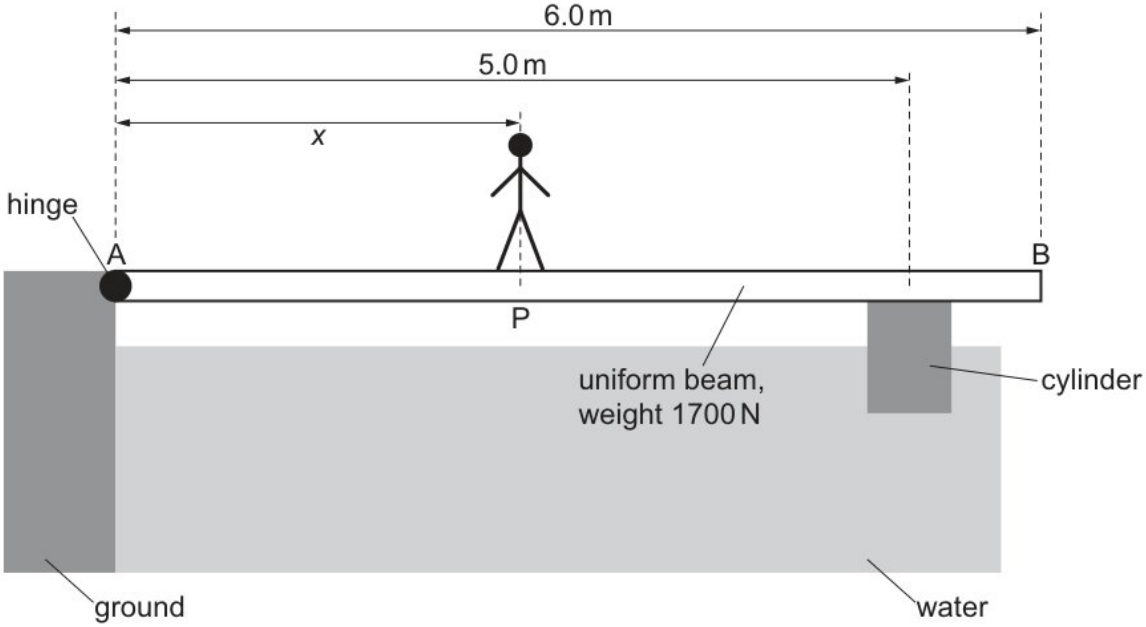
(iv) the matrix **A**,



[4]

21 Find the probability that a box is rejected.

(b) (ii) displacement = velocity × time



curve with equation $y = \frac{2-\sin x}{\cos x}$ has one stationary point in the interval $-\frac{1}{2}\pi < x < \frac{1}{2}\pi$.

[8]

(i) could M and N be?

row correctly identifies the properties of all electromagnetic waves?

[6]

(a) (i) Find the probability that the die lands on 4 and the number of times the coin shows heads is 2 .

[6]

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

Given that $\begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$ is an eigenvector of $\mathbf{A}$, find the corresponding eigenvalue.

[8]

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

Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

[15]

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

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.

[2]