15 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.

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

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.

[10]

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

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

body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

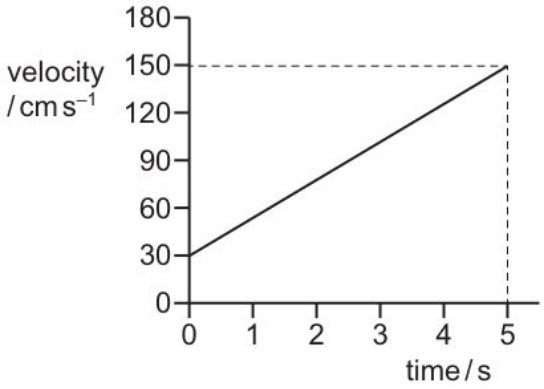
[2]

(iv) Find the speed of P when it passes through L.

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

[8]

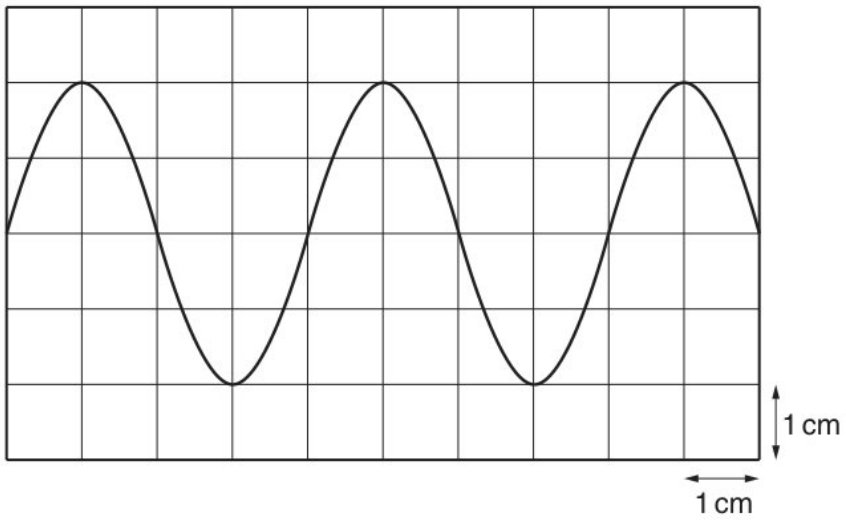
(a) (iii)



is given that $y = \frac{1}{12}\pi$ when $x = \frac{1}{2}\pi$.

[5]

(vi)



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.

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.

passengers, = ... *is* **[3]**

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

(c) (iv) second coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{4}$.

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

[6]

(i) the probability that the 3 customers bought computers all made by different companies.

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.

make = ... af **[8]**

(b) (ii) expression gives the value of $\frac{v}{u}$?

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

that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\mathrm{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

[6]

(i) the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

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

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

[4]

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

$5\sin\left(x + \frac{1}{6}\pi\right) - 4\cos x$ in the form $R\sin(x - \alpha)$, where $R > 0$ and $0 < \alpha < \frac{1}{2}\pi$. State the exact value of R and give the value of α correct to 3 decimal places.

uniform solid hemisphere, of radius a and mass M, is placed with its curved surface in contact with a rough plane that is inclined at an angle α to the horizontal. A particle P of mass m is attached to the rim of the hemisphere. The system rests in equilibrium with the rim of the hemisphere horizontal and P at the point on the rim that is closest to the inclined plane (see diagram). Given that the coefficient of friction between the plane and the hemisphere is $\frac{1}{2}$, show that

[6]

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

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]

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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted

[10]

(f) (ii) 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.

1 Which quantity is a scalar quantity?

[6]

(i) State the name of this type of reaction.

$$\mathrm{p}(x) = 6x^3 + ax^2 + bx + 10$$

[5]

(iii) the length of C.

researcher wishes to test at the 1% significance level whether the mean concentration of the protein in the blood stream of patients taking the drug is less than 0.185 .

[3]

(iv) the moment of a force about a point.

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.

[12]

17 the time taken for the ball to reach its maximum height

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.

(c) (i) is an approximate value for the speed of sound in air?

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.

graph = ... *ip* **[6]**

(v) only one of the following two alternatives.

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.

packed packed = ... ph **[6]**

(a) (i) is the magnitude of the net force acting on the ball?

no digit can be repeated,

direction = ... vn **[4]**

(ii) 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.

Hence obtain the expansion of $\mathrm{f}(x)$ in ascending powers of x, up to and including the term in x^2.

stretched show = ... py **[8]**

(ix) exactly at point T

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

Find the equations of the asymptotes of C.

[10]

19 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 $x = a$.

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

(c) (ii) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

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]

(i) 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 .

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

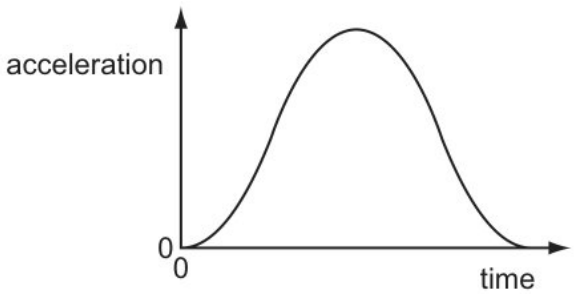
[6]

(iii) the solution of the differential equation

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

after = ... ib **[4]**

(b) (v)

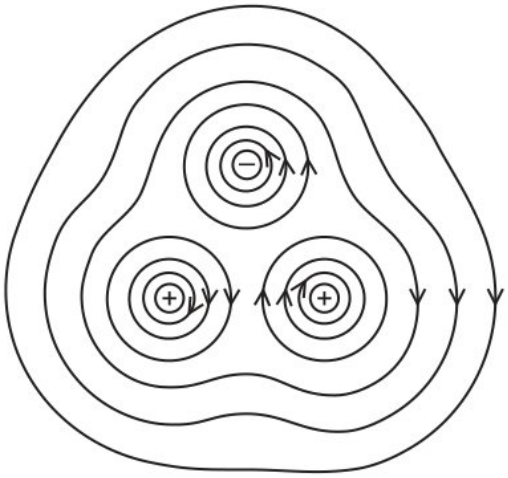


Deduce the value of $\sum_{r=1}^{\infty} \frac{2r+1}{r(r+1)(r+2)}$.

$$\sin 5\theta = 5\sin\theta - 20\sin^3\theta + 16\sin^5\theta$$

[6]

(ii) neutron decays to form a proton.



[4]

(iv) that $k = 3$ and $p = 26$.
leptons are emitted from the sodium-21 nucleus during the decay?

stretched = ... vg **[4]**

(a) (iii) C, stating the coordinates of the intersections with the axes.

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

compares = ... wh **[6]**

(i) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where
changes to R_1 and to R_2 will increase the value of V_{out} ?

[6]

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

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

aeroplane is flying at a constant speed.

[5]

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

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

not have a unique solution.

[12]

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

is the value of R ?

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & -1 & 1 \\ 2 & -1 & -4 & 3 \\ 3 & -3 & -2 & 2 \\ 5 & -4 & -6 & 5 \end{pmatrix}.$$

noting = ... xo **[4]**

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

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

the torque of a couple.

[4]

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

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 .

[5]

(v) 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 .

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

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

[2]

(vii) 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 .

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

circular = ... rj **[15]**

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

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.

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.

(g) (v) single change would double the value of this ratio?

It limits the range of values obtained in repeated measurements.

[8]

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

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

[6]

(c) (ii) 3×3 matrix $\mathbf{A}$ has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

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

[15]

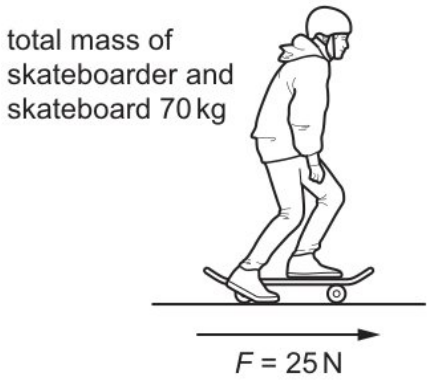
(iii) For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

	M	N
A	microwaves	visible light
B	microwaves	γ-rays
C	γ-rays	microwaves
D	visible light	microwaves

[8]

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

(d) (iv)



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.

[3]

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

the values of the constants k_1 and k_2 are to be determined.

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.

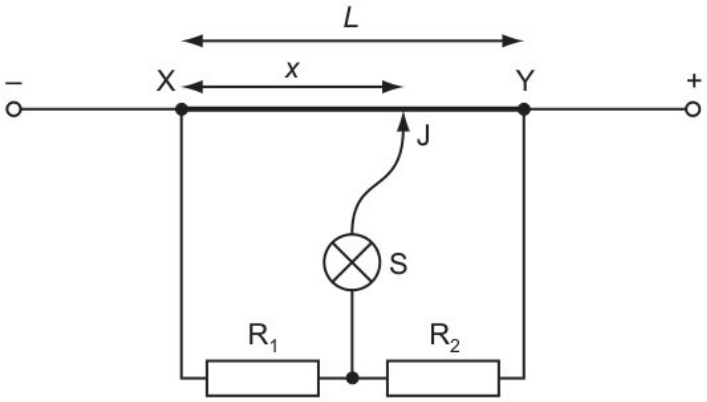
support = ... *ul* **[5]**

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

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

Trulite = ... *tc* **[3]**

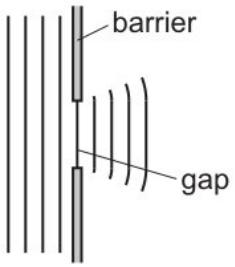
(i) is given that



position vectors of the points A, B, C, D are

[8]

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



[4]

(v) students are selected at random from the students who study Science.

which direction does the droplet accelerate, and which change needs to be made to the separation of the plates in order to stop this acceleration?

[2]

14 Find the angle between the vertical and the side AO of the lamina.

the distribution function of X.

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, $\mathrm{H}_1 : p < 0.2$.

(d) (ii) Find the values of a and b.

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

[8]

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

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

[10]

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

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]

(a) (i) the number of different arrangements of the 7 men in a line in which Ali and Ben do not stand next to each other.

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

moment = ... bg **[8]**

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

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

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

[15]

(ii) by calculation that $0.9 < a < 0.95$.

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

[10]

(iii) 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.

Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

0.50 Assume = ... wt **[3]**

13 The matrix **B**, where

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

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.

[3]

(iv)

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

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

appropriate = ... kn **[4]**

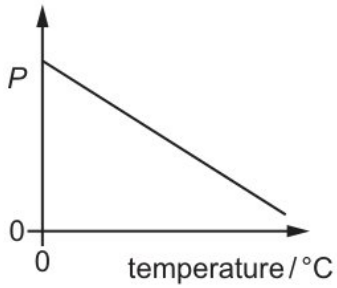
(a) (ii) is a general description of a baryon?

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}.

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

moving = ... ix **[8]**

(i) $\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5$.



[5]

(iii) that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

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

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

[6]

8 linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

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

(a) (iii) State one other feature of this orbit.

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

[8]

(i) the solution of the differential equation

many different colour arrangements are there of the 10 books with exactly 4 books between the 2 yellow books?

[6]

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

Show that $b = 1 - a$.

random = ... ep **[3]**

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

Show that the tension in the string is 10 N .

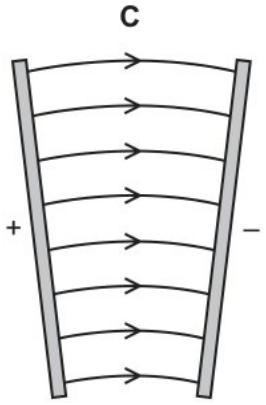
[5]

(iii) is a necessary condition for observable interference fringes to be produced?

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.

[5]

(e) (iv) 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 .



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.

[8]

(ii) λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.
curve C has equation $y = \frac{1}{2}\left(\mathrm{e}^{x} + \mathrm{e}^{-x}\right)$ for $0 \leqslant x \leqslant \ln 5$. Find

[6]

(i) is the force exerted on the wall by the water?
be written as a quadratic equation in x.

[15]

10 that, at the point $A(-1, 1)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -4$.
competitors who took part in this Saturday's event are selected at random.

(b) (vi) 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.

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

[8]

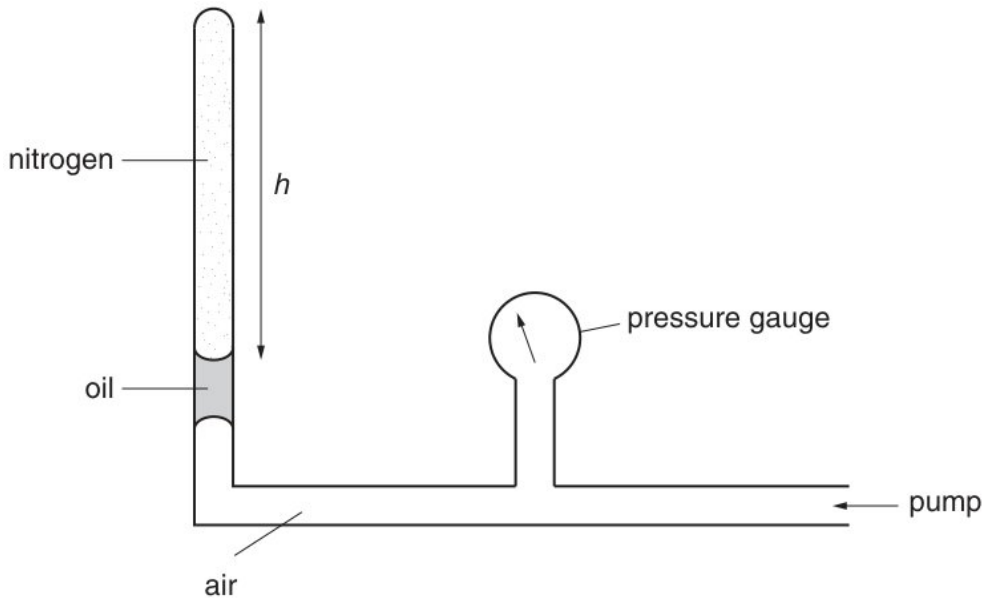
(iii) constant resultant force F acts on a car of mass m. The car moves from rest with constant acceleration a along horizontal ground. When the car has displacement s, the speed of the car is v.

at the 2.5% significance level whether this evidence supports Mr Lee's assertion.

[6]

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

coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.



[8]

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

Given that $F = 0, G = 75$ and $\alpha = 60°$, find the magnitude and direction of the resultant force.

selected = ... tm **[4]**

(iv) the probability that both marbles chosen are the same colour.

The powers to X, Y and Z will all increase.

Use de Moivre's theorem to show that

[4]

(a) (i) is given that P remains at rest in this new position.

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

Over 50 198 212 217 229 235 242

[6]

(ii)

	wavelength	width of gap
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Find the area of the triangle ABC.

[2]

(iii) quartile: 28, Median: 39, Upper quartile: 67.

Both light waves and sound waves show the Doppler effect.

[4]

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

(a) (ii) the particular solution of the differential equation

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

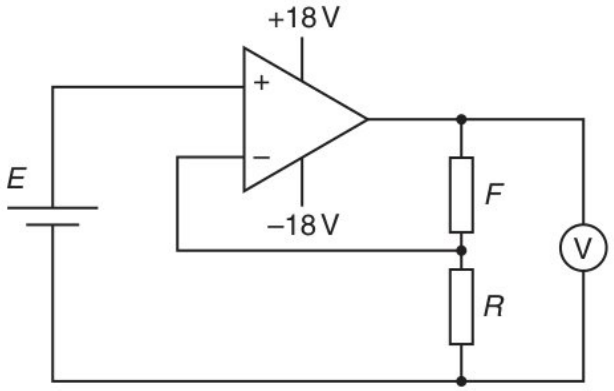
6.1. = ... ux **[6]**

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

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

twelve = ... du **[4]**

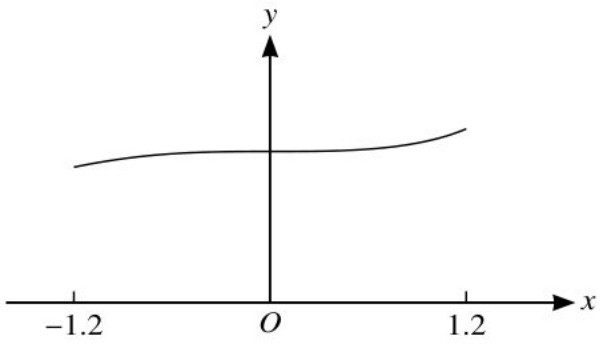
(b) (iii) child of weight 600 N stands in different positions on the plank.



horn, = ... lw **[2]**

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

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



[15]

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

point D is such that $ABCD$ is a parallelogram.

[6]

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

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

uniform rod AB of length $3a$ and weight W is freely hinged to a fixed point at the end A. The end B is below the level of A and is attached to one end of a light elastic string of natural length $4a$. The other end of the string is attached to a point O on a vertical wall. The horizontal distance between A and the wall is $5a$. The string and the rod make angles θ and 2θ respectively with the horizontal (see diagram). The system is in equilibrium with the rod and the string in the same vertical plane. It is given that $\sin\theta = \frac{3}{5}$ and you may use the fact that $\cos 2\theta = \frac{7}{25}$.

[4]

23 many images of the slit does he see?

curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.

(b) (iii) the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

State what happens to the electron and to the positron.

[6]

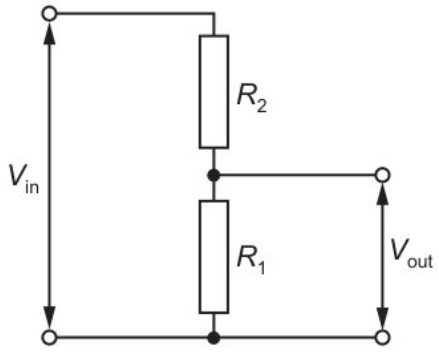
(iv) the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

specific latent heat.

the torque of a couple.

[4]

(ii) 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 $\frac{84}{5}Ma^2$.



number = ... ac **[8]**

(c) (i) the set of values of p for which C has two distinct turning points.

graph shows the variation with time of the velocity of the object?

[12]

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

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & -1 & 1 \\ 2 & -1 & -4 & 3 \\ 3 & -3 & -2 & 2 \\ 5 & -4 & -6 & 5 \end{pmatrix}.$$

[6]

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

the value of V.

[8]

(vi) 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.

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

acts = ... rm **[5]**

(e) (ii) car sounds its horn continuously as it travels. The horn emits sound of constant frequency.

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

[2]

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

$$\mathrm{p}(x) = ax^3 + bx^2 - 17x - a$$

[4]

18 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.

(b) (v) what is meant by the de Broglie wavelength.

the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

time radius = ... qa **[2]**

(vii) is the change to the quark composition of a nucleus that takes place during β^+decay?

linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$
$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}$.

[8]

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

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

[8]

(i) 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.

that, when $t = 0, x = 3$ and $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

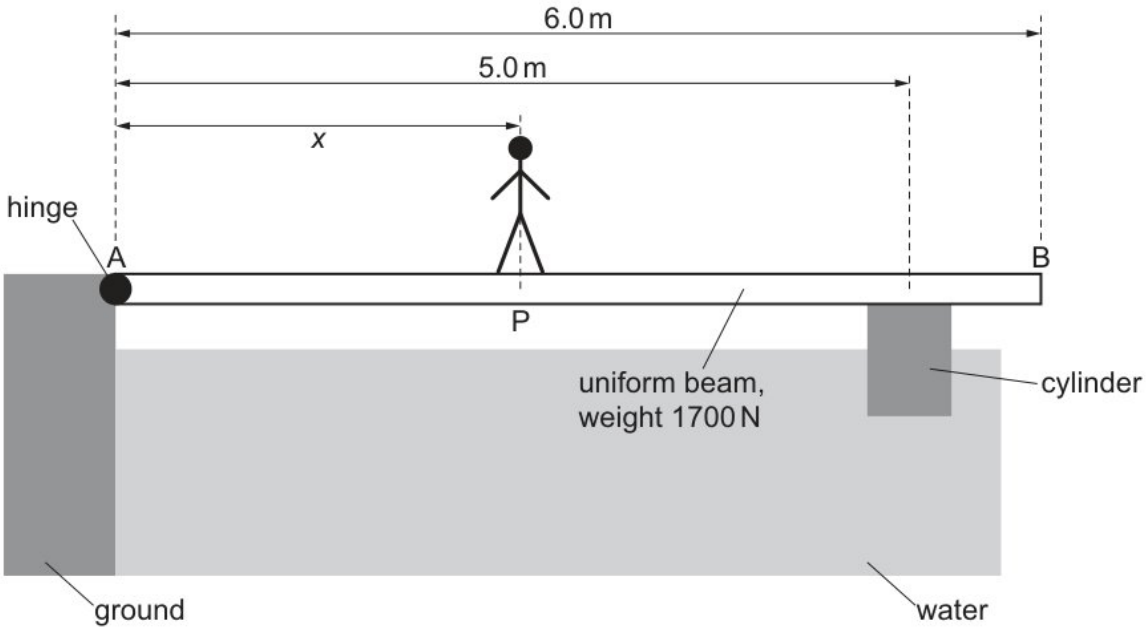
suitable = ... fm **[8]**

(iv) projectile is launched at 45° to the horizontal with initial kinetic energy E.

that u_{2n} is divisible by u_n for $n \geqslant 1$.

[3]

(f) (i)



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

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).

[3]

(iii) Find the standard deviation of x.

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

[2]

(vi) the differential equation, obtaining a relation between x and y.

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

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.

length = ... *um* **[12]**

(a) (iii) Find the values of a and b.

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

speed = ... *cc* **[10]**

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

Find the values of a and b.

[6]

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

Find the equations of the asymptotes of C.

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

[4]

(c) (ii) Find the x-coordinate of the point P at which the tangent to the curve passes through the origin.

row gives the sub-multiples or multiples represented by pico (p) and giga(G)?

[10]

(iii) obtain the roots of the equation

equation gives v in terms of A and u ?

vector = ... zm **[5]**

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

(a) (i) Show that $m = 0.9$.

points A, B, C have position vectors

[4]

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

$$\tanh^2 t + \operatorname{sech}^2 t = 1$$

[6]

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

was the by-product of this reaction?

[5]

(c) (v) wires are extended with the same strain and obey Hooke's law.

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

region R is enclosed by C and l, and contains the pole. Find the area of R.

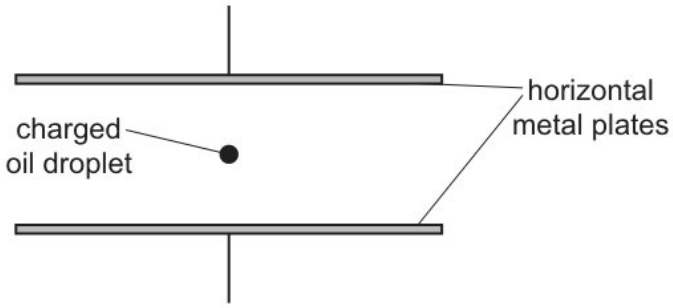
from = ... kw **[2]**

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

the coordinates of C,

[5]

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



[6]

(d) (iii) spherical object falls through water at constant speed. Three forces act on the object.

curve $y = 4x^2 \ln x$ has one stationary point.

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{x+5}{x^2+10x+61}y = 1,$$

[4]

(iv) Show by calculation that a lies between 2 and 4 .

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

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.

[4]

(b) (iv) throws three coins at the same time.

this compression, work W is done on the gas.

When the tensile force is removed, the wire does not return to its original length.

[8]

(ii) only one of the following two alternatives.

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

[8]

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

(d) (i) star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

$$x = \ln(\tan t), \quad y = \sin^2 t,$$

ball = ... dw **[5]**

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

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?

base attached. = ... xu **[5]**

(ii) particle is not involved in the decay process?

measuring instrument should be used?

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

towards = ... bi **[12]**

(vii) 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 .

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

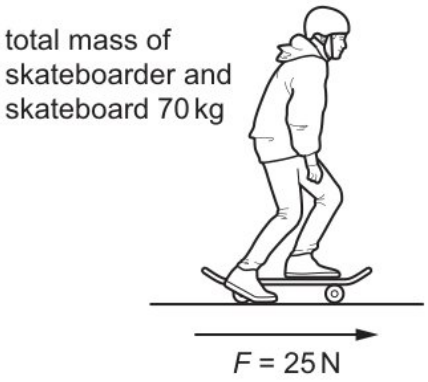
0.86 = ... hu **[8]**

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

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.

[20]

(v)



none of them

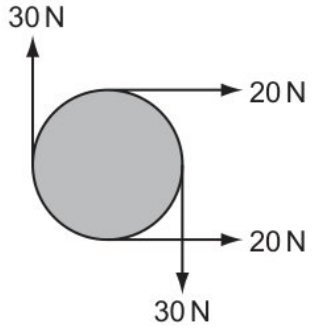
[8]

(b) (iii) 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.

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.

between = ... *sb* **[1]**

(ii)



Find the position vector of D.

[12]

17 Find the distance OM.

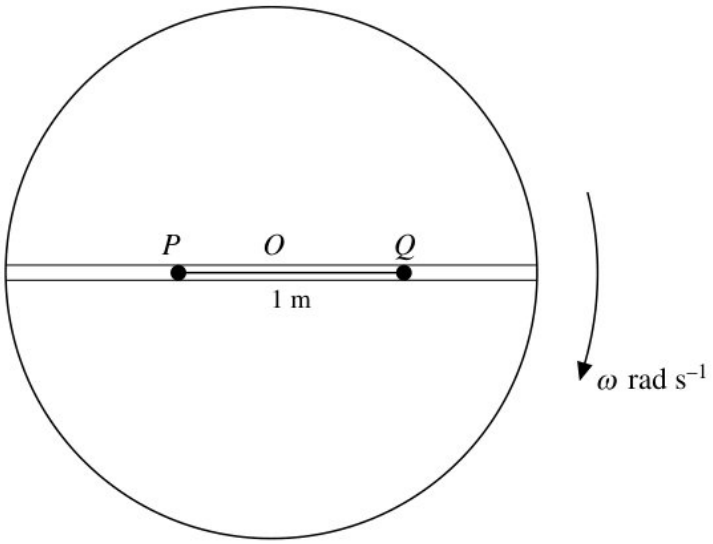
air resistance to be negligible, what will be the kinetic energy of the projectile when it reaches its highest point?

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

volume of oil. Pressure is applied by a pump. The applied pressure is measured on a

B bounces when it strikes the plane, and leaves the plane with speed 20 m s^{-1} but with its horizontal component of velocity unchanged.

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



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

[3]

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

matrix **A**, given by

[6]

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

ball is thrown against a vertical wall. The path of the ball is shown in Fig. 3.1.

rough rest = ... fh **[8]**

(i) the distribution function of X.

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

[6]

(c) (i) Pressure is force per unit area.

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.

same variables = ... dt **[8]**

(ii) 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 $AC = a$.

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

[4]

(iii) It limits the precision of the measured value.

cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

[10]

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

the term interference.

Show that the mass of P is 0.8 kg .

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

Draw up a probability distribution table for X.

projected = ... xr **[6]**

(iii) are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

$$a_{n+1} = \left(\frac{7 + 2a_n^{\frac{3}{2}}}{3 \ln a_n} \right)^{\frac{2}{3}}$$

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.

[5]

(v) the general solution of the differential equation

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} .

Calculate the modulus of elasticity of the string.

[12]

(d) (i) only one of the following two alternatives.

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

[6]

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

Hence find the largest integer y satisfying the inequality $|2 \ln y - 5| < |\ln y + 3|$.

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

made = ... *lh* **[10]**

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

now that the standard deviation of the population is known to be 5.6 minutes. Find the smallest sample size that would lead to a 95% confidence interval for μ of width at most 5 minutes.

diagram, = ... eb **[15]**

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

an expression for $\tan\theta$ in terms of e.

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.

[8]

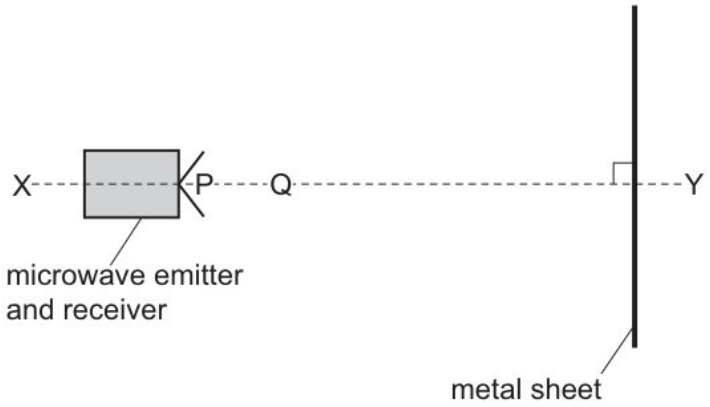
(e) (iii) $I_n = \int_0^1 x^n(1-x)^{\frac{1}{2}}\,\mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

Prove that, for $n \geqslant 2$,

Find the coordinates of the point A on C at which $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and $x \neq 0$.

[6]

(ii)



Prove that $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) \equiv 4\cos 2\theta$.

[15]

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

(a) (ii)

	amplitude /V	period /ms
A	1.5	4
B	5.0	10
C	6.0	20
D	12.0	20

V remains the same because the decrease of p.d. across r is balanced by the increase of p.d. across R.

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

[4]

(i) activity of a radioactive sample.

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

[6]

(c) (ii) 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}.

what can be deduced from this about the rotation of Mars on its axis.

uniform solid hemisphere, of radius a and mass M, is placed with its curved surface in contact with a rough plane that is inclined at an angle α to the horizontal. A particle P of mass m is attached to the rim of the hemisphere. The system rests in equilibrium with the rim of the hemisphere horizontal and P at the point on the rim that is closest to the inclined plane (see diagram). Given that the coefficient of friction between the plane and the hemisphere is $\frac{1}{2}$, show that

[12]

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

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.

$$x^2 + y^2 = a\left(x + \sqrt{\left(x^2 + y^2\right)}\right).$$

[5]

(iii) Find the upward force on the parachutist due to the parachute, during the second stage.

only one of the following two alternatives.

normally = ... tv **[3]**

(iv) 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.

electric current I is given in the list of formulae on page 3 as $I = Anvq$.

[4]

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

The matrix **B**, where

[4]

(i) the probability generating function of Z to find $\mathrm{E}(Z)$.

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

Find = ... qi **[5]**

29 is a general description of a baryon?

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

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

cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

[8]

(ii) the speed of the combined particle after this collision.

the matrix **A**,

$\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5$.

[5]

(v) find the volume of the tetrahedron $OABC$, given that the volume of a tetrahedron is $\frac{1}{3}\times$ area of base $\times$ perpendicular height.

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.

[5]

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

curves C_1 and C_2 have polar equations

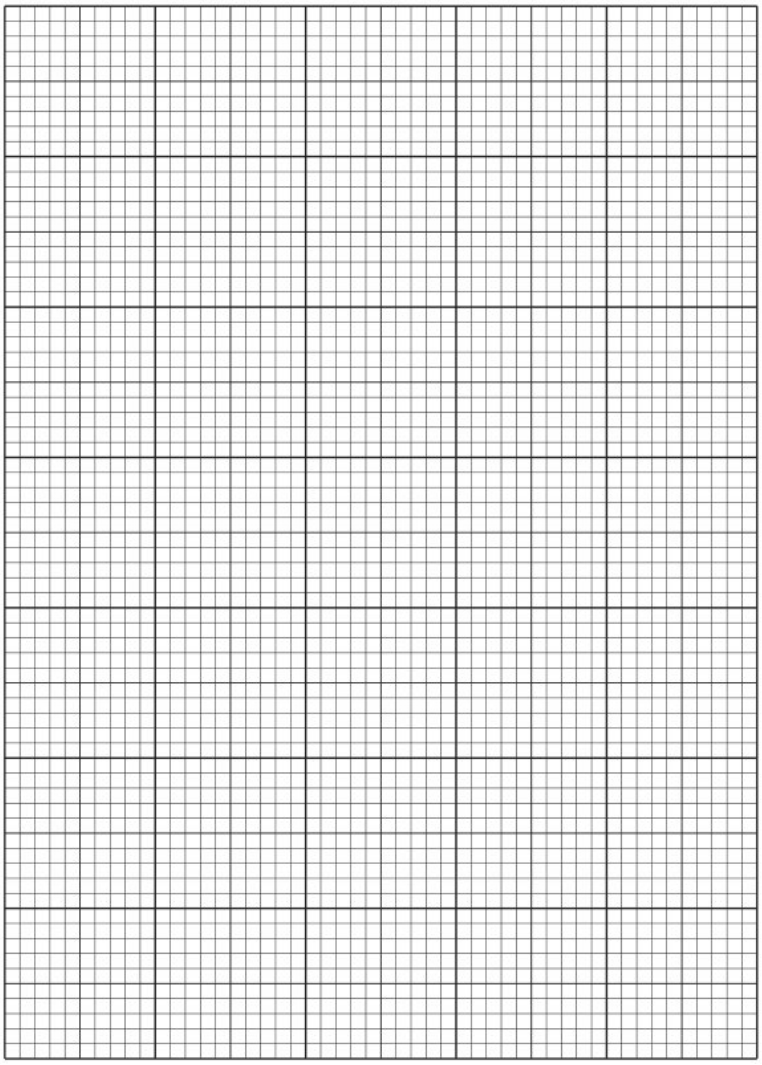
[4]

(b) (ii) time taken by P to travel directly from L to M is 2 s .

the value of n.

through magnetic = ... qg **[5]**

(iii)

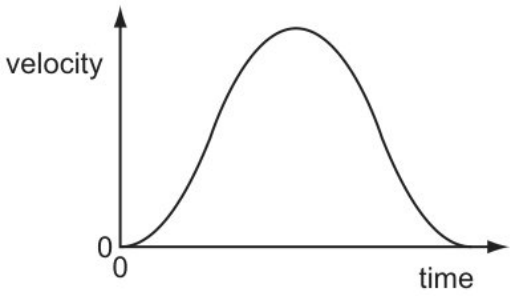


Find the total distance travelled by the particle in the first 10 seconds of motion.

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

[8]

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



(c) (ii) roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

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

State one other feature of this orbit.

[6]

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

that l_1 and l_2 do not intersect.

[12]

(a) (iv) the probability that the 3 customers bought computers all made by different companies.

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

variables x and y satisfy the differential equation

[3]

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

resultant force of 3800 N causes a car of mass of 1500 kg to accelerate from an initial speed of 15 ms^{-1} to a final speed of 30 ms^{-1}.

[5]

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

the average output power of the car during this time

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

rooms = ... *bn* **[20]**

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

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

Hence show that the differential equation

constant. Trulite 2000 = ... *ib* **[6]**

(b) (i) Find the equations of the asymptotes of C.

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

[1]

(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.

are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

[5]

(iii) 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.

is the angle between the second-order maximum and the third-order maximum?

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.

[6]

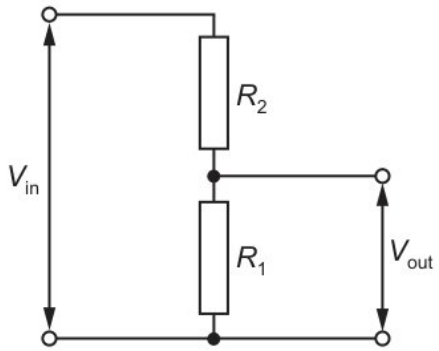
15 force = mass × acceleration

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

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

first = ... qg **[5]**

(iv) Find the x-coordinate of the point P at which the tangent to the curve passes through the origin.



[2]

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

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}.

uniform rod AB of length $3a$ and weight W is freely hinged to a fixed point at the end A. The end B is below the level of A and is attached to one end of a light elastic string of natural length $4a$. The other end of the string is attached to a point O on a vertical wall. The horizontal distance between A and the wall is $5a$. The string and the rod make angles θ and 2θ respectively with the horizontal (see diagram). The system is in equilibrium with the rod and the string in the same vertical plane. It is given that $\sin\theta = \frac{3}{5}$ and you may use the fact that $\cos 2\theta = \frac{7}{25}$.

[10]

(c) (ii) Find the distance OM.

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

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.

ramp. reaches = ... wu **[8]**

(v) that the distance travelled by the ball when it is moving upwards is $x = \frac{1}{2k}\ln\left(\frac{g+kU^2}{g+kv^2}\right)$.

Find the area of the triangle ABC.

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

[3]

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

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

Find the product moment correlation coefficient for the data.

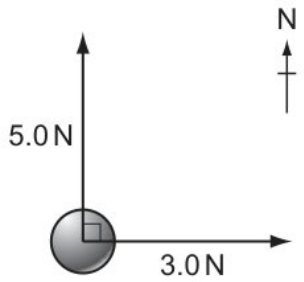
[4]

(b) (iv) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

polar equation of a curve C is $r = a(1+\cos\theta)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

mean = ... *oe* **[5]**

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



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

[4]

(ii) the principle of moments.

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.

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

[5]

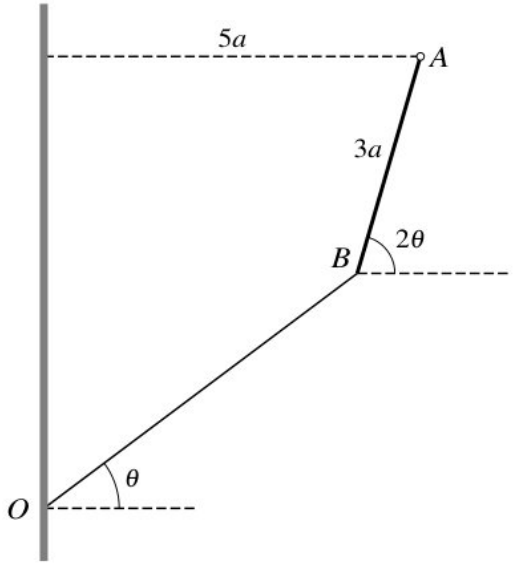
(iii) diagram shows the curve $y = x^2e^{-x}$.

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

[20]

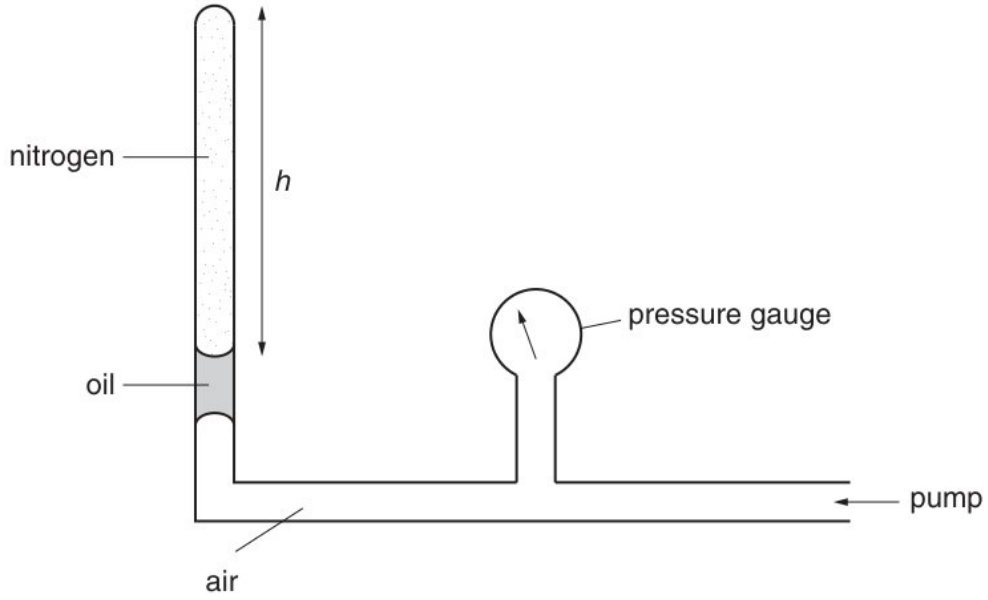
(e) (i) The power to X will increase and the powers to Y and Z will remain unaltered.

shop sign weighing 75 N hangs from a frame attached to a vertical wall.



[5]

(v)



is an approximate value for the speed of sound in air?

[5]

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

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

(i) (e) 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 $\lambda\mu$.

circuit contains four resistors and a battery of electromotive force (e.m.f.) 8.0 V with negligible internal resistance. When the variable resistor has resistance R, the currents in the circuit are 0.030 A, I_1 and I_2, as shown in Fig. 6.1.

[8]

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

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

[8]

(ii) (d) 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.

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

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.

[8]

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

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.

[5]

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

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

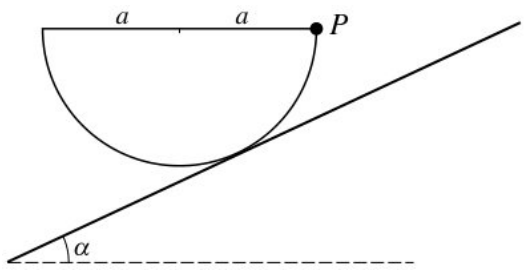
[4]

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

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

[4]

(c)



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.

[12]

12 (c) resistivity of copper is $1.8 \times 10^{-8}\Omega$ m.

(iii) find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

[4]

(vi) Find the general solution of (*), giving y in terms of x.

some = ... lq **[4]**

(a) height of the liquid in the beaker is 0.20 m $\pm$ 2%.

(iv) statement about light waves and sound waves is correct?

same horizontal = ... ez **[8]**

(v) that the distance travelled by the ball when it is moving upwards is $x = \frac{1}{2k} \ln\left(\frac{g+kU^2}{g+kv^2}\right)$.

[8]

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

is the efficiency of the process?

[4]

(b) the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm .

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

[6]

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

[20]

15 definition is correct and uses only quantities rather than units?

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

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

[3]

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

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.

[10]

(i) (b) that $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$ is an eigenvector of the matrix **D**, where

Find the work done by the tension.

horizontal straight, = ... *we* **[5]**

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

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]

(c)

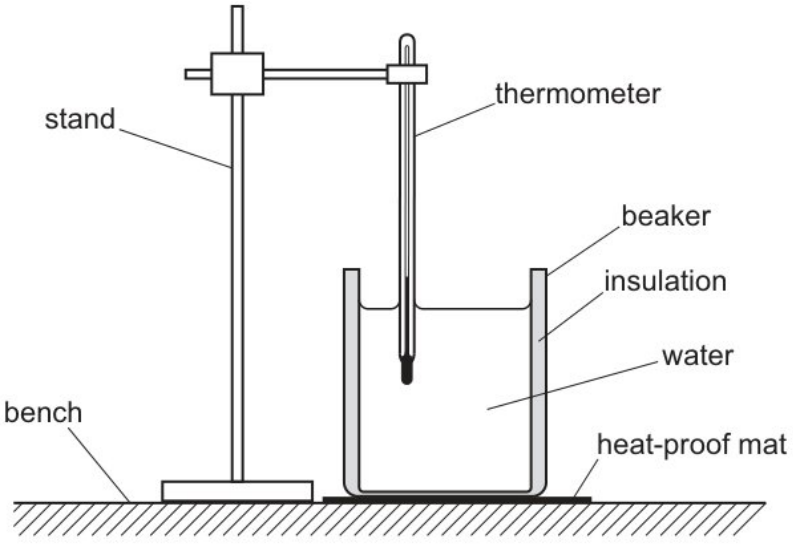
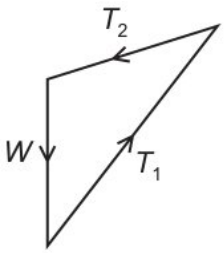


diagram illustrates successive wavefronts.

[8]

(d)



Both light waves and sound waves show the Doppler effect.

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

selected value = ... pf **[4]**

13 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.

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

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

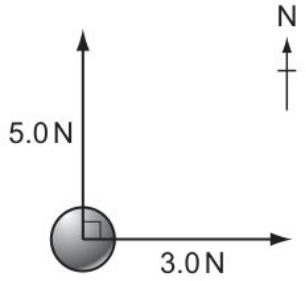
second coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{4}$.

[4]

(iii)

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

Show that $\frac{\mathrm{d}s}{\mathrm{d}x} = \frac{1}{2}\left(\mathrm{e}^{x} + \mathrm{e}^{-x}\right)$, where s denotes the arc length of C, and find the surface area generated when C is rotated through 2π radians about the x-axis.



[3]

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

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

[4]

(iii)

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

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

[8]

(c) (iii) 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.

three quantities that are conserved during the decay.

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.

[2]

(ii) B contains 5 red marbles and 3 blue marbles.

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 $\frac{84}{5}Ma^2$.

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

[3]

10 is the current in the load resistor?

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

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

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

is a statement of the principle of conservation of momentum for a system?

[3]

(i) satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

particle P of mass m is placed at the point Q on the outer surface of a fixed smooth sphere with centre O and radius a. The acute angle between OQ and the upward vertical is α, where $\cos\alpha = \frac{9}{10}$. The particle is released from rest and begins to move in a vertical circle on the surface of the sphere. Show that P loses contact with the sphere when OP makes an angle θ with the upward vertical, where $\cos\theta = \frac{3}{5}$, and find the speed of P at this instant.

800 nm to 1000μ m

that = ... qk **[8]**

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

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

[6]

(b) (ii)

	first higher note /Hz	second higher note /Hz
A	113	150
B	150	225
C	150	300
D	225	375

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.

Graphs Graphs stretched along = ... wa **[12]**

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

plane Π_2 contains the lines

[10]

(c) (iii) throws three coins at the same time.

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

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

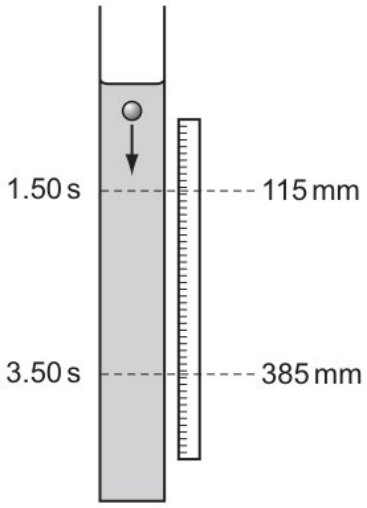
[8]

(iv) that $(z_1 z_2)^* = {z_1}^* {z_2}^*$.

is the mass of the car?

[8]

(e) (iv)



curve C has equation $y = \frac{x^2-3x+6}{1-x}$.

[2]

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

diagram shows the force-extension graph produced.

[1]

23 Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

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

points A, B, C have position vectors

exactly at point S

State the name of this type of reaction.

(b) (iii) Show that the total distance fallen is 1048 m .

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

[5]

(iv) electric potential difference across a component.

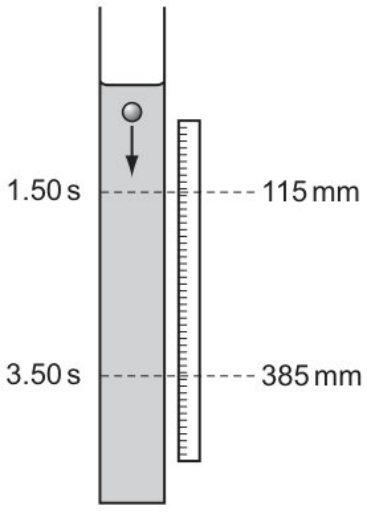
student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).

the value of μ.

days, = ... *bl* **[2]**

(f) (iv) competitors who took part in this Saturday's event are selected at random.

is the change to the quark composition of a nucleus that takes place during β^+ decay?



[2]

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

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

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]

(d) (ii) 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.

the number of different selections if the 4 books include at least 1 red book, at most 1 blue book and exactly 1 yellow book.

[3]

(iv) car is accelerated by a constant resultant force of 300 N for 5.0 s .

is the density of the mixture with volume 2.0 m^3 ?

them = ... *oi* **[3]**

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

(iii) 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.

[2]

(ii) Find the cartesian equation of Π_2.

[12]

(ix) quartile: 28, Median: 39, Upper quartile: 67.

[4]

(a)

Find the upward force on the parachutist due to the parachute, during the second stage.

cuboidal block floats in a liquid with its base horizontal, as shown in Fig. 5.1.

(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 $\frac{8}{3}Ma^2$.

$0.02 =$ ..... hb **[4]**

(v) wavelength of light is 550 nm .

[10]

(i) By setting up and solving a differential equation, show that the equation of the curve is $y = 2\mathrm{e}^{x^2-1}$.

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.

[4]

(ii) wavelength of light is 550 nm .

[2]

25 relationship is used in the derivation of the equation shown?

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

(a) (vi) 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.

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.

[5]

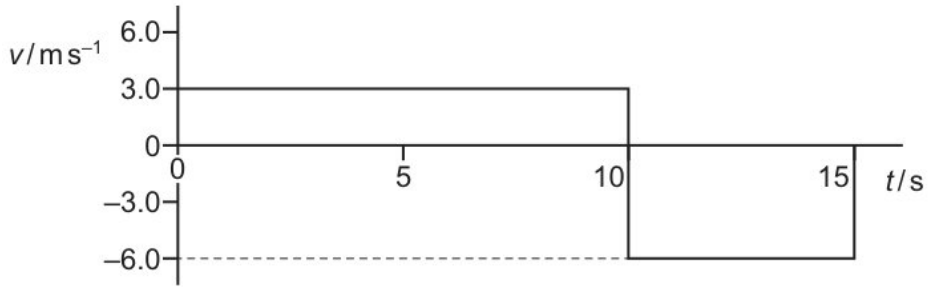
(i) transmitted light has intensity I.

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

[2]

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

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.



[15]

(iii) that u_{2n} is divisible by u_n for $n \geqslant 1$.

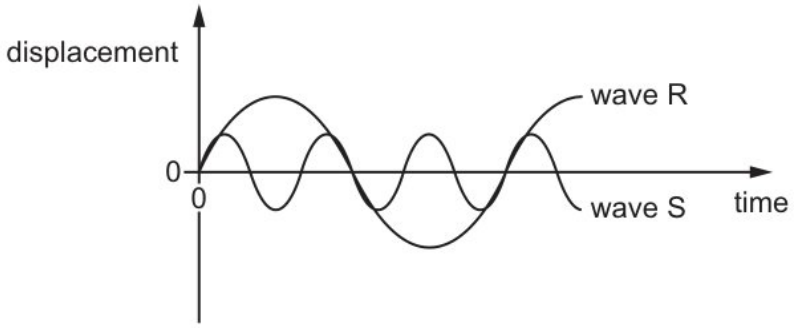
$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 2\frac{\mathrm{d}x}{\mathrm{d}t} + 5x = 10\sin t$$

[5]

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

radio-controlled toy car travels along a straight line for a time of 15 s .

(c) (iv)



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

[4]

(i) It results in the measured value being different from the correct value.

Calculate the acute angle between the planes p and q.

Show that the speed of B after its collision with the wall is $\frac{5}{18}u$.

[2]

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

$$\sum_{r=1}^{n} \frac{1}{(2r+1)(2r+3)}$$

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.

smooth = ... *em* **[6]**

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

525 520 522 524 518 520 519 525 527 516

shows = ... *lu* **[6]**

(i) Hence find the value of $\frac{1}{\alpha^2} + \frac{1}{\beta^2} + \frac{1}{\gamma^2}$.

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.

sample has an activity of 180 Bq at time $t = 0$.

where = ... *vx* **[8]**

(ii) isotopes of the element uranium are $^{235}_{92}\mathrm{U}$ and $^{238}_{92}\mathrm{U}$.

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

[2]

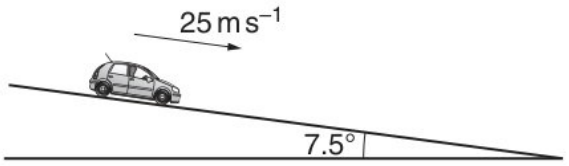
18 bolt is subjected to a tensile force, as shown.

(g) (ii) is meant by elastic deformation?

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

[8]

(i)



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

level fixed = ... ox **[6]**

(c) (i) The waves must have equal amplitudes.

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

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 $\frac{84}{5}Ma^2$.

[2]

(iii) 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.

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

[6]

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

Hence solve the equation

side. = ... nq **[8]**

(b) (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.

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

[10]

(ii) your graph to find an estimate for k.

the values of a for which the system of equations

[8]

(iv) plane Π_1 passes through the points $(1, 2, 1)$ and $(5, -2, 9)$ and is parallel to the vector $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$.

diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm .

[12]

(iii) curve C has equation

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.

[8]

14 1,2 and 3

(a) (iv) Find the upward force on the parachutist due to the parachute, during the second stage.

the probability density function of Y,

the expected value and variance of Y.

[4]

(i) amplitude $\propto$ intensity

expression gives the value of $\frac{v}{u}$?

[12]

(b) (ii) sample has an activity of 180 Bq at time $t = 0$.

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 value of V.

[10]

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

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

[5]

(f) (i) the expected value and variance of Y.

is given that

[6]

(iii) the distribution function of X.

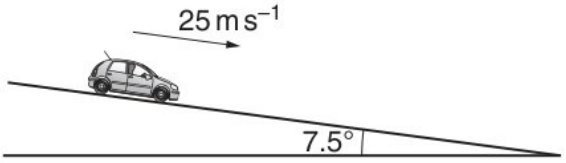
particles A and B have masses 0.3 kg and 0.1 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley, and the particles hang vertically below the pulley. Both particles are initially at a height of x m above horizontal ground (see diagram). The system is released from rest.

[5]

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

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

are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.



(d) (iv) Given that $\cos\alpha = \frac{1}{6}$, find the greatest speed achieved by the centre of the sphere in the subsequent motion.

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.

[6]

(iii) 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.

the general solution of the differential equation

[3]

(c) (iii) 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.

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

[4]

(ii) position vectors of the points A, B, C, D are

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

1400 = ... ko **[6]**

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

(b) (i) the number of different arrangements of the 7 men and 4 women in a line in which all the men stand together and all the women stand together.

no unique solution.

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

drift unit = ... xi **[4]**

(ii) 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 $t = 4$.

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.

exactly at point S

[5]

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

two assumptions of the simple kinetic model of a gas.

[5]

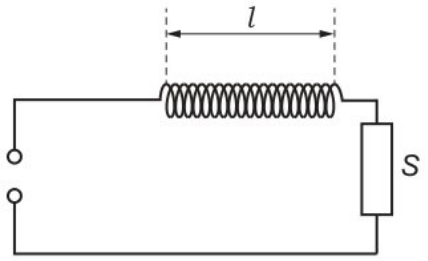
(vi) or otherwise solve the inequality $|3x - 2a| < x + 5a$.

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

Find the speed of P when it passes through L.

[4]

(c) (iii) Both light waves and sound waves show the Doppler effect.



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

[12]

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

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.

By sketching a suitable pair of graphs, show that the equation

[3]

14 (e) Light waves can be diffracted but sound waves cannot be diffracted.

(iii) Pressure is force per unit area.

[3]

(vi) Given also that -1 is an eigenvalue of **A**, find a corresponding eigenvector.

follows. = ... ab **[8]**

(iv) 1.1 shows the measurements for cube A.

[2]

(d) Show that, at the points (other than the pole) at which a tangent to C is parallel to the initial line,

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

table. = ... cp **[3]**

(iii) 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 .

[8]

(vii) 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.

books, = ... fq **[10]**

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

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

(vii) curve C has parametric equations

centre = ... zn **[4]**

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

[6]

(ii) the exact volume of the solid generated

then it converges to a.

[5]

8 positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Find the coordinates of A and M.

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

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

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

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

such = ... xn **[8]**

(iii) 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.

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.

[8]

(ii) equation of a curve is $x^3y - 3xy^3 = 2a^4$, where a is a non-zero constant.

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 $\lambda\mu$.

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.

[4]

(b) (iv) 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.

525 520 522 524 518 520 519 525 527 516

now that the standard deviation of the population is known to be 5.6 minutes. Find the smallest sample size that would lead to a 95% confidence interval for μ of width at most 5 minutes.

[20]

(v) Find the probability that the total income produced by the two fields in a day is at least \$670 million.

Find the value of x.

[5]

(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.

Show that $m = 0.9$.

[8]

(c) (ii) Q always hears a sound of higher frequency than person P .

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.

a digit can be repeated and the number made is even.

[4]

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

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

moving = ... *gq* **[20]**

(vi) the range of f,

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

[6]

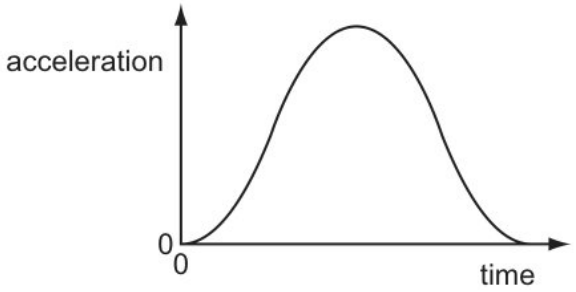
(a) (iii)

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

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.

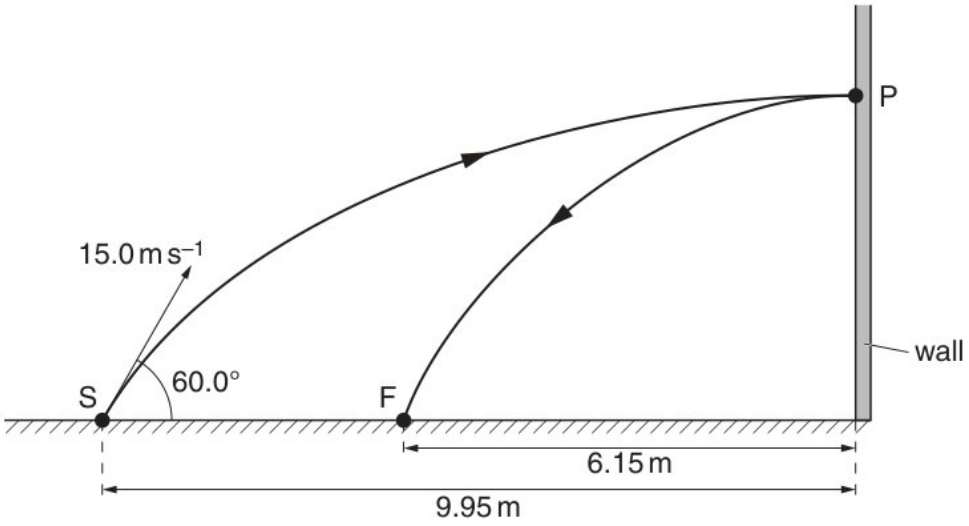
hemisphere. = ... *hm* **[6]**

(vi) the probability density function of Y



[3]

(i)



plane Π_2 contains the lines

[2]

(d) (i)

There will always be 9.0 V across the battery terminals.

rest light = ... qx **[2]**

(iii) 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.

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

solid = ... we **[4]**

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

$$\mathbf{D} = \begin{pmatrix} 1 & -1 & 1 \\ -6 & -3 & 4 \\ -9 & -3 & 7 \end{pmatrix},$$

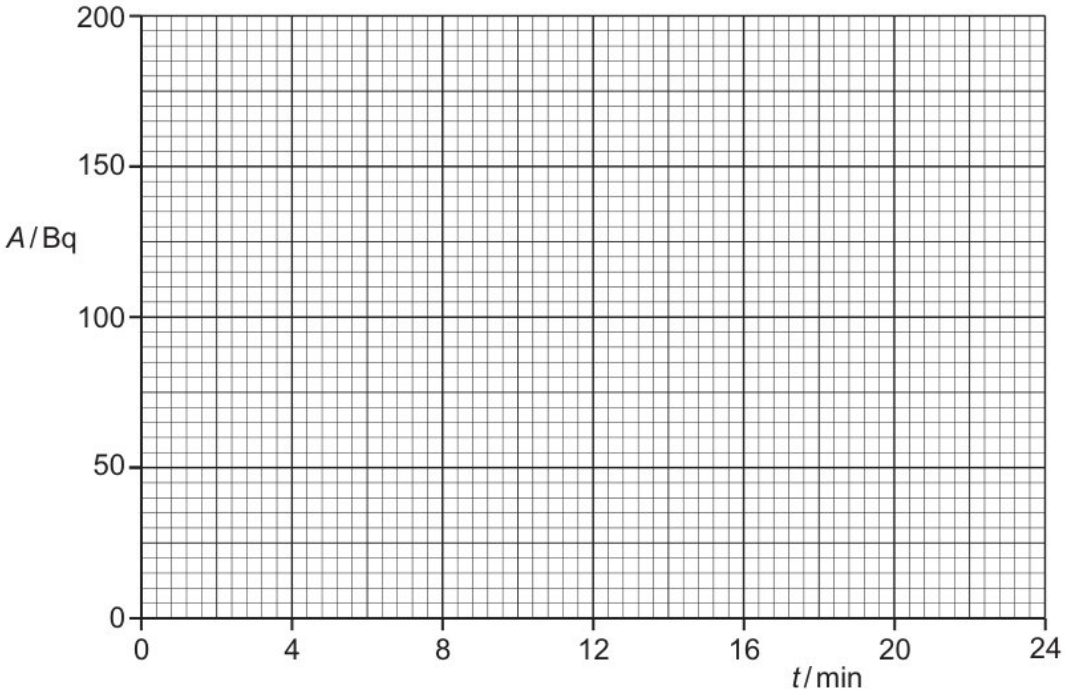
wire. = ... xm **[12]**

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

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]

22 the length of C.

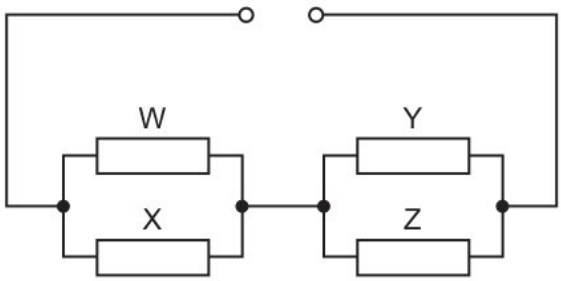


(c) (i) ABC is a uniform triangular lamina of weight 19 N , with $AB = 0.22$ m and $AC = BC = 0.61$ m. The plane of the lamina is vertical. A rests on a rough horizontal surface, and AB is vertical. The equilibrium of the lamina is maintained by a light elastic string of natural length 0.7 m which passes 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).

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, $H_1 : p < 0.2$.

joins = ... *va* **[10]**

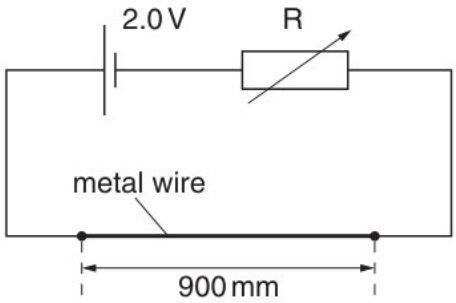
(ii)



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.

height = ... *al* **[3]**

(b) (iii)



is given that $\mu = 0.15$ and $X = 20$.

[5]

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

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

is the minimum constant acceleration necessary for the aircraft?

[4]

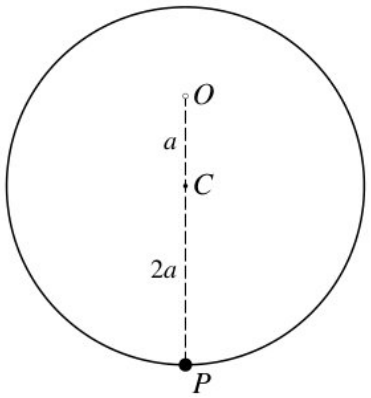
(ii) quartile: 28, Median: 39, Upper quartile: 67.

the particular solution of the differential equation

Show that $a = \frac{1}{3}\ln\left(251 - a - a^2\right)$.

[5]

(a) (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.

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.

[3]

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

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

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

[2]

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

that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

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

mean, $\bar{x}$, is 28.325 .

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

[2]

(iv)

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		

continuous random variable X has probability density function f given by

[5]

(b) (iv) line l passes through B and C.

the value of n.

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

speed = ... et **[12]**

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

$\tan x = x + \pi$.

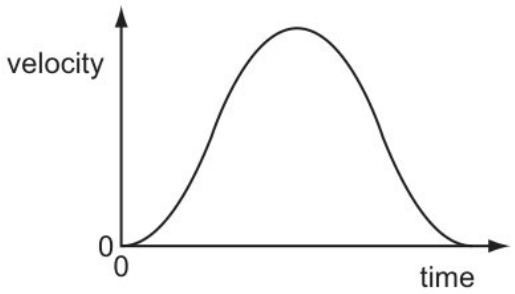
[12]

(ii) circuit is set up as shown in Fig. 2.1.

the total time for which she is in motion from the instant that she passes O.

[15]

(c) (iii) a cartesian equation of the plane Π containing l_1 and l_2.



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

acting applied = ... fv **[5]**

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

238, $^{238}_{92}$U, decays by α-emission into a daughter product which in turn decays by β-emission into a grand-daughter product.

Find the area of the region enclosed by C.

event. = ... bb **[3]**

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

	F/N when child is at X	F/N when child is at Y
A	600	0
B	600	150
C	750	0
D	750	150

equal where collision. = ... mg **[6]**

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

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.

[8]

18 is the work done by F on the skateboarder and skateboard?

$$\sum_{r=1}^{n} \frac{1}{\sqrt{r}} \mathrm{e}^{\sqrt{r}} < \left(2 + \frac{1}{\sqrt{n}}\right) \mathrm{e}^{\sqrt{n}} - 2\mathrm{e}.$$

truck R of mass 9400 kg moves with constant acceleration in a straight line down a slope, as illustrated in Fig. 3.1.

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

activity of a radioactive sample.

[10]

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

1.1 lists some physical quantities. Identify with ticks (✓) which quantities are vectors and which are scalars.

slit, = ... *no* **[5]**

(i) a vector equation for l.

$$I_n = \int_0^{\frac{1}{4}\pi} \tan^n x \, \mathrm{d}x$$

equilibrium equilibrium = ... *ar* **[4]**

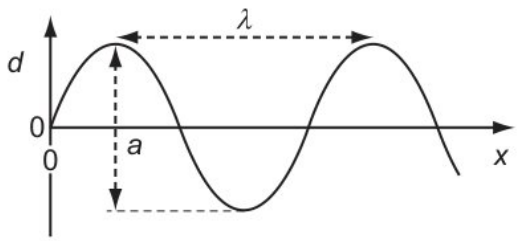
(ii) force = mass × acceleration

When the tensile force is removed, the wire returns to its original length.

is the magnitude of the net force acting on the ball?

together other = ... *wp* **[6]**

(a) (v)



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

[8]

(iv) satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

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

through = ... *gv* **[6]**

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

is a statement of the principle of conservation of momentum for a system?

[4]

(i) is its change in momentum?

Find the exact coordinates of this point.

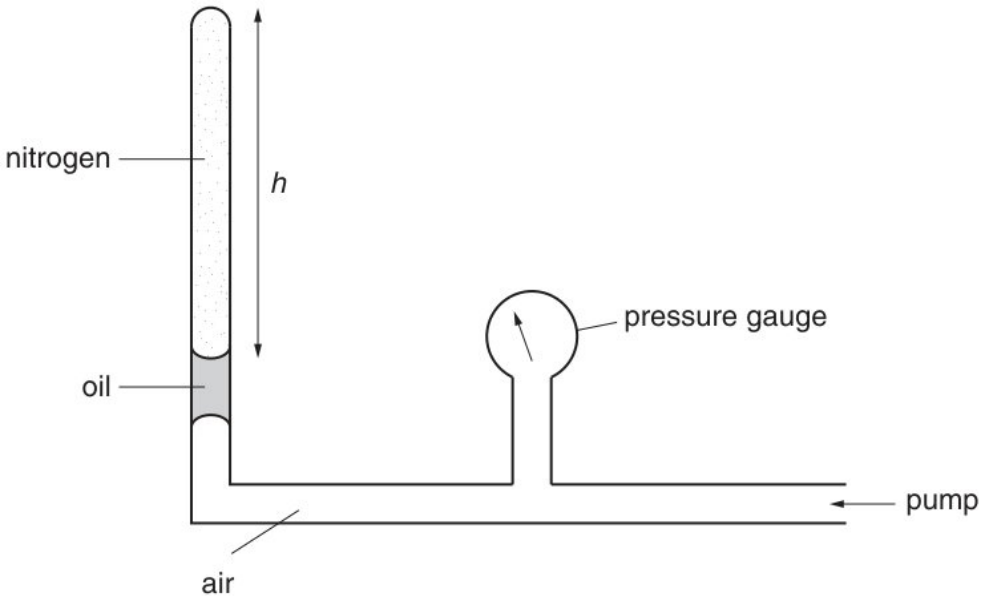
weigh = ... lz **[12]**

(vii) 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 $AC = a$.

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

[4]

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



(e) (ii) Use de Moivre's theorem to prove that

continuous random variable X has probability density function f given by

[8]

(i) that $x^2y = z$, show that

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

[2]

(v) the coordinates of C,

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

point D is such that $ABCD$ is a parallelogram.

[6]

(b) (ii) the iterative formula in part (c) to calculate a correct to 4 decimal places. Give the result of each iteration to 6 decimal places.

an estimate for the mean length of these 250 leaves.

Find the equations of the asymptotes of C.

[10]

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

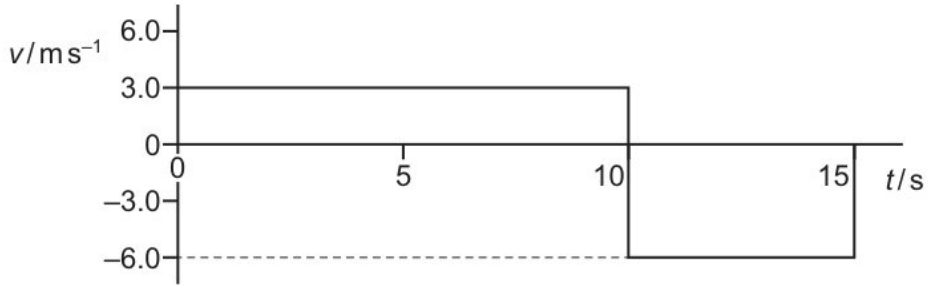
row best specifies the correct $I - V$ graphs for the lamp and the diode?

[3]

12 exactly at point S

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

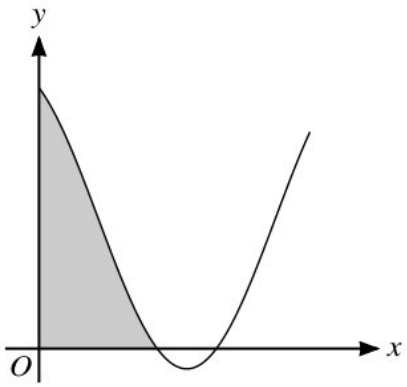
(c) (ii)



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

[20]

(v) Calculate the speed of the star relative to the Earth.



Given also that -1 is an eigenvalue of **A**, find a corresponding eigenvector.

[3]

(i) wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

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

[2]

(a) (ii) row correctly identifies the properties of all electromagnetic waves?

to the value α.

after moves = ... *hy* **[4]**

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

$n \geqslant 0$. Show that, for all $n \geqslant 2$,

constant = ... *ok* **[15]**

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

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.

[2]

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

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

800 nm to 1000μ m

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.

[8]

(vii) the median and the interquartile range of the times of the runners from the Gulls.

[6]

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

[12]

(b) the particular solution of the differential equation

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

taken, = ... yr **[4]**

(iii) is a necessary condition for observable interference fringes to be produced?

collides = ... nf **[5]**

(ii) 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.

[6]

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

(ii) star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

[8]

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

[6]

(e) only one of the following two alternatives.

(v) Calculate the acceleration of P when it is at instantaneous rest and $x > 0$.

number = ... xh **[5]**

(ii) de Moivre's theorem to show that

between equal = ... lu **[3]**

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

(b) (ii) 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.

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.

[10]

(iii) a laboratory experiment to determine the absorption coefficient of glass. You should

verify that this equation has a root between 5 and 5.05.

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

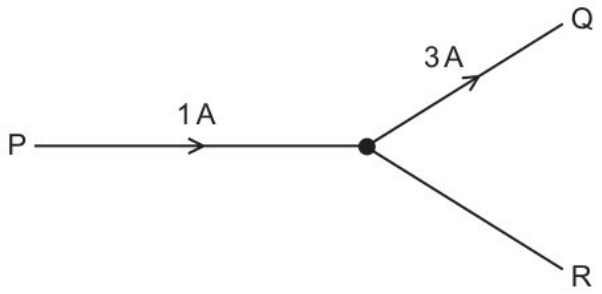
[4]

(iv) a, b and c are integers to be determined.

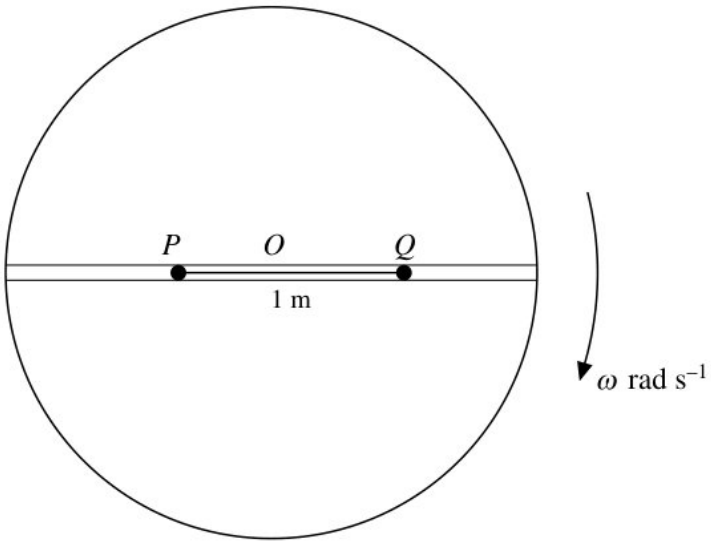
moment of a force.

[12]

(a) (i)



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]

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

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

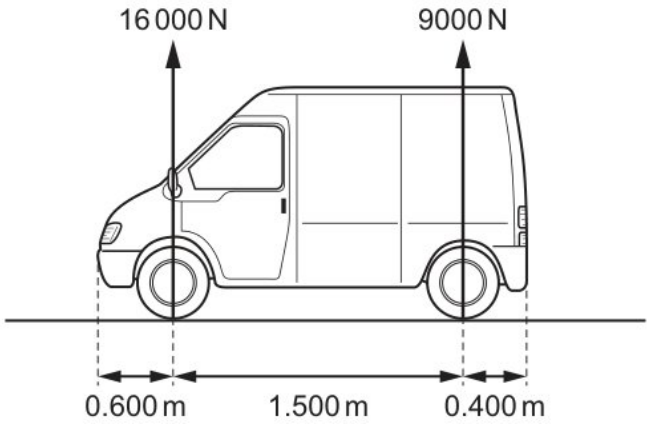
[3]

(d) (i) is the effect of a systematic error on the measurement of a physical quantity?

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

third = ... *fb* **[6]**

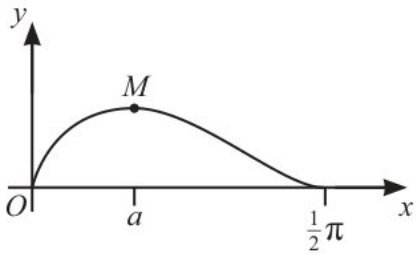
(ii)



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

[1]

(iii) diagram shows a trace of a wave on a cathode-ray oscilloscope.



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.

from = ... *db* **[6]**

13 (a) the grid below, draw a cumulative frequency graph to illustrate this information.

(i) Find the general solution of (*), giving y in terms of x.

Find the set of values of t for which the particles are travelling in opposite directions.

[3]

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

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

[12]

(ii) that $y = 0$ when $x = 3$ Give your answer in an exact form

$$I_n = \frac{1}{n-1} - I_{n-2}$$

the expected value and variance of Y.

[5]

(b) a set of 40 values of x, it is found that

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

(iv) this Saturday's event, 60% of the competitors had times less than 36.0 minutes.

[4]

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

[2]

(iii) 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.

In the case where $k = 2$,

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

[3]

(d) 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.

1,2 and 3

(i) function f is such that $\mathrm{f}(x) = 3 - 4\cos^k x$, for $0 \leqslant x \leqslant \pi$, where k is a constant.

from the definitions of tanh and sech in terms of exponentials, prove that

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

[5]

(v) 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.

[6]

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

years = ... fe **[2]**

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

(iii) places the books in a row on her shelf. She is only interested in the arrangement of the colours.

[6]

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

only one of the following two alternatives.

[6]

(ii) your answer correct to 2 decimal places.

[2]

(vi) 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.

magnetic flux density.

positive = ... rg **[6]**

13 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 $0 < \theta < 2\pi$

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

process does not require energy to be supplied?

[10]

(ii) Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

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

$$n = 60 \quad \sum t = 3678 \quad \sum t^2 = 226313.36$$

[6]

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

the exact value of the positive constant k for which

[6]

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

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

[8]

14 diagram best represents the electric field surrounding the charges?

(a) (i) that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

the exact value of I_2.

both = ... *to* **[1]**

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

measuring instrument should be used?

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?

results = ... *xc* **[4]**

(b) (i) 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.

diagram shows the electric field between the plates?

[8]

(vi) Find the proportions of large, small and medium pineapples.

$$x = 1 + 2\sin^2\theta, \quad y = 4\tan\theta$$

[4]

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

combined resistance is 66kΩ.

(g) (i) Show that the cartesian equation of C is

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

mass = ... gc **[6]**

(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.

Find the exact area of the shaded region.

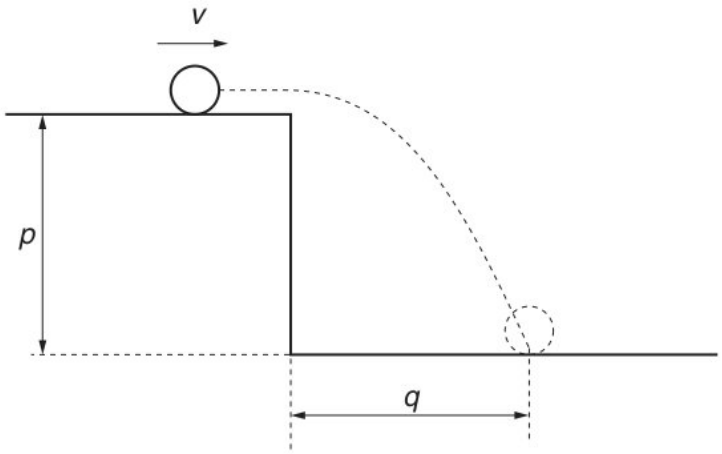
[3]

(b) (v) C, stating the coordinates of the intersections with the axes.

$$\sum x = 168 \quad \sum x^2 = 720 \quad \sum y = 228 \quad \sum y^2 = 900$$

with = ... wb **[6]**

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



[6]

7 the subsequent motion find, in terms of r, the greatest height above O reached by the particle.

curve C with equation

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

number, x, of beech trees was counted in each of 50 randomly chosen regions of equal size in beech forests in country A. The number, y, of beech trees was counted in each of 40 randomly chosen regions of the same equal size in beech forests in country B. The results are summarised as follows.

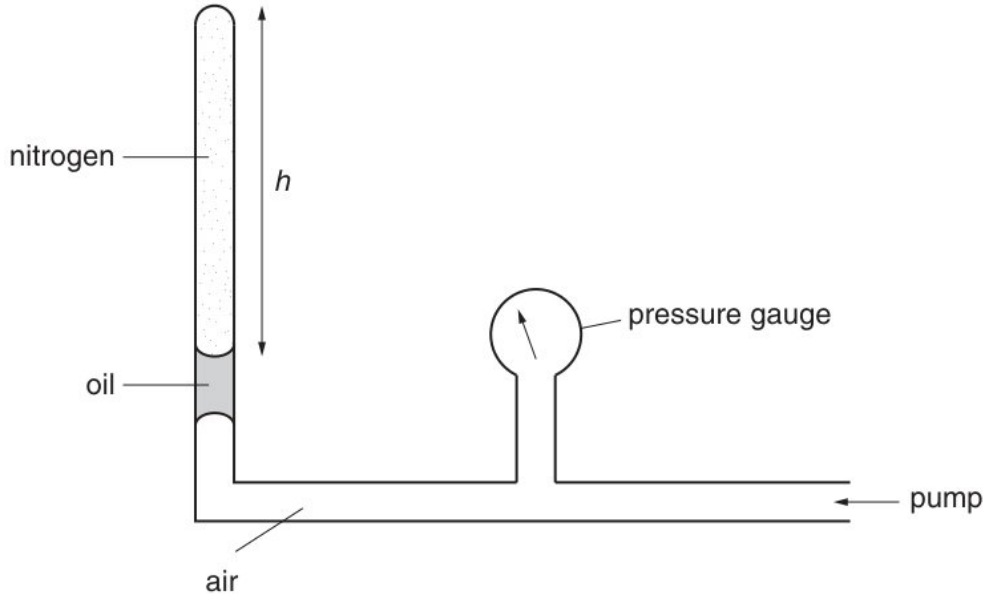
[6]

(i) the coordinates of any stationary points on C

number, x, of beech trees was counted in each of 50 randomly chosen regions of equal size in beech forests in country A. The number, y, of beech trees was counted in each of 40 randomly chosen regions of the same equal size in beech forests in country B. The results are summarised as follows.

water = ... *ie* **[3]**

(c) (i)



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

[15]

(ii) only one of the following two alternatives.

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 $-\pi \leqslant \theta < \pi$.

[5]

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

is the useful power output of the power station?

[15]

(a) (i) Find the values of p and q.

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

[6]

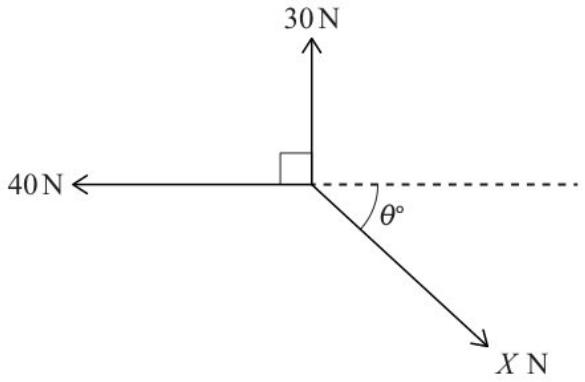
(ii)

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

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

[5]

(d) (iii)



is the average useful power at which he is working?

[12]

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

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

[8]

(ii) 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.

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

[8]

21 Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

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

the complex numbers z for which $\frac{z+4}{z+4\mathrm{i}}$ is real and $|z| = \sqrt{10}$. Give your answers in the form $z = x + \mathrm{i}y$, where x and y are real.

(d) (iii) many different colour arrangements are there of the 10 books with exactly 4 books between the 2 yellow books?

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

Find the equations of the asymptotes of C.

axis = ... *cp* **[20]**

(iv) the gradients of the tangents to the curve when $x = 0$.

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

constant resultant force F acts on a car of mass m. The car moves from rest with constant acceleration a along horizontal ground. When the car has displacement s, the speed of the car is v.

[6]

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

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

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

from = ... my **[2]**

(c) (ii) child of weight 600 N stands in different positions on the plank.

down to up

[10]

(iii) the significance level of the test.

considering momentum, calculate the speed of nucleus R after the decay.

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]

10 much work is done by the gas during this expansion?

Calculate the acute angle between the planes p and q.

(c) (iv) Calculate the initial speed and the angle of projection of P.

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

[4]

(ii) Find the area of the triangle ABC.

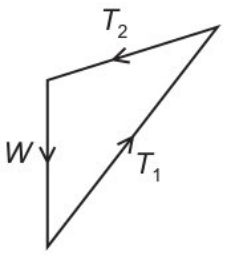
the number of different ways in which the 12 letters of the word STRAWBERRIES can be arranged

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.

[15]

(a) (iii) 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.

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



[12]

(ii) Find $\frac{\mathrm{d}}{\mathrm{d}x}\left(x\left(4+x^2\right)^{-n}\right)$ and hence show that

Show that the cartesian equation of C is

magnitude = ... ax **[10]**

15 expression has the same SI base units as pressure?

- decelerating at a constant rate with the parachute open,

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

uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.

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

[10]

(c) the expected value and variance of Y.

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

[3]

(a) that u_{2n} is divisible by u_n for $n \geqslant 1$.

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

[6]

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

the rank of **M** and a basis for the range space of T ,

bulb = ... qf **[3]**

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

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

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

[3]

(c) 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.

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.

standard = ... fc **[6]**

10 Draw up the probability distribution table for X.

de Moivre's theorem to prove that

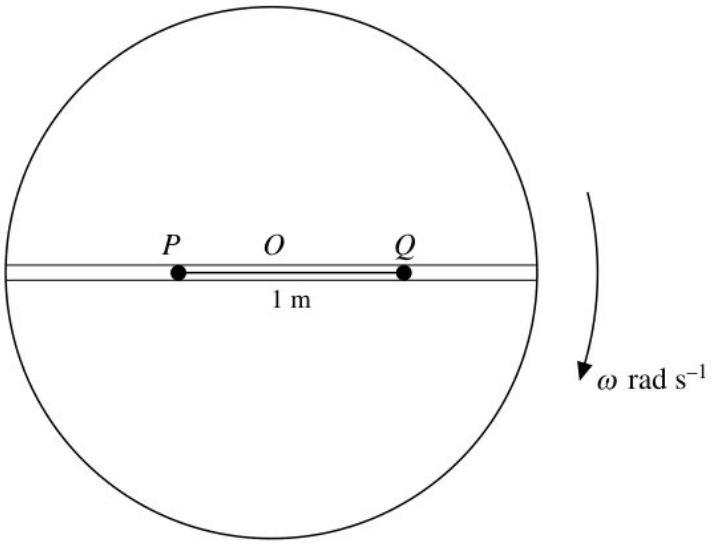
a group of 20 musicians, there are 9 guitarists, 6 pianists and 5 drummers.

(d) (ii) Deduce that the cartesian equation of C is

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

[15]

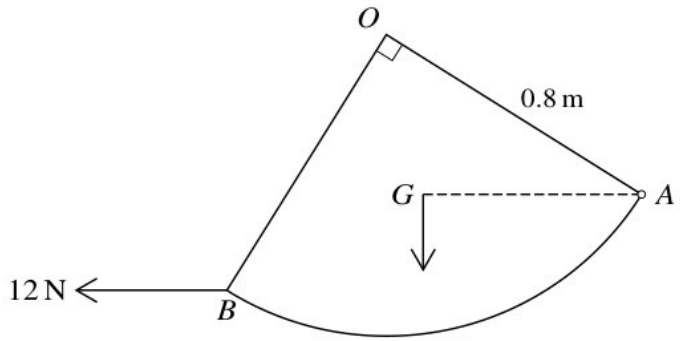
(iv)



Show that if

velocity particle = ... ig **[6]**

(b) (v)



your graph to find an estimate for k.

[10]

(iii) an estimate for the mean length of these 250 leaves.

satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

4 astronauts are chosen to go on a mission. Each of these astronauts can take 3 personal possessions with him. How many different ways can these 12 possessions be arranged in a row if each astronaut's possessions are kept together?

[6]

(ii) 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.

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

[5]

(c) (ii) matrix $\mathbf{A}$, given by

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

[8]

(i) variables x and y satisfy the differential equation

curve C has equation

which = ... nm **[8]**

(a) (i) safety precautions to be taken.

parametric equations of a curve are

[6]

(ii) time to complete a crossword has a normal distribution with mean μ minutes. Calculate a 95% confidence interval for μ.

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

[8]

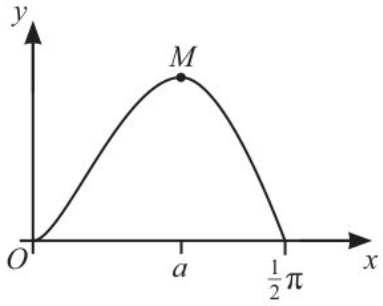
(iv) V decreases because there is a p.d. across r.

block is released from rest at the top of a slope inclined at an angle to the horizontal. The slope has length L as shown in the diagram.

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, $H_1 : p < 0.2$.

[8]

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



economy = ... *zd* **[4]**

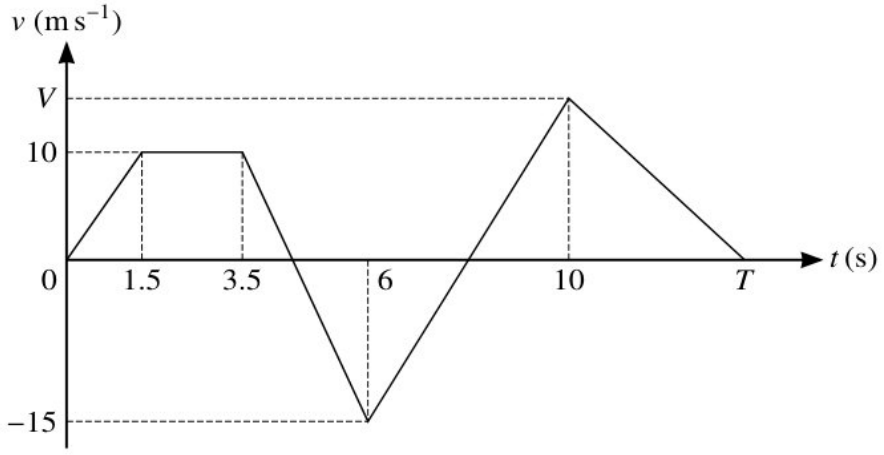
11 are the weight and the mass of the body when it is on the Moon?

(e) (i) 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 $ax + by + cz = d$.

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.

fields = ... *tt* **[3]**

(ii) the particular solution of the differential equation



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

with upward = ... *oy* **[6]**

(b) (iv) B has speed 38 m s^{-1} immediately before it strikes the plane.

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.

water is added to an insulated beaker, as shown in Fig. 2.1.

[5]

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

the distribution function of X.

[4]

(v) 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.

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

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

emails = ... *dd* **[6]**

15 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.

(b) (ii) the value of σ.

complex number u is defined by $u = \frac{5}{a+2\mathrm{i}}$, where the constant a is real.

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

[5]

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

diagram shows the force-extension graph produced.

[10]

(v) control of variables,

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

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

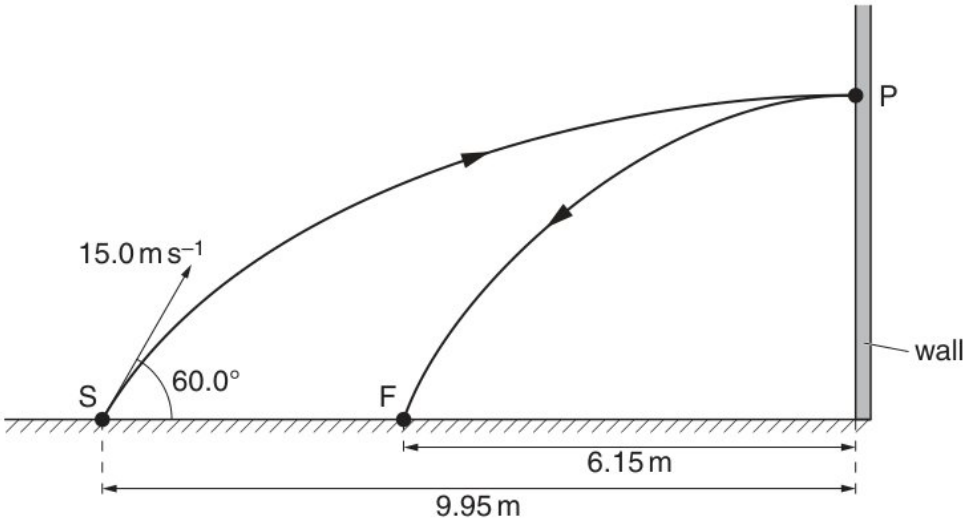
[8]

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

X and Y are connected in series to a cell.

[5]

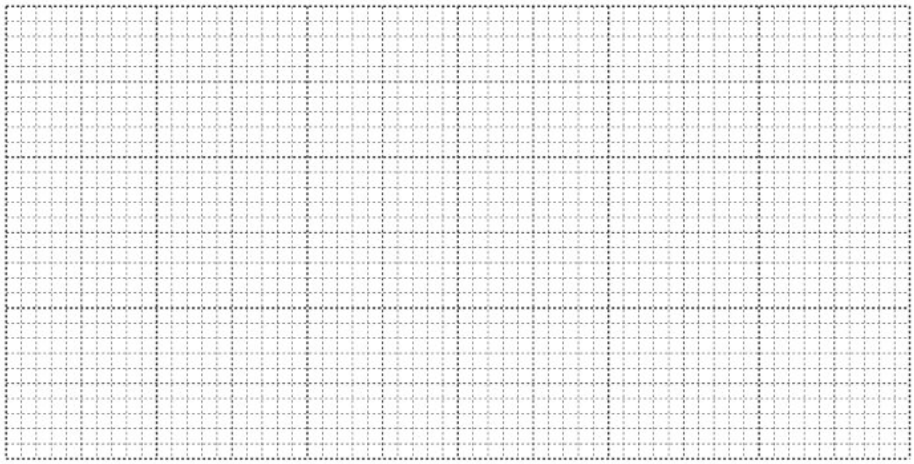
(i)



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.

[6]

(a) (ii)



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

[6]

(i) is the useful power output of the power station?

is given that $y = \frac{1}{12}\pi$ when $x = \frac{1}{2}\pi$.

copper = ... *oj* **[5]**

13 (c) the number of different arrangements of the 7 men and 4 women in a line in which all the men stand together and all the women stand together.

(i) Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

[5]

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

[2]

(b) is given that a is a positive constant such that

(i) is the magnitude of the component of the final momentum of the combined objects in the original direction of P ?

[6]

(ii) that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

[3]

14 Hence show that the differential equation

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

Show that the equation

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

line = ... ds **[4]**

(i) Show that the mass of P is 0.8 kg .

should pay particular attention to

[4]

(a) (i) find the position vectors of P and Q.

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

[3]

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

is given instead that $\mu \neq 0.15$ and that when $X = 10$, the block is on the point of moving down the plane.

Find the cartesian equation of Π_2.

positive = ... li **[2]**

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

a t test at the 5% significance level to find the range of values of k for which the result of the test is to reject the null hypothesis

the period of small oscillations,

[3]

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

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

Hence, or otherwise, obtain an expression for $\mathrm{f}^{-1}(x)$.

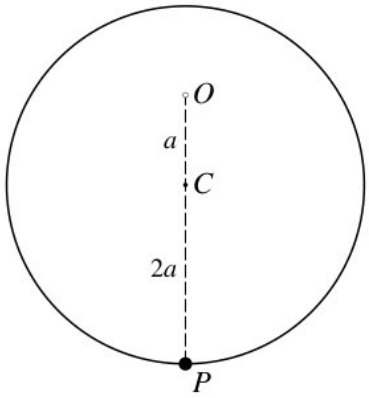
[4]

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

the number of different ways in which these three bands can be selected.

speed speed = ... fu **[5]**

(c) (iv)



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

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

[5]

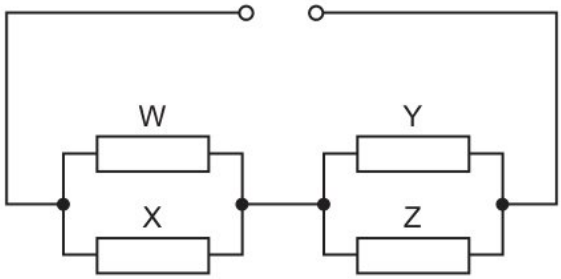
(iii) diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

is the density of the mixture with volume 2.0 m^3 ?

[4]

(ii)



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

[6]

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

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

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]

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

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.

blue = ... dx **[15]**

(a) (i)

for a wire,

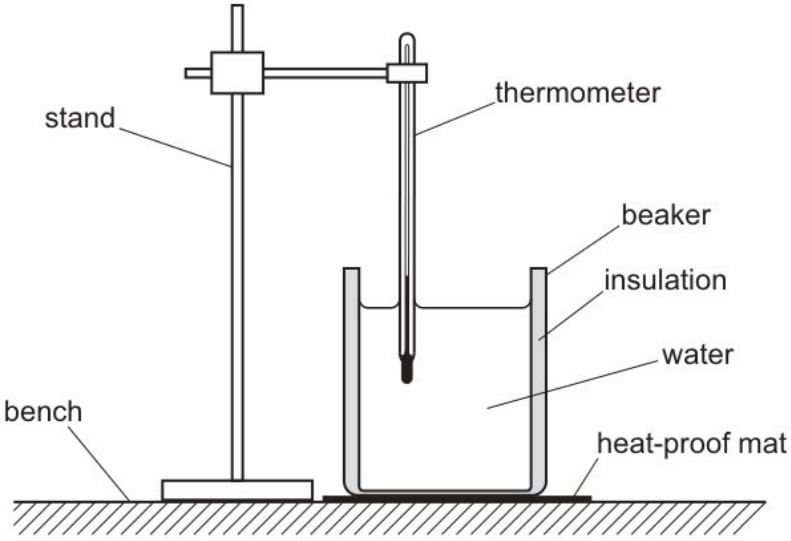
[10]

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

curve C has equation $x^3 - 3xy + y^2 = 4$. Find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $(0, 2)$ of C.

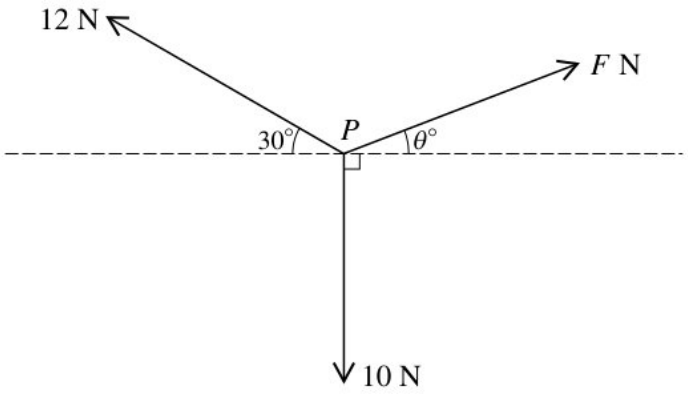
took = ... *no* **[8]**

(vii) the standard deviation of these 40 values of x.



[5]

(c) (i) transmitted light has intensity $0.75I$.



[12]

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

Find the mean and variance of the daily income, in millions of dollars, generated by field A.

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

rest = ... *aa* **[5]**

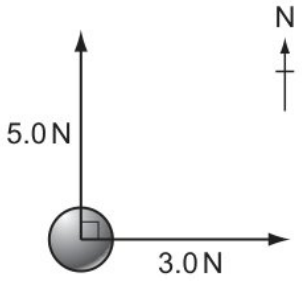
(ii) the probability that the mass of peaches sold on any given day is between 56 kg and 75 kg

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

randomly = ... *is* **[5]**

15 Find the values of p and q.

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



student investigates the cooling of a liquid in a beaker.

[10]

(i) equation gives v in terms of A and u ?

the graph to estimate how many people took between 4 and 7.5 minutes to complete the puzzle.

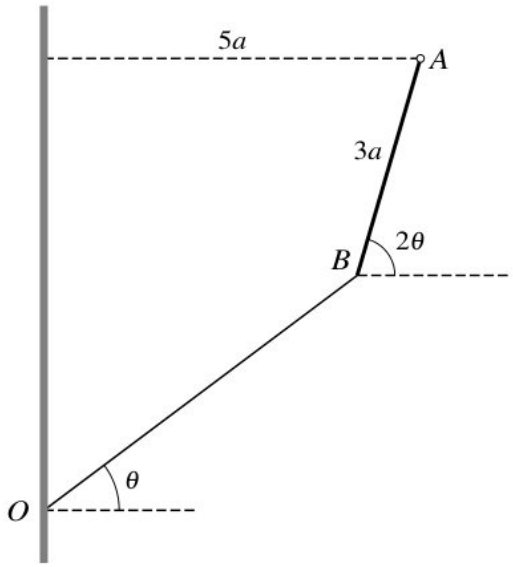
[6]

(iv) that $y = 0$ when $x = 3$ Give your answer in an exact form

Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

random = ... ky **[3]**

(c) (iii)



the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

[4]

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

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

[3]

(i) is the current in the load resistor?

Find the angle between the vertical and the side AO of the lamina.

[6]

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

(b) (i) why the variation with time of the activity of a radioactive sample is exponential in nature.

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

[3]

(iii) density of the water is ρ. The water does not rebound from the wall.

that $\mathrm{E}(X) = 3.05$, find the values of p and q.

if the 4 vowels $\mathrm{A}, \mathrm{E}, \mathrm{E}, \mathrm{I}$ must all be together.

[4]

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

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) 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.

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

resistance force = ... wt **[6]**

(i) Find the value of a.

the distribution function of X.

[8]

(c) (vi) the differential equation to obtain an expression for y^2 in terms of x.

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

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

rest = ... ye **[4]**

(i) the probability that more than 7 study Art or Music.

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

[5]

13 the probability that more than 7 study Art or Music.

a group of 20 musicians, there are 9 guitarists, 6 pianists and 5 drummers.

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

State what happens to the electron and to the positron.

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.

[8]

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

amplitude $\propto$ (intensity $)^2$

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

[5]

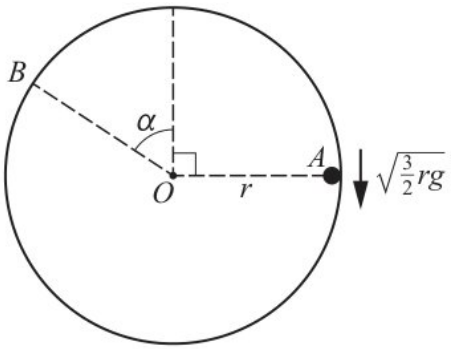
(c) (iii) Show that $b = 1 - a$.

a 90% confidence interval for the difference in mean crop mass associated with each type of fertiliser.

mass of the liquid is 0.36 kg $\pm$ 10%.

[4]

(vi)



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 $t = 2$.

[4]

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

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 .

[4]

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

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

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

[4]

(iii) de Moivre's theorem to show that

Hence find the value of $\frac{1}{\alpha^2} + \frac{1}{\beta^2} + \frac{1}{\gamma^2}$.

[4]

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

the range of f,

random without = ... *sh* **[4]**

(i) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

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

[6]

(b) (i) the probability that the marble chosen from bag A is blue, given that the marble chosen from bag B is blue.

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

the distance AC.

[5]

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

Both light waves and sound waves show the Doppler effect.

sold = ... *yo* **[4]**

(iii) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$.

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 $t = 2$.

[3]

(d) (ii) combination of changes must increase the amount of spreading due to diffraction?

graph is correctly labelled?

[8]

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

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

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

[6]

21 the position vector of D.

- falling with constant speed with the parachute open,

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

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

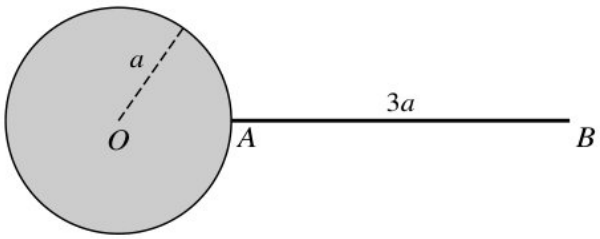
[3]

(c) force is caused only by a pressure difference?

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

[6]

(iii) (f)



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

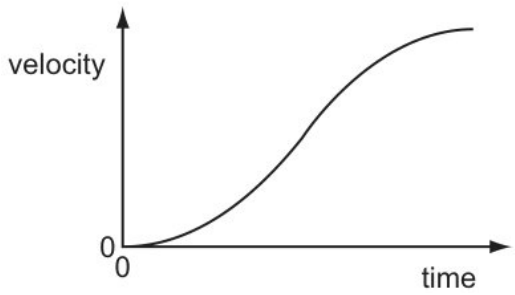
after ground = ... *cu* **[4]**

(a) the median value of X.

$$f(x) = \begin{cases} kx & 0 \leqslant x < 1 \\ k(8 - x) & 1 \leqslant x \leqslant 8 \\ 0 & \text{otherwise} \end{cases}$$

guests. = ... *te* **[6]**

(i) (b)



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

size = ... *sm* **[10]**

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

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.

[12]

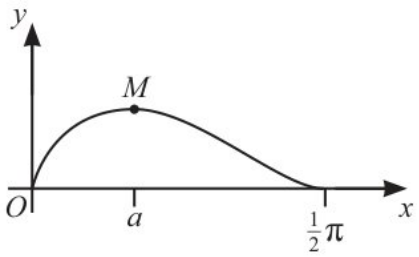
(iv) (d)

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

[6]

(a)

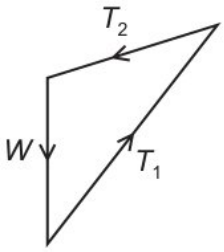


satellite of mass 122 kg is in orbit around Mars at a constant height of 1.7×10^6 m above the surface of the planet.

the period of small oscillations,

[6]

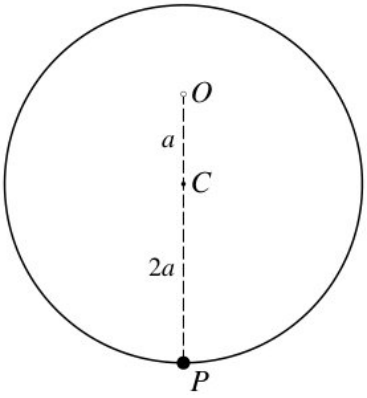
(b) The powers to X, Y and Z will all increase.



is given that $k = 0.025$ and that $U = 20$

[15]

(c)



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

proton number =

nucleon number =

radius = ... xt **[2]**

(v) (d) projectile is thrown at an angle to the ground.

Find the coordinates of the point A on C at which $\frac{dy}{dx} = 0$ and $x \neq 0$.

[10]

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

Write down the least value of $15\cos\theta - 9\sin\theta$ as θ varies.

that $rp^3 = q^3$.

mark. = ... *vh* **[6]**

(c) an electron and an antineutrino

speed = ... *er* **[6]**

25 coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.

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

Find the equations of the asymptotes of C.

AOB is a uniform lamina in the shape of a quadrant of a circle with centre O and radius 0.6 m (see diagram).

(a) (ii) that, when $t = 0, x = 3$ and $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

points A, B, C have position vectors

[8]

(iii) the particular solution of the differential equation

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

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

[3]

(i) Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

Hence solve the equation

bottom energy = ... *up* **[4]**

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

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

[4]

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

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.

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

value days, = ... *cs* **[8]**

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

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

that, at the point $A(-1, 1)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -4$.

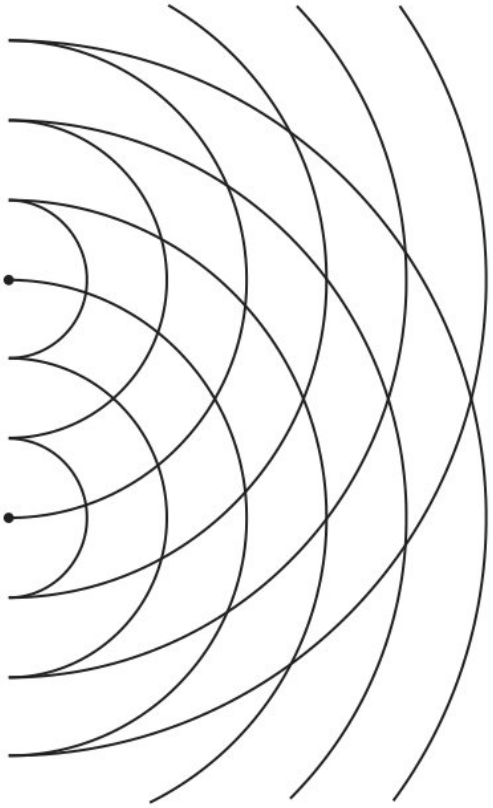
[4]

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

525 520 522 524 518 520 519 525 527 516

[5]

(c) (v) 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.



[20]

(i) only one of the following two alternatives.

is the angle between the second-order maximum and the third-order maximum?

Without using a calculator, find the exact values of

[8]

22 (b) the general solution of the differential equation

(iii) Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is -10 m s^{-2}.

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

[15]

(i) find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

equation = ... *ca* **[1]**

(ii) continuous random variable X takes values in the interval $0 \leqslant x \leqslant 3$ only. For $0 \leqslant x \leqslant 3$ the graph of its probability density function f consists of two straight line segments meeting at the point $(1, k)$, as shown in the diagram. Find k and hence show that the distribution function F is given by

number, x, of beech trees was counted in each of 50 randomly chosen regions of equal size in beech forests in country A. The number, y, of beech trees was counted in each of 40 randomly chosen regions of the same equal size in beech forests in country B. The results are summarised as follows.

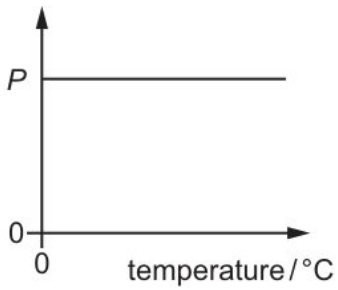
[3]

(v) from the definitions of tanh and sech in terms of exponentials, prove that

that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - y\mathrm{e}^x}{x\mathrm{e}^x + 2y}$.

[6]

(a)



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

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

springs = ... wf **[2]**

(v) stationary nucleus has nucleon number A.

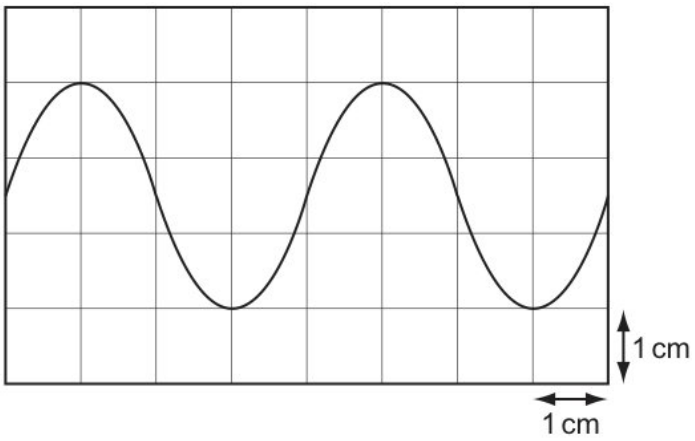
the equations of the asymptotes of C.

[8]

(d) 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.

object is fully submerged in a liquid.

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



[5]

(iii) the speed of the aeroplane.

restaurant manager buys 160 of these large bags of pasta.

$$\left(x^2 + y^2\right)^{\frac{3}{2}} = -4axy.$$

[6]

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

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

down to antiup

other angular = ... *wb* **[3]**

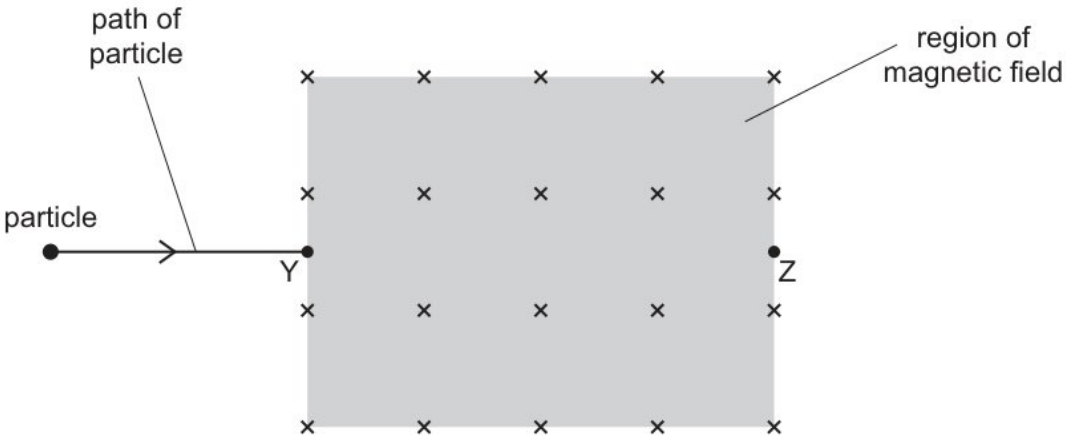
(ii) the coordinates of C,

region = ... *po* **[8]**

21 (a) Calculate the distance of the centre of mass of the lamina from A.

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

curve C has polar equation $r = a(1 + \sin\theta)$ for $-\pi < \theta \leqslant \pi$, where a is a positive constant.



(v) 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.

formula iteration = ... *ps* **[15]**

(ii) the probability density function of Y,

[8]

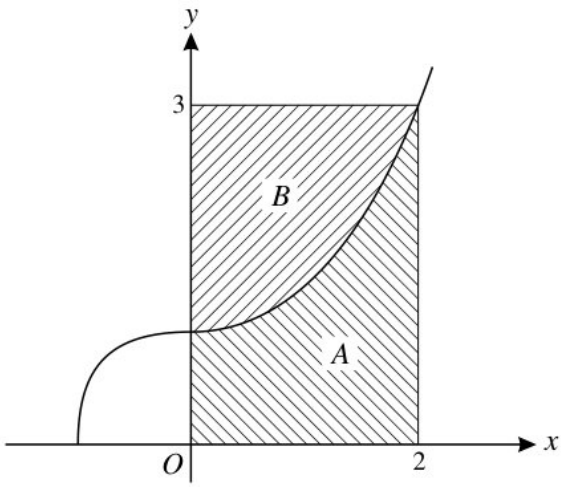
(iv) function f is defined by $\mathrm{f} : x \mapsto \frac{x+3}{2x-1}, x \in \mathbb{R}, x \neq \frac{1}{2}$.

[4]

(c) measurements to be taken,

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

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



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

Pressure is force per unit area.

[6]

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

[6]

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

(iii) The waves must be coherent.

the moment of a force about a point.

[8]

(ii) 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'.

from have = ... ub **[8]**

(i) the expected value and variance of Y.

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

[5]

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

(e) (iv) satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \mathbf{a} + t\mathbf{b}$$

[6]

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

In the case where $k = 1$,

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

[8]

(b) (iii) points A, B, C have position vectors

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

gravitational potential at a point.

classified = ... rz **[8]**

(vi) the exact area of one loop of the curve.

that, when $t = 0, x = 3$ and $\frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[12]

(i) Find the constant speed that the tractor could maintain on the hill when working at this power.

the torque of a couple.

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

[3]

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

the probability density function of Y,

a t test at the 5% significance level to find the range of values of k for which the result of the test is to reject the null hypothesis

shows = ... ki **[12]**

(iii) only one of the following two alternatives.

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.

$$\int_0^k e^{4x} dx = \int_0^{2k} e^x dx$$

rough = ... *bn* **[3]**

(ii) Obtain a basis for the null space of T .

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

[6]

(d) (ii) safety precautions to be taken.

the exact value of the positive constant k for which

Find the rank of **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.

Ahmad, people, = ... *ug* **[10]**

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

your answer correct to 2 decimal places.

[5]

19 Given instead that $\mu = 0$ and that the tension in the string is 0.48 N , calculate

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

Show that the tension in the string is 10 N .

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

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

astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

speed = ... hk **[5]**

(vii) parametric equations of a curve are

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = -2x\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2$$

[6]

(iv) the number of different ways in which these three bands can be selected.

Length (cm)	$5-9$	$10-14$	$15-19$	$20-24$	$25-29$	$30-39$
Frequency	18	28	60	72	48	24

[5]

(a) (ii) by calculation that $0.9 < a < 0.95$.

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

[6]

(iv) internal diameter of the beaker is 0.05 m $\pm$ 3%.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(\mathrm{e}^x \sin x\right) = 2^{\frac{1}{2}n}\mathrm{e}^x \sin\left(x + \frac{1}{4}n\pi\right)$$

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

[3]

(f) (vi) that $rp^3 = q^3$.

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.

[6]

(i) point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

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.

[8]

(ii) Prove by mathematical induction that, for all positive integers n,

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

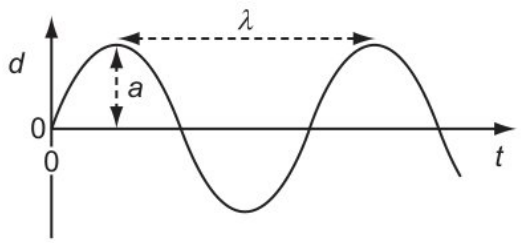
[5]

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

(v) 3×3 matrix $\mathbf{A}$ has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

[10]

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



horizontal friction = ... ko **[5]**

(i) The power to X will increase and the powers to Y and Z will remain unaltered.

[15]

(c) plank rests on fixed supports at its ends X and Y.

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.

(ii) find the variance of the number of 4 s obtained in 30 throws,

diagram shows the curve $y = \sqrt{}(1 + x^3)$. 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 $y = 3$.

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.

[6]

(vi) gravitational potential at a point.

[6]

16 Find the equations of the asymptotes of C.

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

Use the iterative formula

diagram shows part of the curve

[6]

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

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

[10]

(iii) plane Π_2 contains the lines

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

[5]

(e) (iii) 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.

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

[5]

(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.

by calculation that a lies between 2 and 2.1.

time-base setting on the oscilloscope should be used?

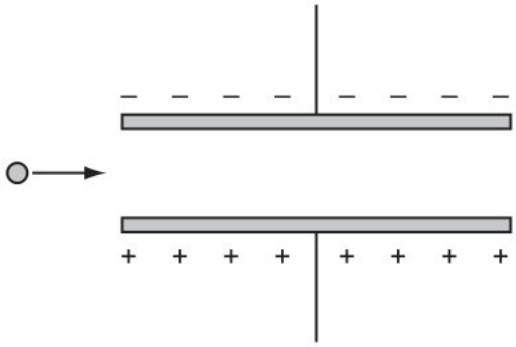
[6]

(ii) 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 $0 < \theta < 2\pi$

a group of 20 musicians, there are 9 guitarists, 6 pianists and 5 drummers.

[4]

19 random variable X is the number of heads obtained.



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

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

(a) (ii) the value of V.

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.

[10]

(v) Find a vector equation for the line of intersection of the planes.

competitors who took part in this Saturday's event are selected at random.

point D is such that $ABCD$ is a parallelogram.

[12]

(i) Find the standard deviation of x.

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.

[6]

(b) (i) student takes measurements to calculate the density of a liquid in a beaker.

is given that $y = \frac{1}{12}\pi$ when $x = \frac{1}{2}\pi$.

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

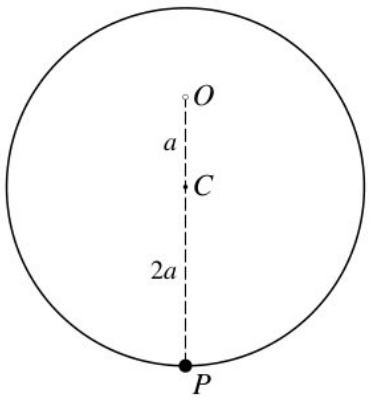
[8]

(iii) the median and the interquartile range of the times of the runners from the Gulls.

find the volume of the tetrahedron $OABC$, given that the volume of a tetrahedron is $\frac{1}{3}\times$ area of base $\times$ perpendicular height.

[2]

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



[12]

(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.

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]

(e) (iii) cable has tensions T_1 and T_2 as shown.

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

[20]

(i) the general solution of the differential equation

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

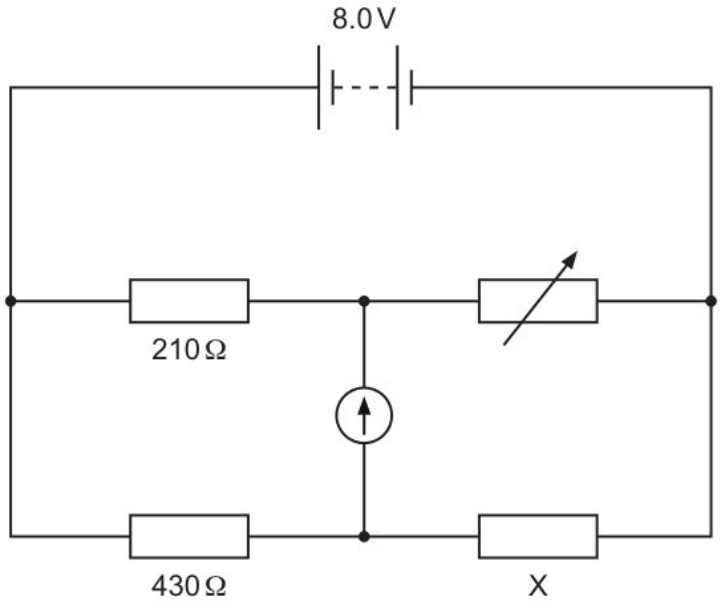
[10]

(d) (iv) your answer correct to 2 decimal places.

State the value of E(X).

[8]

(i)



sample has an activity of 180 Bq at time $t = 0$.

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

[4]

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

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.

[10]

(g) (iii) Find also the exact value of the surface area generated when C is rotated through 2π radians about the x-axis.

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

[8]

(ix) 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.

the expected value and variance of Y.

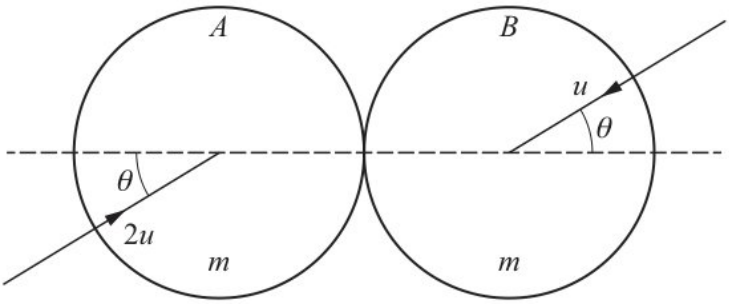
the position vector of P.

[10]

23 Find the value of I_2.

thermistor is connected to a cell with negligible internal resistance.

(c) (ii)



gravitational potential at a point.

region R is enclosed by C and l, and contains the pole. Find the area of R.

[2]

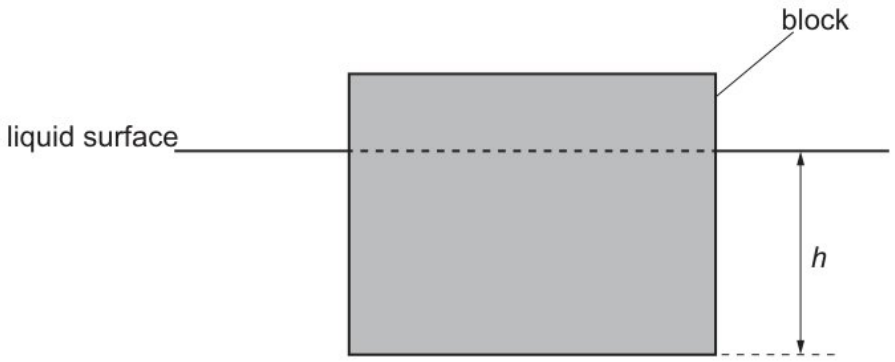
(i) matrix **M** represents a sequence of two geometrical transformations in the $x - y$ plane.

on the graph would the elastic limit be found?

[5]

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

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



random = ... mq **[4]**

(b) (iii) 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.

Express u in the form $x + \text{i}y$, where x and y are real.

[10]

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

$$\theta \cos\theta + \left(\frac{1}{8}\theta + 1\right)\sin\theta = 0$$

[10]

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

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.

gravitational potential at a point.

[4]

13 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.

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

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

de Moivre's theorem to show that

[3]

(iii) cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

object weighs 6.0 N on Earth.

beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

[4]

(v) 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 $\frac{8}{3}Ma^2$.

a, b and c are integers to be determined.

Hence, or otherwise, obtain an expression for $\text{f}^{-1}(x)$.

[6]

(c) (i) 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 $\frac{1}{n}$.

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

[5]

(vii) 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 speed of P when it passes through L.

[5]

(a) (ii) the set of values of p for which C has two distinct turning points.

safety precautions to be taken.

[6]

(i) object hangs by means of two cords around two rods, as shown.

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}.

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

mean = ... yc **[8]**

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

the number of different arrangements of the 7 men and 4 women in a line in which all the men stand together and all the women stand together.

[20]

(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.

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.

[2]

(iv) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.

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 = ... kx **[10]**

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

(c) (iv) 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 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.

[3]

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

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 $\lambda\mu$.

[12]

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

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

specific latent heat.

solid = ... ya **[6]**

(vi) The power to X will increase and the powers to Y and Z will remain unaltered.

uniform solid hemisphere, of radius a and mass M, is placed with its curved surface in contact with a rough plane that is inclined at an angle α to the horizontal. A particle P of mass m is attached to the rim of the hemisphere. The system rests in equilibrium with the rim of the hemisphere horizontal and P at the point on the rim that is closest to the inclined plane (see diagram). Given that the coefficient of friction between the plane and the hemisphere is $\frac{1}{2}$, show that

[8]

(g) (ii) statement about sound waves in air at constant temperature is correct?

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

that $x^2y = z$, show that

[12]

(iv)

was the by-product of this reaction?

[5]

(d) (ii) 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.

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.

are selected from these 20 to perform at a concert.

[4]

(iv) diagram illustrates successive wavefronts.

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

express = ... uo **[15]**

10 obtain the roots of the equation

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

diagram best represents the electric field surrounding the charges?

up the probability distribution table for X.

[6]

(ii) is the total resistance between the two ends of the coil?

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

[8]

(b) (i) region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

car is accelerated by a constant resultant force of 300 N for 5.0 s .

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

[5]

(vi) 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).

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

[12]

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

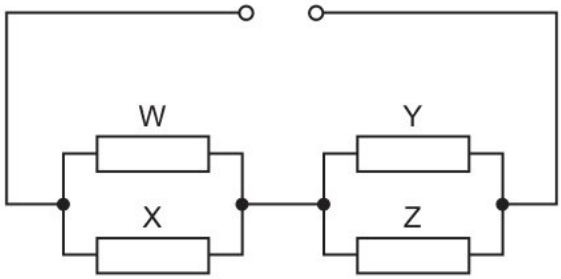
[15]

(d) (ii) Find also the value of $\frac{1}{\alpha^2\beta^2} + \frac{1}{\beta^2\gamma^2} + \frac{1}{\gamma^2\alpha^2}$.

Show that, for $n > 2$,

that gets = ... ib **[2]**

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



[6]

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

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

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

(b) (iv) Prove by mathematical induction that, for all positive integers n,

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.

have pulley. from = ... qx **[6]**

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

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}.

processes. internal show, = ... yo **[6]**

(iii) curve $y = 4x^2 \ln x$ has one stationary point.

By sketching a suitable pair of graphs, show that the equation

[1]

(a) (ii) Find the probability that the die lands on 4 and the number of times the coin shows heads is 2 .

continuous random variable X has probability density function f given by

[5]

(i) the probability generating function of Z to find $\mathrm{E}(Z)$.

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.

[10]

(iii) the solution of the differential equation

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.

modelled = ... ni **[6]**

(d) (ii) the Young modulus.

diagram shows a trace of a wave on a cathode-ray oscilloscope.

[4]

(iii) the exact value of I_2

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

[3]

(v) 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 $\lambda\mu$.

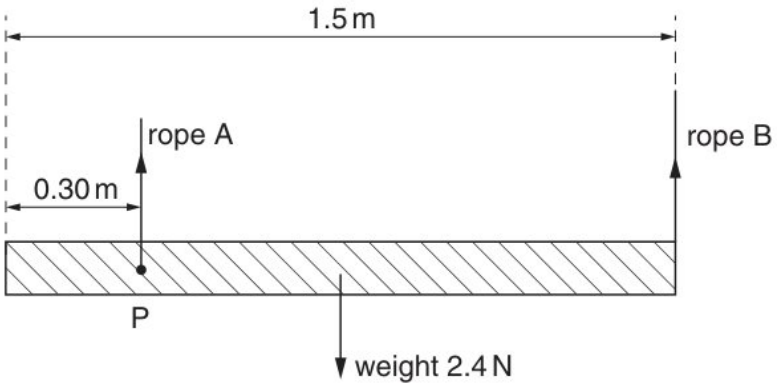
smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the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

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

[8]

17 the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

(b) (ii) 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 $ax + by + cz = d$.



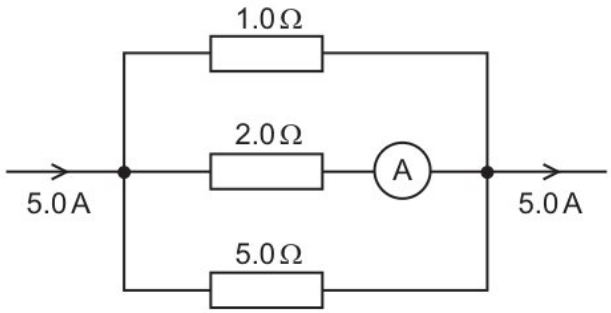
smallest size = ... dw **[6]**

(i) The waves must be coherent.

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.

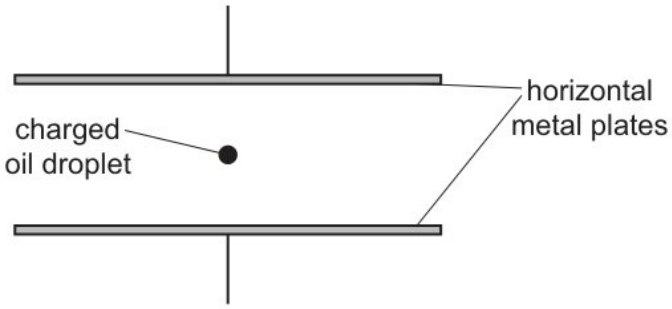
[3]

(c) (i) the general solution of the differential equation



[6]

(ii)



that $x^2y = z$, show that

[5]

19 Hence, or otherwise, obtain an expression for $\mathrm{f}^{-1}(x)$.

(a) (iii) Show that, at the points (other than the pole) at which a tangent to C is parallel to the initial line,

$$I_n = \frac{1}{n-1} - I_{n-2}$$

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 $t = 4$.

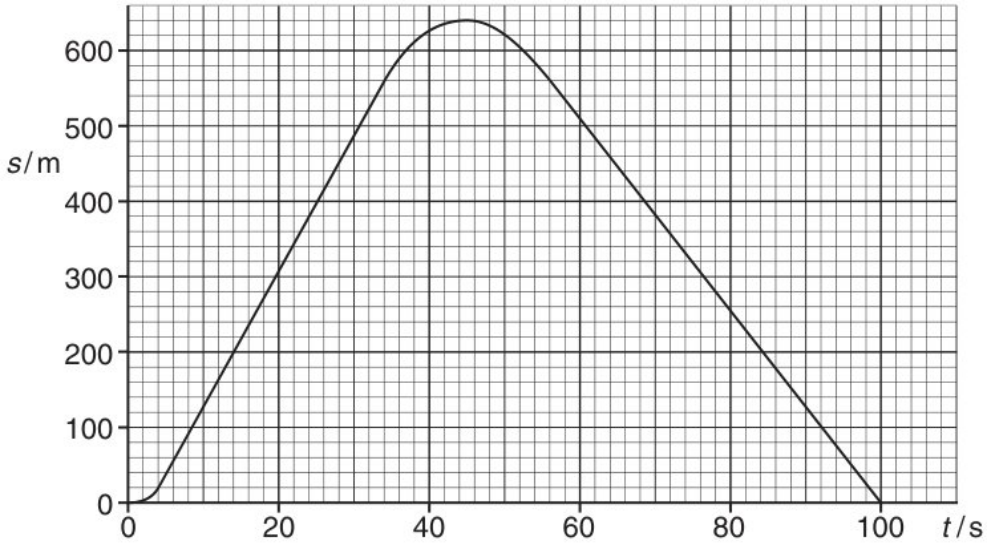
[5]

(i) are the weight and the mass of the body when it is on the Moon?

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

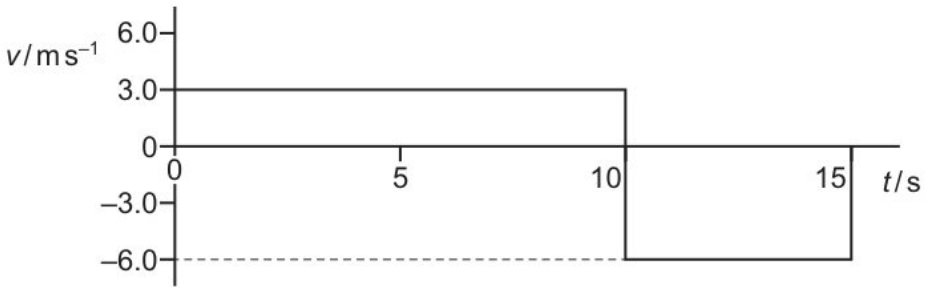
[3]

(ii) the general solution of the differential equation



seconds, recorded = ... jh **[6]**

(v)



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

[1]

(b) (v) velocity = acceleration × time

the expected value and variance of Y.

[3]

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

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

other Mary, = ... ps **[4]**

(i) P hears a sound of increasing frequency.

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).

[8]

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

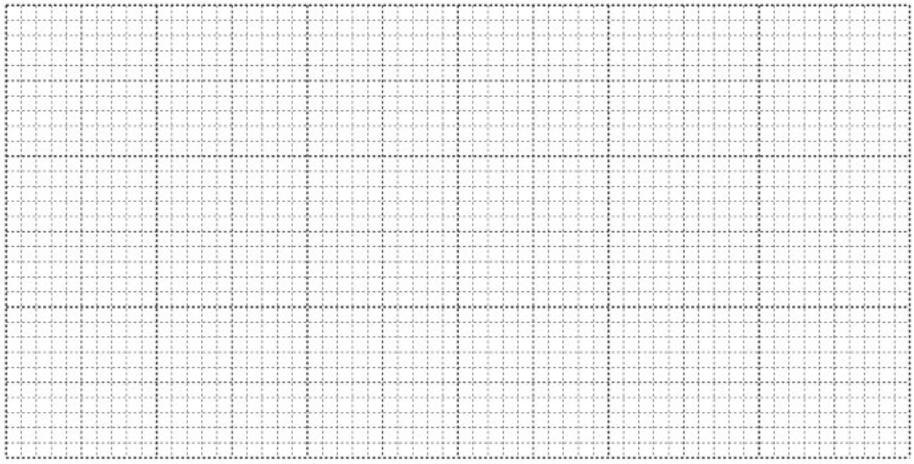
$$\mathrm{f}(t) = \begin{cases} 0 & t < 0 \\ \lambda \mathrm{e}^{-\lambda t} & t \geqslant 0 \end{cases}$$

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

[10]

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

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 $\lambda\mu$.



[6]

(iv) an expression for $\tan\theta$ in terms of e.

that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

[12]

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

$$\mathrm{f}(x) = \begin{cases} 0 & x < 0 \\ a\mathrm{e}^{-x\ln 2} & x \geqslant 0 \end{cases}$$

tube. passes = ... *ro* **[3]**

22 Find the area of the triangle ABC.

(d) (iii) the acute angle between the planes ABC and ABD.

the value of the constant k,

[15]

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

many different colour arrangements are there of the 10 books?

[12]

(b) (iii) diagram shows part of the curve

Length (cm)	$5-9$	$10-14$	$15-19$	$20-24$	$25-29$	$30-39$
Frequency	18	28	60	72	48	24

[6]

(i) Given also that -1 is an eigenvalue of **A**, find a corresponding eigenvector.

is a general description of a baryon?

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + \frac{\mathrm{d}x}{\mathrm{d}t} - 2x = 2t^2 + t - 1,$$

numbered = ... *ci* **[5]**

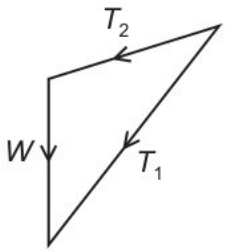
(v) Find the set of values of t for which the particles are travelling in opposite directions.

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

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

[4]

(ii)



resistors of equal value are connected as shown.

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

[12]

(e) (i) 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).

$$\begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}, \quad \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}, \quad \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix},$$

[8]

(iii) region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

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

[3]

19 curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.

(a) (iv) curve C has equation $y = \frac{x^2-3x+6}{1-x}$.

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

[8]

(iii) circuit is set up as shown in Fig. 2.1.

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

[10]

(f) (iv) 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

circuit is set up as shown in Fig. 2.1.

Find the area of the region enclosed by C.

[15]

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

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.

[3]

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

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

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

[4]

(b) (ii) 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.

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.

also = ... ef **[5]**

(iv) other teams of runners, the Eagles and the Swifts, also took part in the event. The recorded times in seconds for 20 runners from the Eagles and 30 runners from the Swifts are denoted by x and y respectively.

state the corresponding eigenvalue.

field = ... rt **[5]**

(e) (iii) the value of the constant k,

In the case where $k = 1$,

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

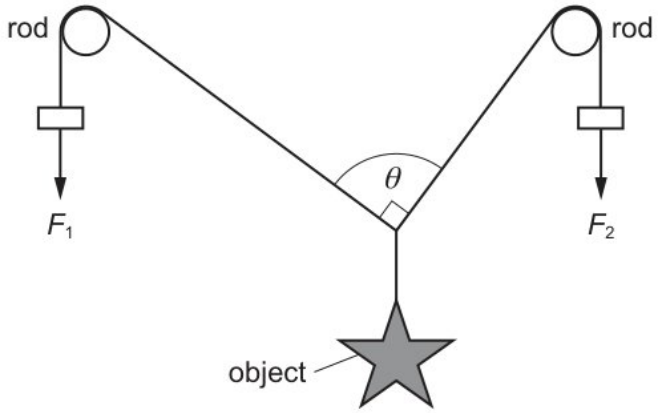
[8]

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

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 .

[6]

(ii) 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.



[12]

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

	F/N when child is at X	F/N when child is at Y
A	600	0
B	600	150
C	750	0
D	750	150

[6]

(iii) 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.

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.

[6]

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

(d) (iii) 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.

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

from where = ... *by* **[8]**

(i) that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\text{sech}^{-1}\, t$.

the exact value of I_2

random = ... *ul* **[3]**

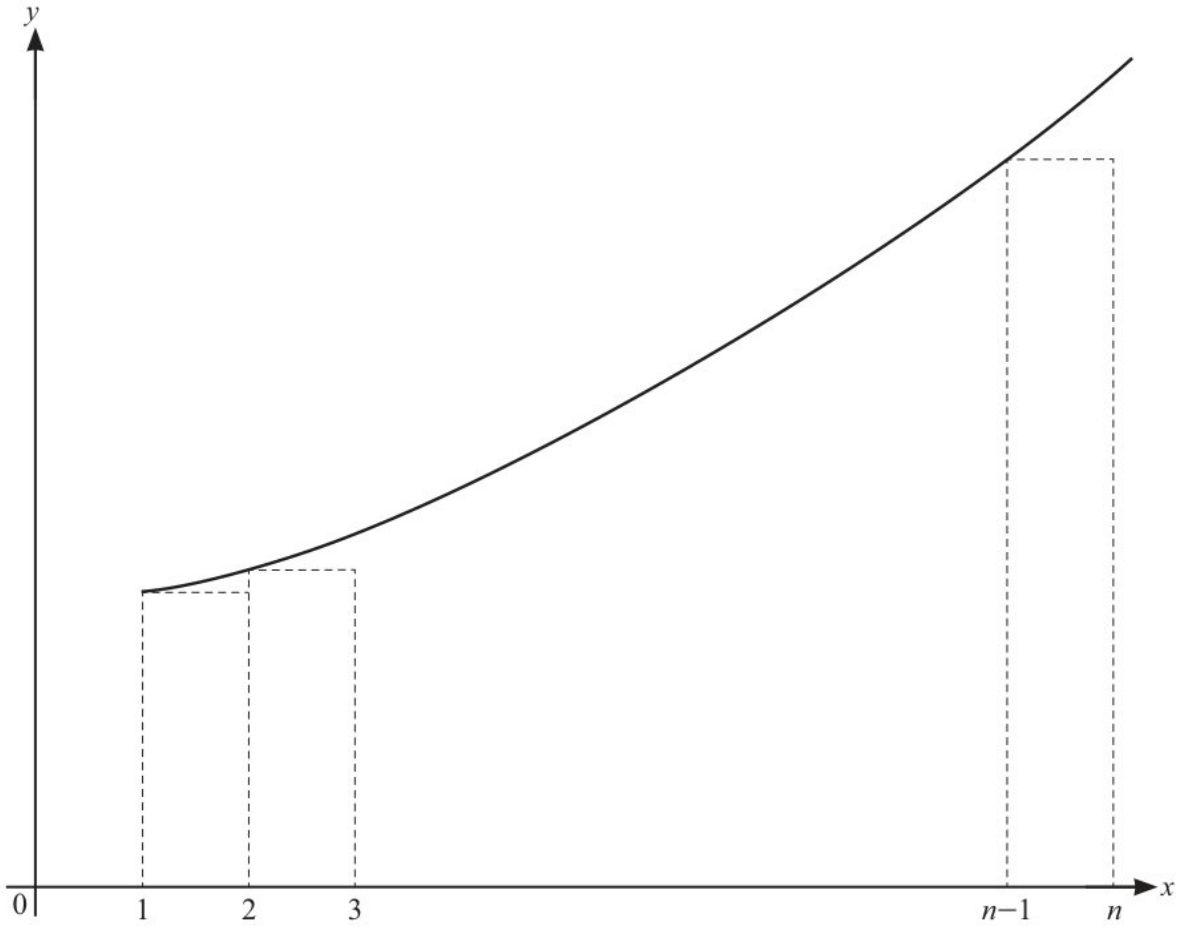
(f) (ii) Find a vector equation for the line of intersection of the planes.

statement about nuclei is correct?

Different isotopic nuclei have different proton numbers.

made = ... *pm* **[2]**

(iv) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$.



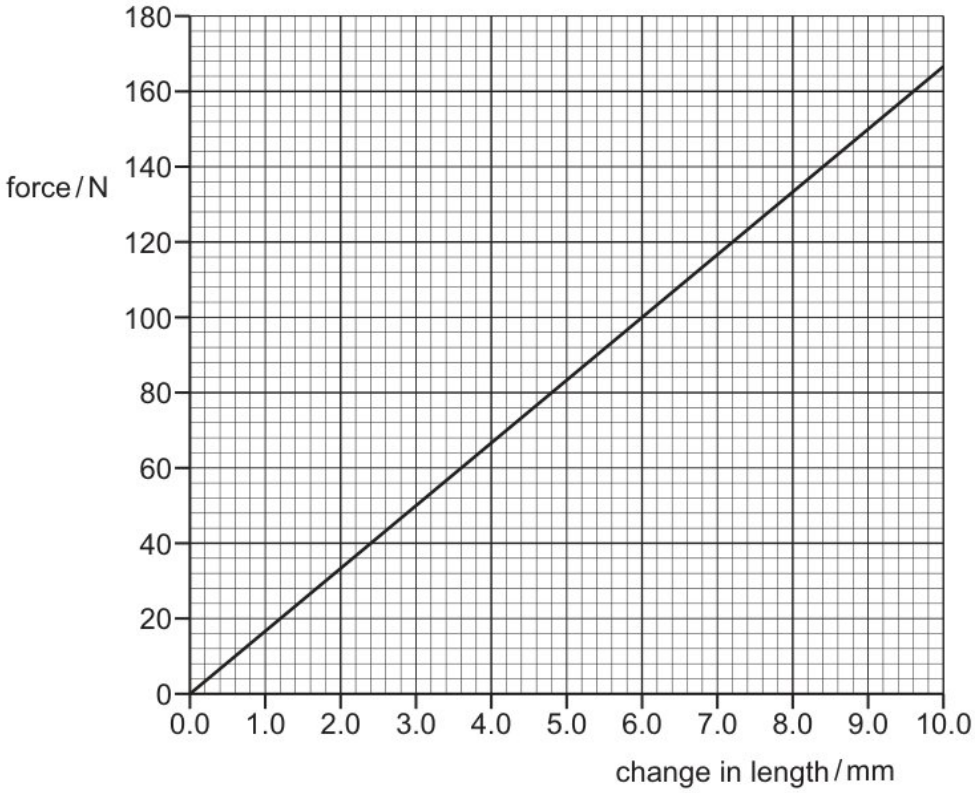
[8]

(i) 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.

time-base setting on the oscilloscope should be used?

pulled = ... nv **[3]**

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



[8]

(b) (i) 3×3 matrix $\mathbf{A}$ has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

moment of a force.

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

masses = ... *dk* **[6]**

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

diagram shows two waves R and S.

points = ... *hh* **[2]**