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

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

(c) (ii) Find the value of x.

Show that the cartesian equation of C is

[8]

(iii) the exact value of I_2

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

[3]

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

parametric equations of a curve are

[8]

(b) (i) State one other feature of this orbit.

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

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

Find = ... ik **[3]**

(ii) 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.

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

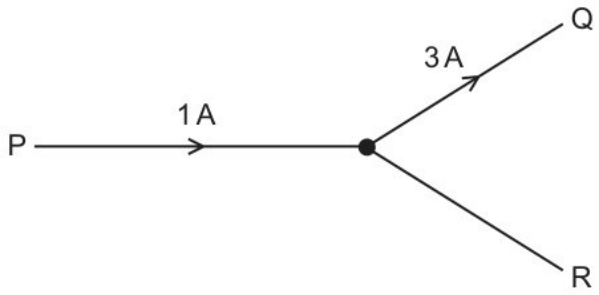
energy = ... qc **[5]**

(iii) 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

statement about sound waves in air at constant temperature is correct?

causing about = ... *jg* **[12]**

(d) (i)



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

[4]

(v) a positron and an antineutrino

region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

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

less = ... *wo* **[5]**

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

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

[5]

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

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

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

through = ... qw **[8]**

(ii) Find angle ABC.

the set of values of x for which the expansion in part (b) is valid.

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

[8]

(iii) Write down the least value of $15\cos\theta - 9\sin\theta$ as θ varies.

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

the graph of $y = \mathrm{f}(x)$,

[4]

(b) (ii) region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

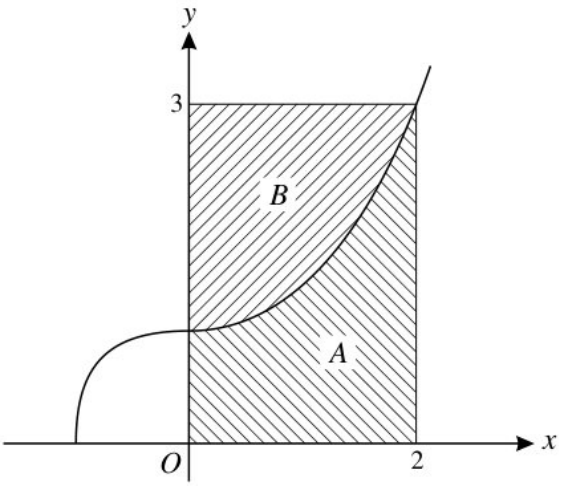
[6]

(iii) sequence $x_1, x_2, x_3, \ldots$ defined by

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

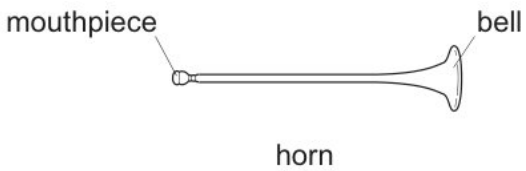
[12]

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



that = ... *ao* **[5]**

(c) (v)



Find the area of the triangle ABC.

[6]

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

marks of the pupils in a Physics examination are summarised as follows.

[8]

23 (b) moment of a force.

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

[20]

(ii) polynomial p(x) is defined by

point makes = ... cn **[6]**

(c) Express $5\cos\theta - 3\sin\theta$ in the form $R\cos(\theta+\alpha)$, where $R > 0$ and $0° < \alpha < 90°$, giving the exact value of R and the value of α correct to 2 decimal places.

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

the ratio $H : D$.

parametric equations of a curve are

equipment. = ... fg **[4]**

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

[3]

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

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

Find the values of F and θ.

[1]

(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.

p and q are given real numbers, then

seats = ... wd **[6]**

(iv)

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

continuous random variable X has probability density function f given by

mass = ... ye **[5]**

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

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

inclined = ... fg **[8]**

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

The weight of the plank is causing a clockwise moment.

[4]

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

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

[1]

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

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

a cubic equation with roots α, β and γ, given that

91.5. weight, = ... ll **[6]**

28 It is given that the determinant of **A** is equal to the product of the eigenvalues of **A**. Use this result to find the third eigenvalue of **A**, and find also a corresponding eigenvector.

(a) (iii) 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.

particle of mass m is attached to the mid-point of a light elastic string. The string is stretched between two points A and B on a smooth horizontal surface, where $AB = 2a$. The string has modulus of elasticity λ and natural length $2l$, where $l < a$. The particle is in motion on the surface along a line passing through the mid-point of AB and perpendicular to AB. When the displacement of the particle from AB is x, the tension in the string is T. Given that x is small enough for x^2 to be neglected, show that

block, where $^{-1}$ = ...sz **[2]**

(ii) are the weight and the mass of the body when it is on the Moon?

[4]

(i) the probability of a Type I error.

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 $\cos 2\theta = \frac{7}{25}$.

[5]

(b) (ii) 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.

Show that the total distance fallen is 1048 m .

[20]

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

State the number of roots of the equation $\mathrm{p}\,(2^y) = 0$, justifying your answer.

plane Π_2 contains the lines

resistance = ... hv **[6]**

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

flows out of a pipe and hits a wall.

[20]

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

current-carrying coil produces a magnetic field.

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

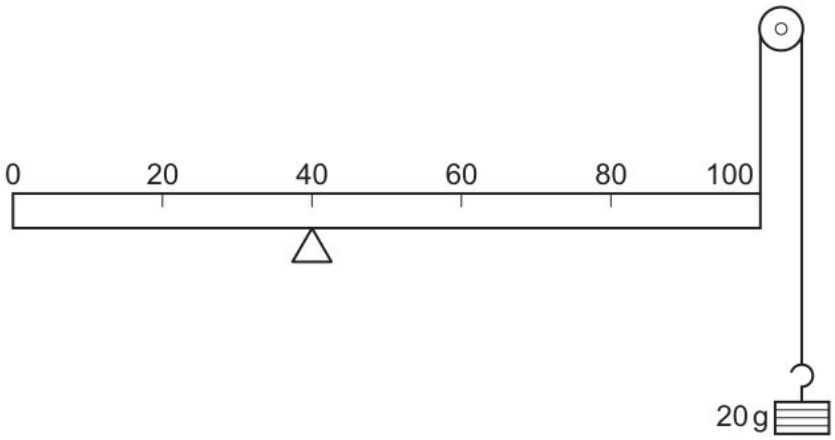
[3]

(iii) Calculate the acute angle between the planes.

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

[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.



[4]

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

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

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

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

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.

(f) (ii) Hence factorise p(x) completely.

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 .

[12]

(iii) 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.

[12]

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

the equations of the asymptotes of C.

[10]

(d) (ii) 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.

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.

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

number = ... pf **[8]**

(iii) Find the position vector of D.

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

bulbs = ... ux **[10]**

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

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

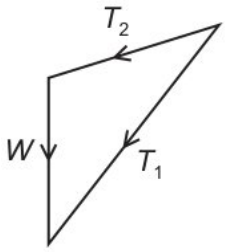
slower = ... *io* **[5]**

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

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

some = ... *ab* **[12]**

(b) (iii) water is added to an insulated beaker, as shown in Fig. 2.1.



object hangs by means of two cords around two rods, as shown.

[10]

(ii) procedure to be followed,

Light waves can be diffracted but sound waves cannot be diffracted.

notes 11.5 = ... *yo* **[6]**

18 does this mean?

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

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

combination of changes must increase the amount of spreading due to diffraction?

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

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

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

[6]

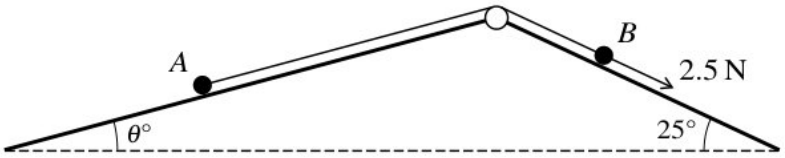
(i) equation of a curve is $xy + y^2 e^{-x} = 4$.

Wavelength is proportional to amplitude.

Show that, for $n > 2$,

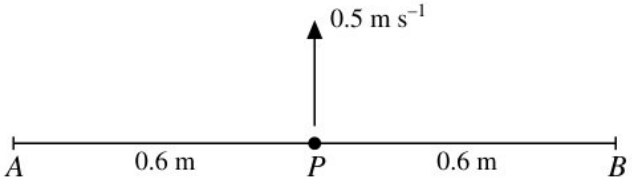
[1]

(ii) find corresponding eigenvectors.



[4]

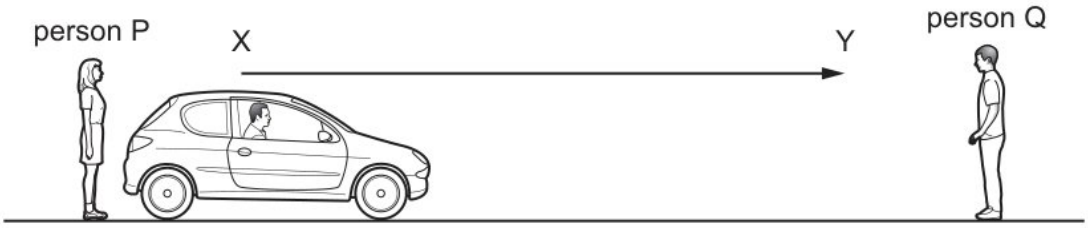
(iv)



Show that the acceleration of the particle between $t = 3.5$ and $t = 6$ is -10 m s^{-2}.

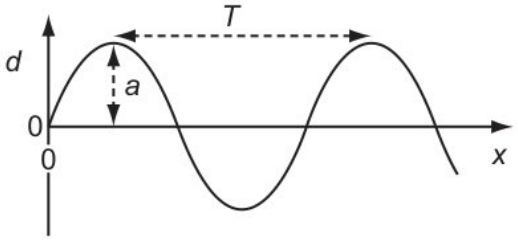
pineapples 'medium'. = ... *yy* **[5]**

(f) (ii) Find a set of corresponding eigenvectors.



units = ... fc **[6]**

(iii) Find the area of the triangle ABC.



student wishes to investigate the effect of adding various thicknesses of glass in front of

[15]

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

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

projection, = ... ri **[10]**

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

with a reason, whether f has an inverse.

[10]

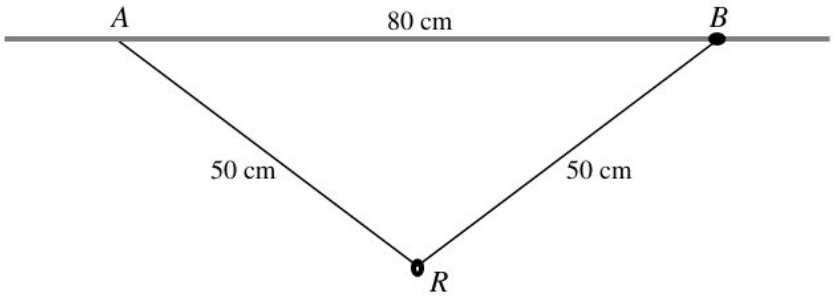
(d) (iv) throws three coins at the same time.

control of variables,

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

[8]

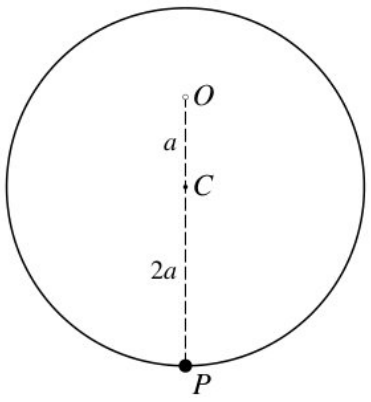
(iii) curves C_1 and C_2 intersect at the point with polar coordinates (a, β). State the value of β.



[15]

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

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



[6]

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

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

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

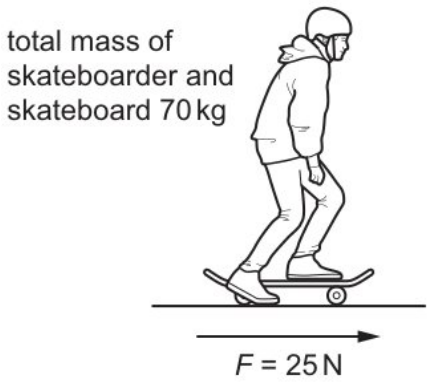
(c) (ii) are speed v_1 and speed v_2 ?

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

$$a^2\left(\frac{1}{6}\pi - \frac{1}{8}\sqrt{3}\right)$$

[2]

(iii)



stationary nucleus has nucleon number A.

[12]

(e) (i) 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 .

an estimate for the mean length of these 250 leaves.

[2]

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

P and Q form an isolated system.

over = ... *yd* **[6]**

(iii) Find the position vector of D.

38% of these leaves are of length k cm or more.

same with = ... *pu* **[6]**

(d) (v) diagram shows the curve with equation $y = \frac{1}{\sqrt{x}}e^{\sqrt{x}}$ for $x \geqslant 1$, together with a set of $n - 1$ rectangles of unit width. of unit width.

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

[1]

(iii) A contains 6 red marbles, 5 blue marbles and 1 green marble.

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

Find the exact area of the shaded region.

[20]

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

is the percentage uncertainty in the calculated density of the liquid?

the matrix **A**,

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

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

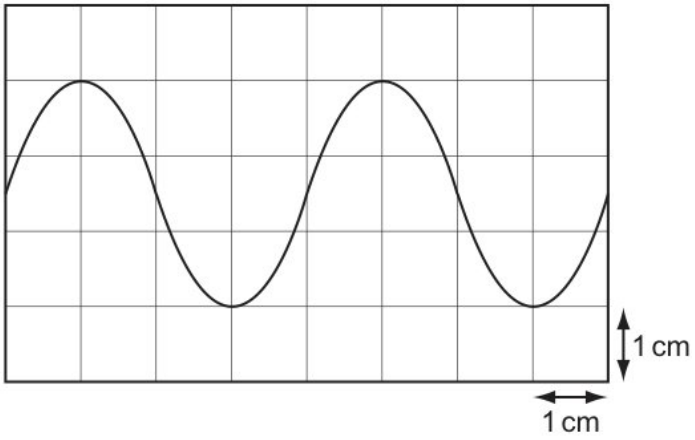
(a) (ii) State the equation of the other asymptote.

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

[3]

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

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



[6]

(iv) is the value of R ?

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

diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

responses were = ... xq **[10]**

(c) (iii) time-base setting on the oscilloscope should be used?

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?

neutron decays to form a proton.

passes = ... gx **[4]**

(v) magnetic flux density.

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

plane = ... vz **[4]**

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

(d) (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

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

end of a light elastic string of natural length 0.4 m and modulus of elasticity 8 N is attached to a fixed point O on a smooth horizontal plane. The other end of the string is attached to a particle P of mass 0.2 kg which moves on the plane in a circular path with centre O. The speed of P is v m s^{-1} and the extension of the string is x m.

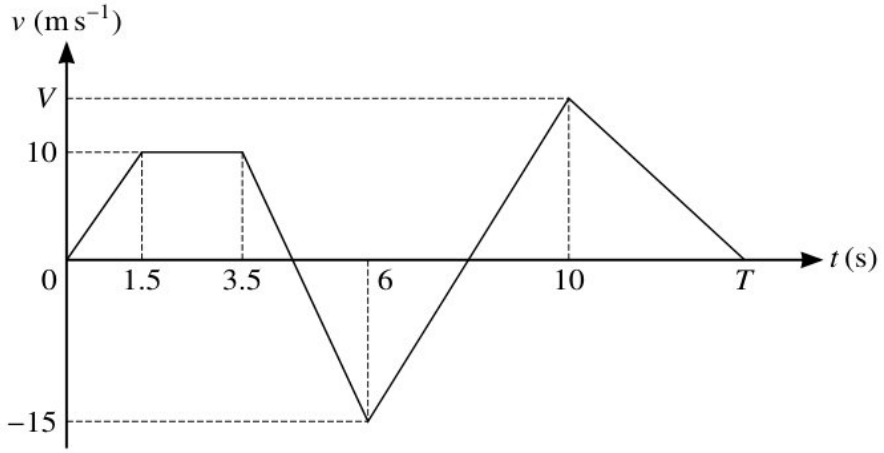
[5]

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

momentum = mass × velocity

[6]

(iii)



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

[4]

(vi) supermarket is open 7 days a week.

$$\tan 3\theta = \frac{3\tan\theta - \tan^3\theta}{1 - 3\tan^2\theta}.$$

[4]

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

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

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.

[3]

(iv) Speed is distance travelled per second.

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

Show that the moment of inertia of the object, consisting of rod, shell and inner sphere, about the axis l is $\frac{289}{15}ma^2$.

[5]

(f) (i) 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.

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.

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

[4]

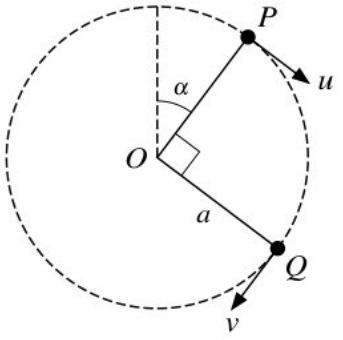
(ii)

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

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

[8]

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



[3]

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

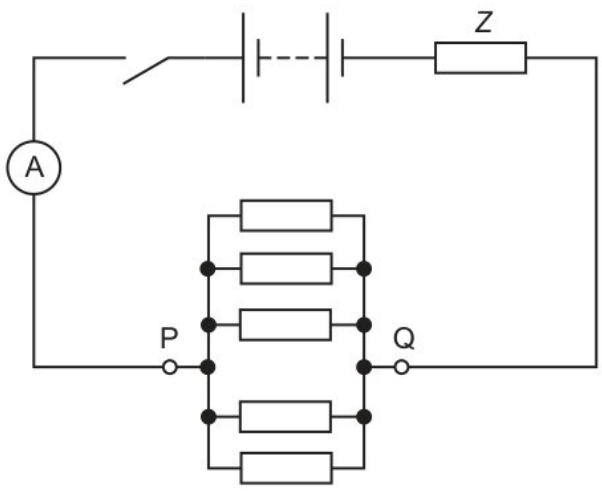
variation with extension x of the force F for a spring A is shown in Fig. 6.1.

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

combination of changes must increase the amount of spreading due to diffraction?

boys, = ... *iu* **[8]**

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



is meant by elastic deformation?

[3]

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

row of the table gives an angle θ of 90° ?

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

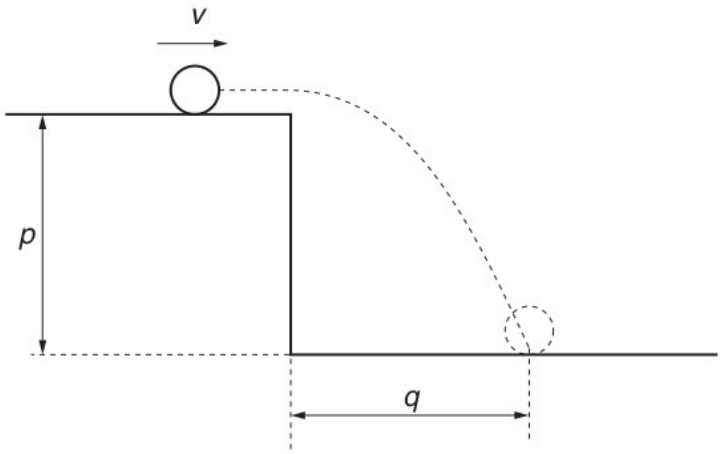
[2]

(i) diagram shows the curve with equation $y = \frac{1}{\sqrt{x}}\mathrm{e}^{\sqrt{x}}$ for $x \geqslant 1$, together with a set of $n - 1$ rectangles of unit width. of unit width.

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.

road road = ... wj **[4]**

(ii)



cubic polynomial p(x) is defined by

[2]

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

is the minimum constant acceleration necessary for the aircraft?

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

[15]

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

resistors of equal value are connected as shown.

moves = ... uf **[5]**

(v) Express f(x) in partial fractions.

the general solution of the differential equation

[2]

10 what is meant by the de Broglie wavelength.

(b) (v) the type of each transformation and make clear the order in which they are applied

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.

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

[6]

(iii) Hence find the solutions of the equation

Find the equations of the asymptotes of C.

[8]

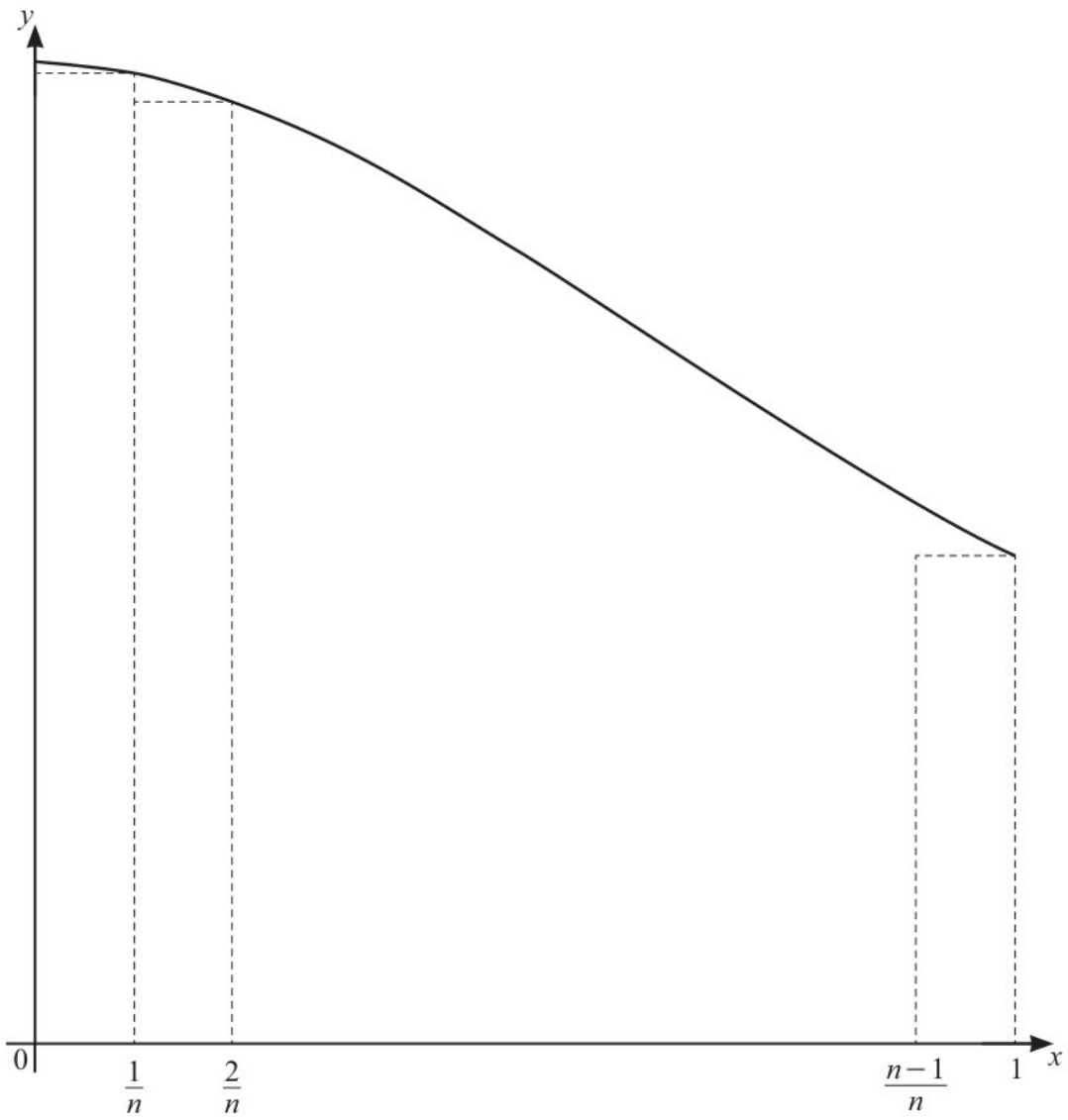
(iv) particle P of mass 0.4 kg is released from rest at a point O on a smooth plane inclined at 30° to the horizontal. P moves down the line of greatest slope through O. The velocity of P is v m s^{-1} when its displacement from O is x m. A retarding force of magnitude $0.2v^2$ N acts on P in the direction PO.

Find the equations of the asymptotes of C.

lamp = ... gi **[12]**

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

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



[4]

(a) (i) manufacturer claims that the machine produces rods with mean length 300 mm .

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

[2]

(iv) resistors, each of resistance R, are connected as shown.
$\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5$.

[5]

(iii) a transformation from $\mathbb{R}^4$ to $\mathbb{R}^4$.
The waves must be coherent.

[8]

(ii) Find the area of the sector of C between $\theta = 0$ and $\theta = \frac{1}{3}\pi$.
the value of $\left(\alpha^3 - 1\right)^3 + \left(\beta^3 - 1\right)^3 + \left(\gamma^3 - 1\right)^3$.

[5]

(f) (v) time taken by P to travel directly from L to M is 2 s .
the ductile material,

book There = ... *nb* **[1]**

(ii) Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16\sin^5\theta \, \mathrm{d}\theta$.
following table shows most of the corresponding expected frequencies, correct to 2 decimal places, using a Poisson distribution with mean 3.25.

vector = ... *ls* **[5]**

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

$$\alpha + \beta + \gamma = -1$$
$$\alpha^2 + \beta^2 + \gamma^2 = 29$$
$$\frac{1}{\alpha} + \frac{1}{\beta} + \frac{1}{\gamma} = -1$$

then it converges to a.

[3]

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

the speed of the aeroplane.

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.

[20]

(i) a positron and a neutrino

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

velocity = ... du **[6]**

24 Find the distance of B from the wall when it collides with A for the second time.

(e) (iii) between gravitational potential energy and electric potential energy.

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

[15]

(iv) only one of the following two alternatives.

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.

[6]

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

Find the equations of the asymptotes of C.

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

[8]

(b) (i) Find angle ABC.

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

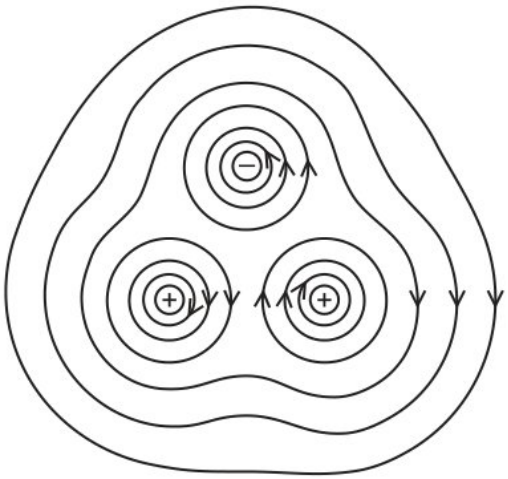
[6]

(iv) 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).

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.

[10]

(ii)



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]

28 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} .

(iv) (d) does this mean?

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

[8]

(b) only one of the following two alternatives.

Show that $v\frac{\mathrm{d}v}{\mathrm{d}x} = 5 - 0.5v^2$.

[6]

(a) variables x and y are related by the differential equation

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

[5]

(v) (c) 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.

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

[2]

(e) 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.

the equations of the asymptotes of C.

probability more = ... re **[5]**

9 Obtain a basis for the null space of T .

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

(b) (iii) the probability generating functions, $\mathrm{G}_X(t)$ of X and $\mathrm{G}_Y(t)$ of Y.

a 90% confidence interval for the difference in mean crop mass associated with each type of fertiliser.

significant find = ... qf **[12]**

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

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

[3]

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

Hence, or otherwise, prove by mathematical induction that f(n) is divisible by 7 for every positive integer n.

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

[6]

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

	α-particle	β-particle	γ-radiation
charge			0
mass	$4u$		
speed		up to $0.99c$	

the set of values of x for which the expansion in part (b) is valid.

[8]

(d) (iv) far apart are two adjacent interference fringes that are formed on the laboratory wall?

a cartesian equation of the plane Π containing l_1 and l_2.

[4]

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

safety precautions to be taken.

does the amplitude a of the vibrating air molecules vary with the distance r from the source?

[12]

(ii) as shown in Fig. 2.1.

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

diagram = ... *dw* **[8]**

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

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

that $v = y^3$, show that

(b) (ii) 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.

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

a positron and a neutrino

Show = ... *pq* **[15]**

(iv) object is fully submerged in a liquid.

the equation representing this decay.

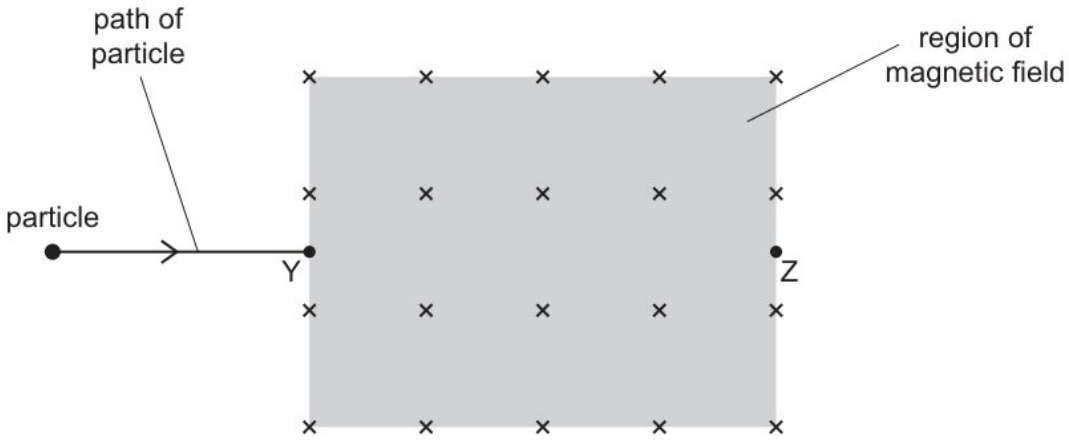
hotel. whether occupied = ... *pg* **[3]**

(v) Find the mean age of all 19 people.

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

[8]

(a) (i) four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x.



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

should = ... cv **[20]**

(iii) Find the value of I_2.

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

[20]

(ii) 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.

as shown in Fig. 2.1.

without number = ... yq **[5]**

15 Find the values of a and b.

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

diagram best represents the electric field surrounding the charges?

(b) (i) 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.

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

[3]

(iii) 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.

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

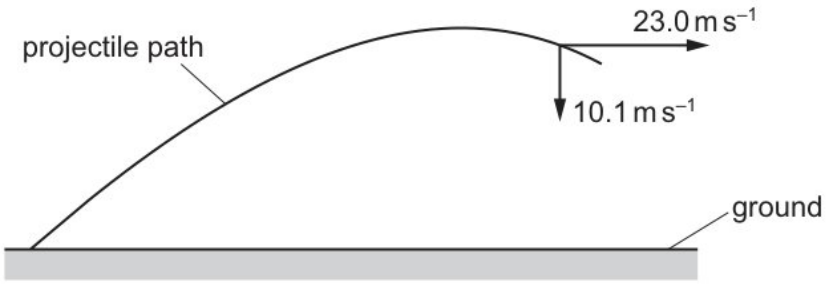
[5]

(ii) 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.

$\mathbf{A}^{2n}$, where n is a positive integer.

[8]

(f) (i)



the equation for this decay.

[8]

(iii) AOB is a uniform lamina in the shape of a quadrant of a circle with centre O and radius 0.6 m (see diagram).

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).

resistance motion, While = ... zr **[6]**

(ii) Show that the cartesian equation of C is

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

both = ... jf **[3]**

(a) (v)

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

the eigenvalues and corresponding eigenvectors of the matrix $\mathbf{A} = \begin{pmatrix} 4 & -1 & 1 \\ -1 & 0 & -3 \\ 1 & -3 & 0 \end{pmatrix}$.

[3]

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

Member	A	B	C	D	E	F	G	H
x	24.2	23.8	22.8	25.1	24.5	24.0	23.8	22.8
y	23.9	23.6	22.8	24.5	24.2	23.5	23.6	22.7

[4]

(i) moment of a force.

the value of α.

[2]

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

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

(c) (i) Use the trapezium rule with three intervals to estimate the value of

the Young modulus.

average = ... gv **[6]**

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

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

Find the arc length of C between the point where $\theta = 0$ and the point where $\theta = \frac{1}{3}\pi$.

[12]

(a) (vi) function f is defined by $\mathrm{f} : x \mapsto \frac{x+3}{2x-1}, x \in \mathbb{R}, x \neq \frac{1}{2}$.

believes = ... *or* **[4]**

(iii) 800 nm to 1000μ m

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

point = ... *rd* **[8]**

(i) The waves must be polarised.

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

[10]

(b) (i) State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

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.

Find the position vector of D.

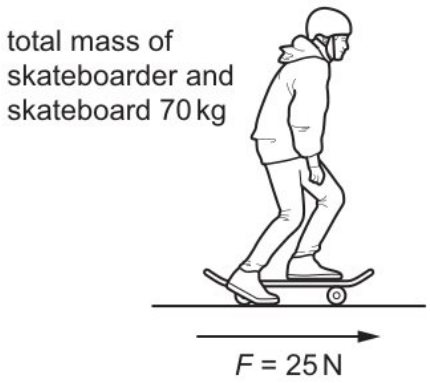
[5]

(v) is the current in the load resistor?

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

find between = ... sx **[1]**

(iv)



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

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

[3]

(ii) anywhere between point R and point S

curve C has polar equation $r = a(1 + \sin\theta)$ for $-\pi < \theta \leqslant \pi$, where a is a positive constant.

by mathematical induction that, for all positive integers n,

[5]

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

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

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

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

[5]

(vii) Find the cartesian equation of Π_2.

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

[10]

(d) (iv) variables x and y satisfy the differential equation

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

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

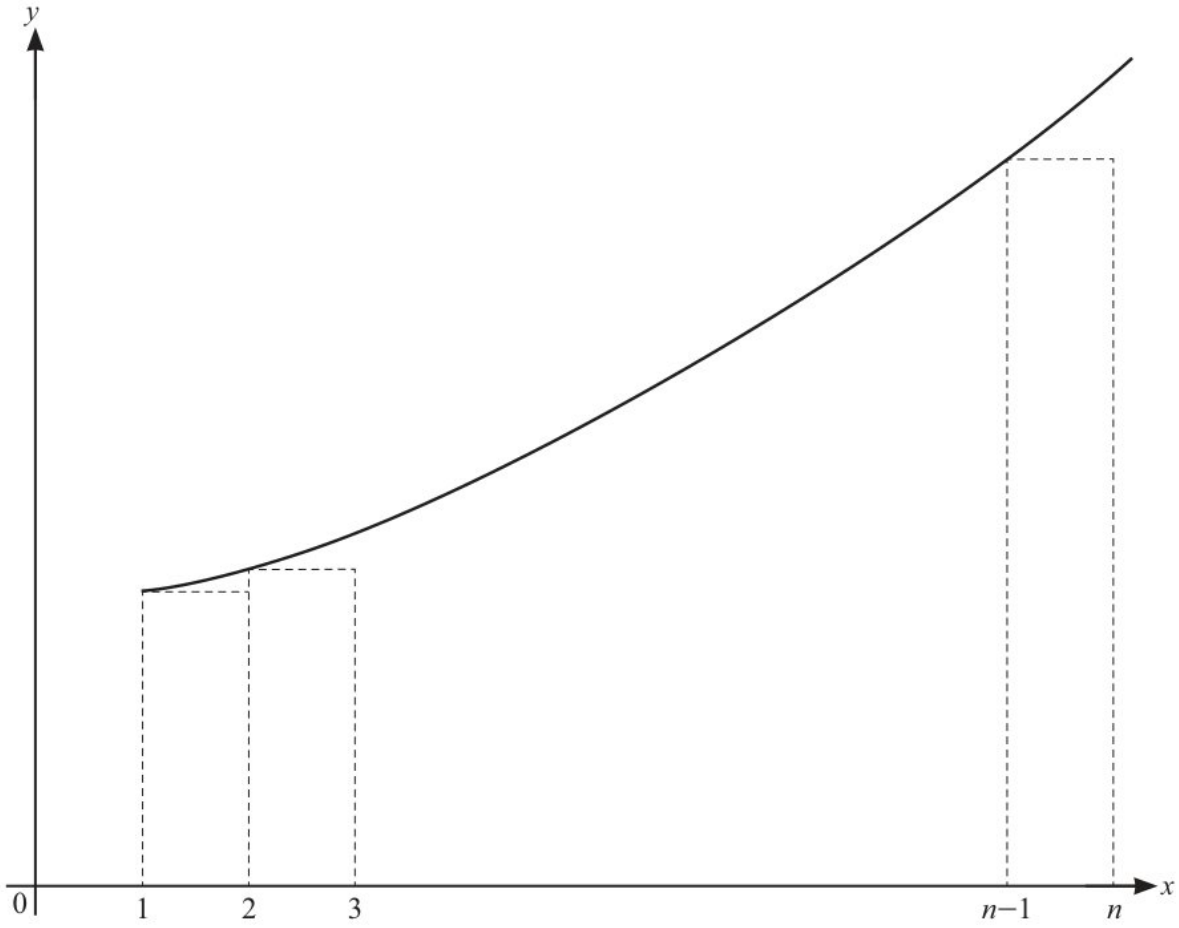
[8]

(ii) that the forces are in equilibrium, find the values of θ and X.

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.

ages = ... *zc* **[2]**

(a) (iii)



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

least = ... *gs* **[8]**

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

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.

equal horizontal = ... *ep* **[12]**

13 small ball B is projected from a point O which is h m above a horizontal plane. At time 2 s after projection B has speed 18 m s^{-1} and is moving in the direction 30° above the horizontal.

(b) (ii) Given instead that $\mu = 0$ and that the tension in the string is 0.48 N , calculate

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

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

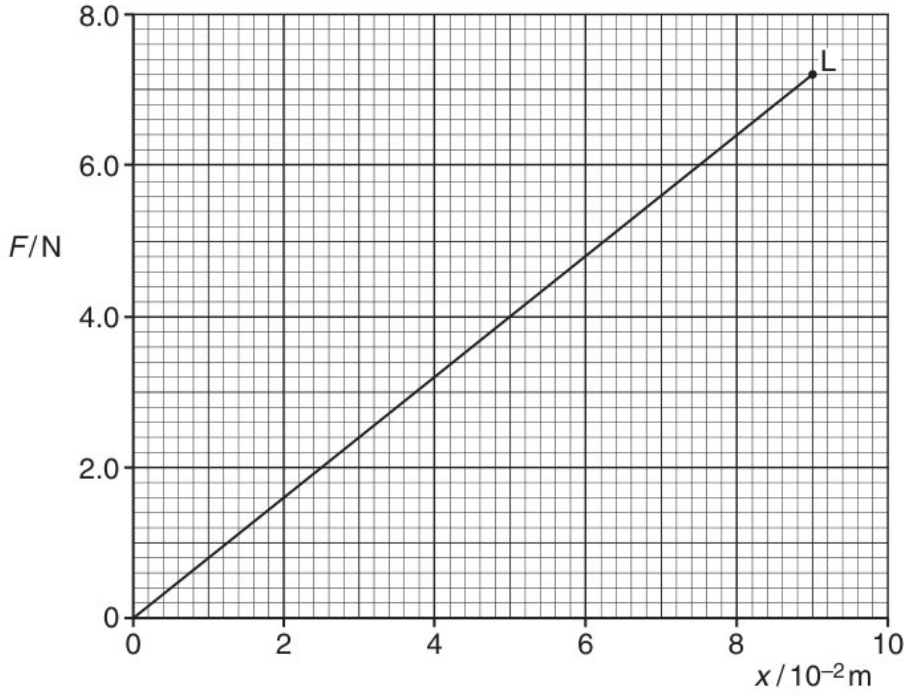
[3]

(iv) mass of cherries sold per day in a supermarket is normally distributed with mean 72.4 kg and standard deviation σkg. It is known that on 10% of days less than 59.1 kg of cherries are sold.

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

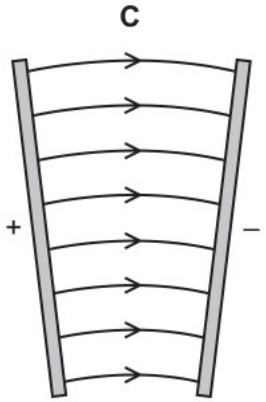
[5]

(iii) all solutions in the interval $0° \leqslant \theta \leqslant 180°$.



[3]

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



[5]

(vi) displacement = velocity × time

line l_3 has equation $\mathbf{r} = \mathbf{i} + 10\mathbf{j} + 3\mathbf{k} + v(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$. Find the shortest distance between l_1 and l_3.

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

[4]

(a) (i) Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

p and q are given real numbers, then

that = ... vx **[5]**

(iii) the particular solution of the differential equation

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

marble is chosen at random from bag A and placed in bag B.

[8]

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

the experimental observations that show radioactive decay is

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

[4]

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

that, at the point $A(-1, 1)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -4$.

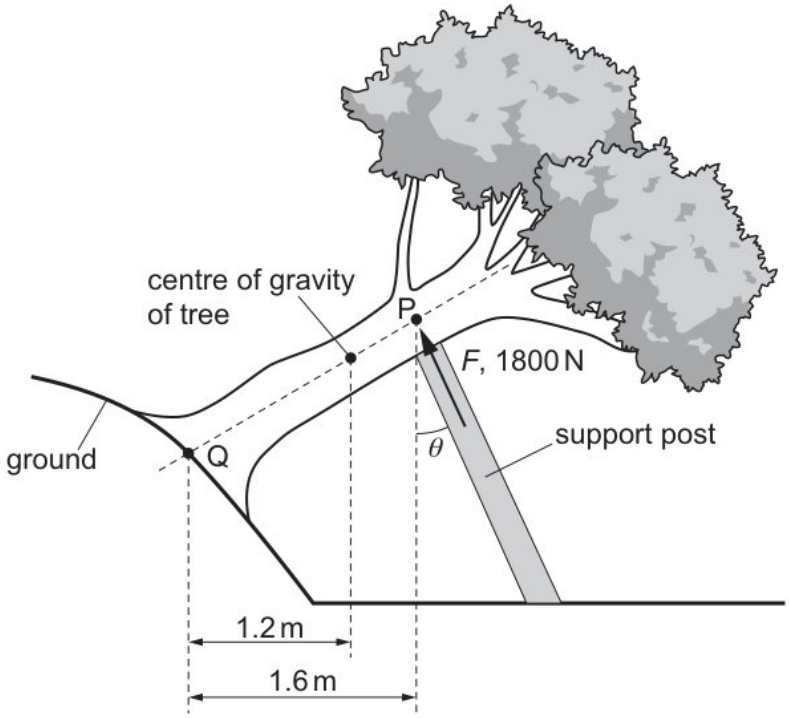
solid cubes, A and B, are measured to determine the density of their materials.

[4]

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

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

(e) (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.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(\mathrm{e}^x \sin x\right) = 2^{\frac{1}{2}n}\mathrm{e}^x \sin\left(x + \frac{1}{4}n\pi\right)$$

[1]

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

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.

The weight of the plank is causing a clockwise moment.

[3]

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

$\frac{1}{(2r+1)(2r+3)}$ in partial fractions and hence use the method of differences to find

numbered = ... *as* **[4]**

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

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

[5]

(i) position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A}^{-1} = \mathbf{PDP}^{-1}$.

[8]

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

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

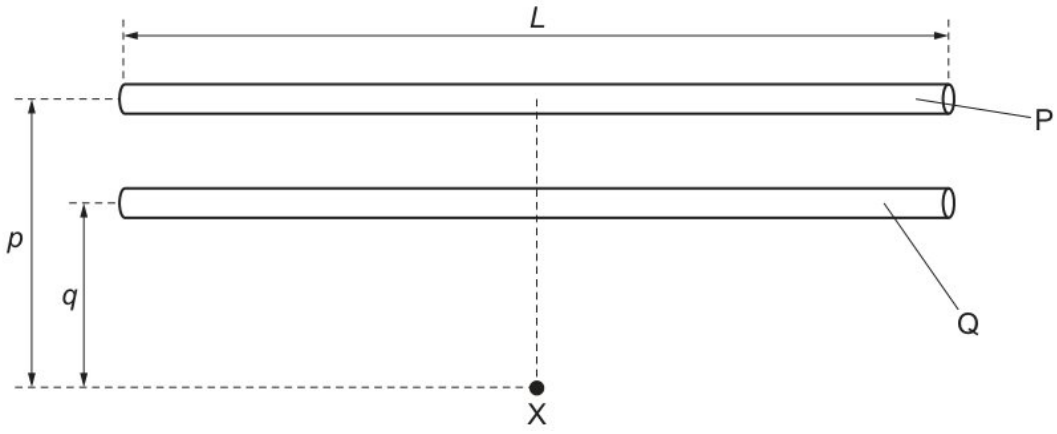
[8]

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

diagram, showing these three forces to scale, is correct?

divided = ... ij **[10]**

(ii)



curve C has equation

Show that the equation

determine = ... lq **[12]**

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

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

[6]

15 uniform spheres A and B, of equal radius, are at rest on a smooth horizontal table. Sphere A has mass $3m$ and sphere B has mass m. Sphere A is projected directly towards B, with speed u. The coefficient of restitution between the spheres is 0.6 . Find the speeds of A and B after they collide.

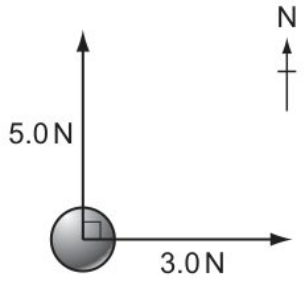
(d) (ii) in either order the value of μ and the value of σ

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

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

[4]

(iv) Find the cartesian equation of Π_1.



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

[4]

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

resistors, each of resistance R, are connected as shown.

[6]

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

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

wires are extended with the same strain and obey Hooke's law.

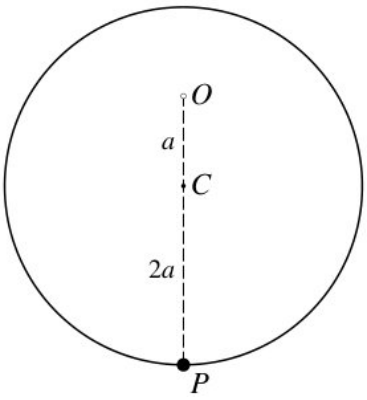
[8]

(a) (i) a diagram, on page 3, showing the arrangement of your equipment. In your account

stationary firework explodes into three pieces. The masses and the velocities of the three pieces immediately after the explosion are shown.

[4]

(iv)

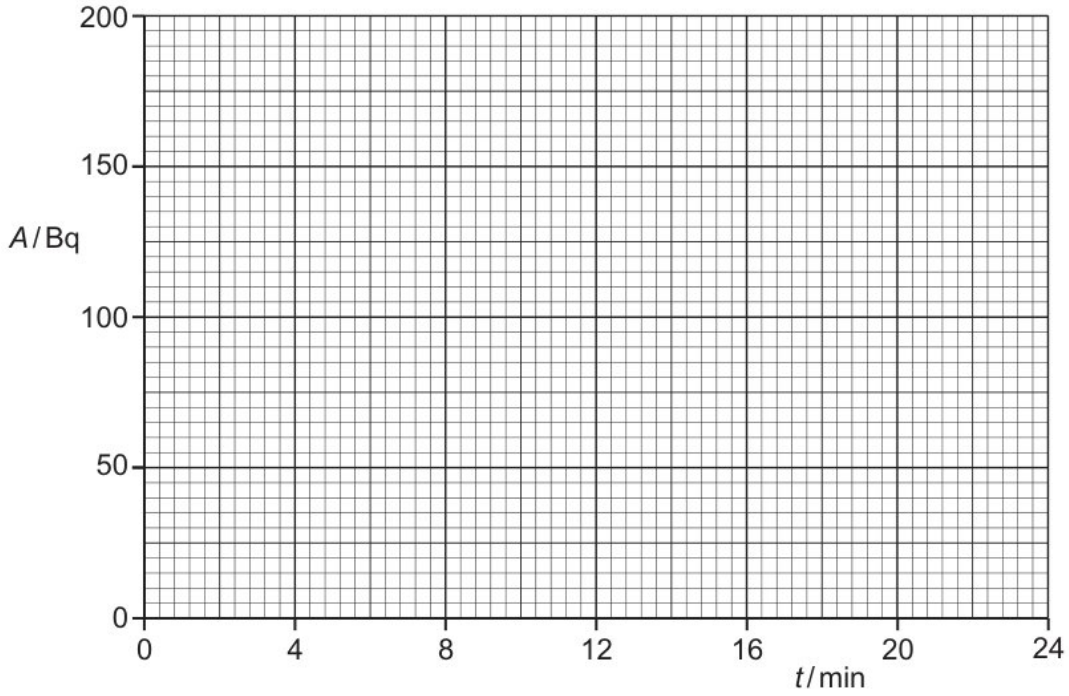


electromagnetic wave phenomenon is needed to explain the spectrum produced when white light falls on a diffraction grating?

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.

circuits = ... *ln* **[6]**

(iii)



current-carrying coil produces a magnetic field.

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

[5]

(ii) that $\tan 2a = -4a$

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

[6]

14 Find the constant speed that the tractor could maintain on the hill when working at this power.

(iii) (c) 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.

1 and 2 only

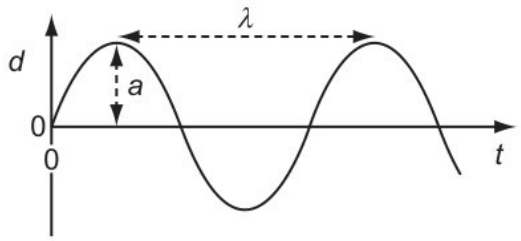
[8]

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

$$I_n + n(n-1)I_{n-2} = n\left(\frac{1}{2}\pi\right)^{n-1}$$

[5]

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



[12]

(a) 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.

are selected from these 20 to perform at a concert.

[8]

(i) (c) the value of $\left(\alpha^3-1\right)^2+\left(\beta^3-1\right)^2+\left(\gamma^3-1\right)^2$

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.

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

[4]

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

transmitted light has intensity $0.75I$.

the exact area of one loop of the curve.

[6]

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

what is meant by the de Broglie wavelength.

projection = ... tr **[10]**

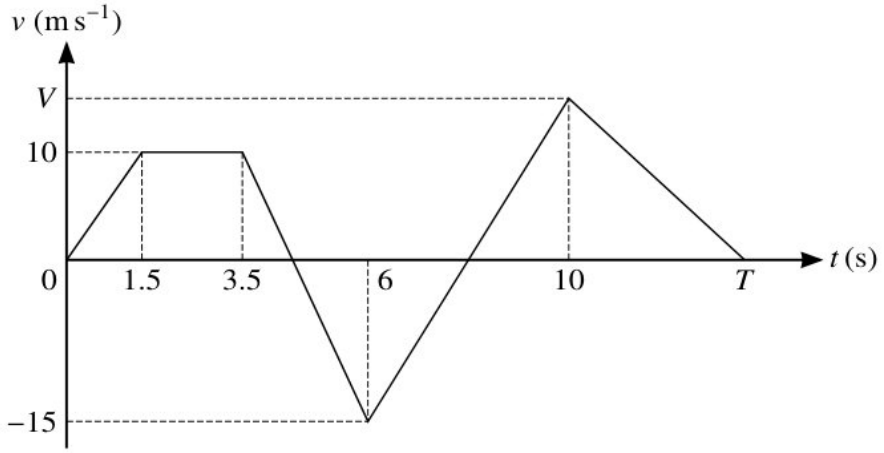
(ii) (b) of these springs is placed in each corner of a horizontal square plate. The axis of each spring is in a vertical direction. These four springs support a total load of 160 N .

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.

only one of the following two alternatives.

curve = ... nr **[8]**

(c)



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

[5]

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

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

[6]

10 diagram shows the electric field between the plates?

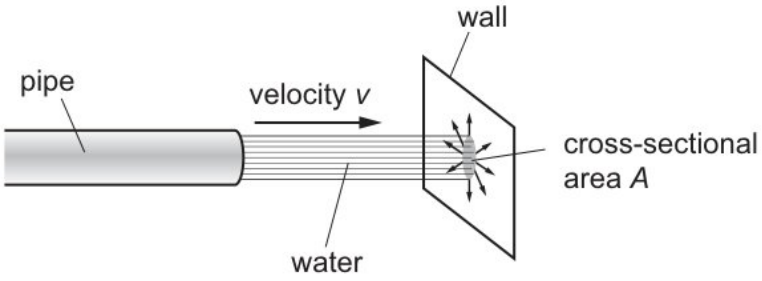
(d) (iii) metal electrical conductor has a resistance of 5.6kΩ. A potential difference (p.d.) of 9.0 V is applied across its ends.

diagram shows a water wave in a shallow tank. The wave is diffracted through a gap in a barrier and spreads. The wavelength of the wave is much smaller than the width of the gap.

parallel = ... *pr* **[8]**

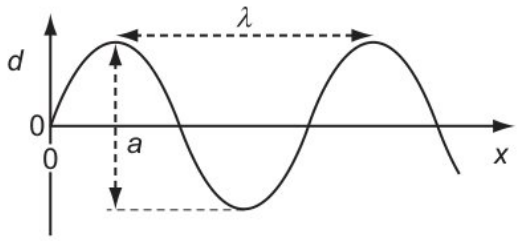
(i) fixed hollow sphere with centre O has a smooth inner surface of radius a. A particle P of mass m is projected horizontally with speed $2\sqrt{(ag)}$ from the lowest point of the inner surface of the sphere. The particle loses contact with the inner surface of the sphere when OP makes an angle θ with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

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



circles = ... rt **[5]**

(iv) frequency of the signal is 50 kHz .



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

[5]

(ii) the principle of superposition.

524 526 520 523 530

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

[12]

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

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

supermarket = ... rm **[6]**

(i) statement about sound waves in air at constant temperature is correct?

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

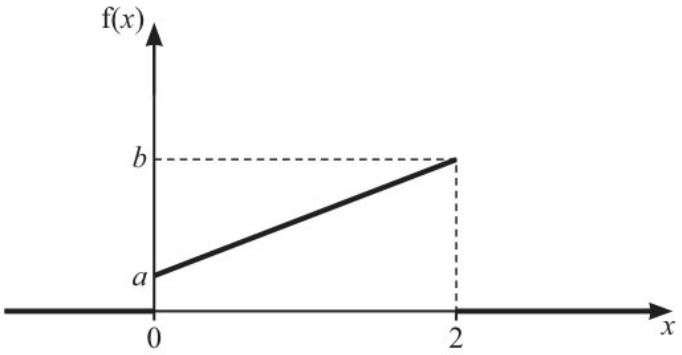
[8]

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

only one of the following two alternatives.

[6]

(b) (ii)



astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

[3]

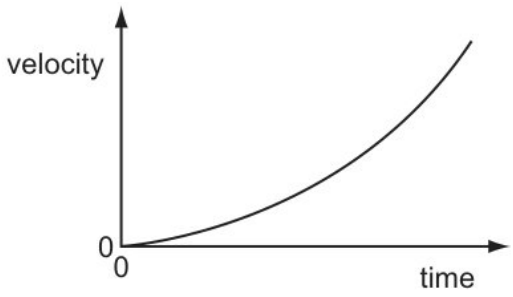
(i) and N are two electromagnetic waves.

is the total resistance between the two ends of the coil?

State = ... fl **[4]**

17 Draw a sketch of C for the case $0 < \lambda < 1$.

(c)(vii)



amplitude $\propto$ intensity

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

these = ... kl **[2]**

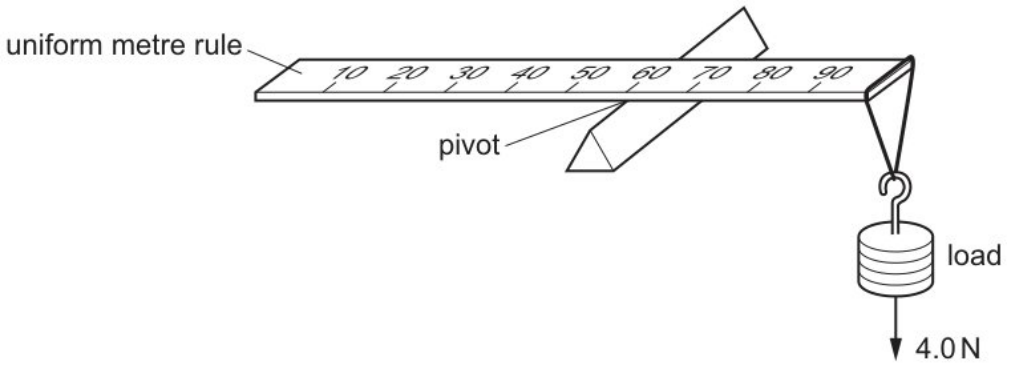
(ii) is the value of R ?

waves are emitted from two sources.

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

[10]

(b) (ii)



combined resistance is 66kΩ.

values taken from = ... *me* **[6]**

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

Explain, with reference to the diagram, why the trapezium rule may be expected to give a good approximation to the true value of the integral in this case.

Show that the cartesian equation of C is

[12]

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

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

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

[8]

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

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

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.

resisting with = ... rw **[3]**

(iv) between gravitational potential energy and electric potential energy.

[6]

(e) Different isotopic nuclei have different proton numbers.

the process by which α-particles lose energy when they pass through air.

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

Carry out the test.

[10]

(iv) 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.

[6]

(i) is the current in the load resistor?

curves C_1 and C_2 have polar equations

no unique solution.

[1]

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

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

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

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

Find time = ... gl **[8]**

(ii) lines l_1 and l_2 have equations

drug = ... bi **[6]**

(a) a vector equation for l.

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

[4]

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

smooth = ... *yr* **[12]**

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

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

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.

book = ... *pl* **[12]**

(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.

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

[4]

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

time T, the particle strikes a smooth horizontal plane at a point which is a horizontal distance D from O and a vertical distance H below O.

[12]

(ii) Using the concept of work done on the car, show that the kinetic energy E_K of the car is given by the equation

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

Calculate the distance of the centre of mass of the lamina from A.

season. = ... zf **[5]**

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

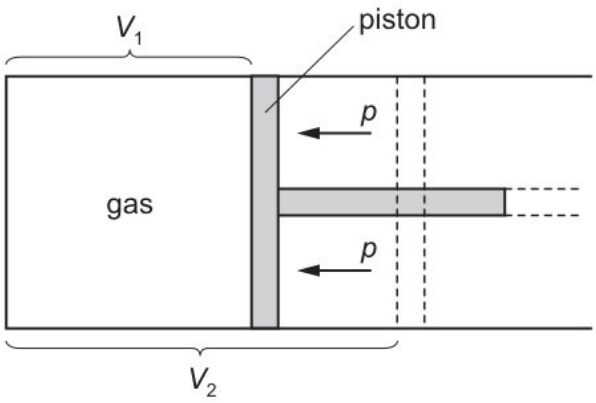
Explain the features of the graphs in (d) that show the characteristics of ductile and brittle materials.

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

Density is mass per cubic metre.

(b) (ii) 400 nm to 700 nm

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



[5]

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

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

[12]

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

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

bulb = ... *wa* **[3]**

(v) Find, showing all necessary working, the equation of the regression line of y on x.

Calculate the greatest deceleration of P.

[5]

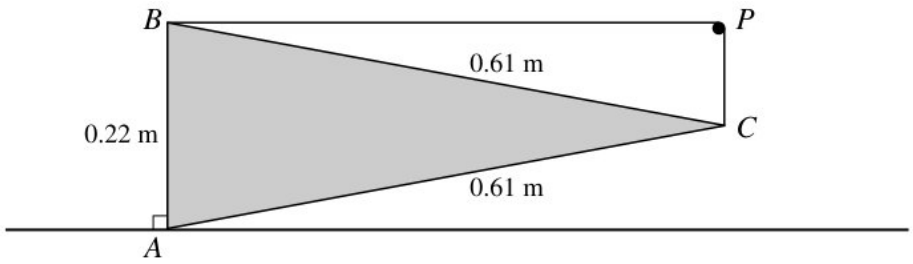
(a) (i) Find angle ABC.

child of weight 600 N stands in different positions on the plank.

[5]

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

the distribution function of X.



[6]

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

Show that x satisfies the equation

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

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

[5]

(ii) 38% of these leaves are of length k cm or more.

Explain = ... fb **[6]**

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

with = ... mj **[3]**

(e) curve C has equation

only one of the following two alternatives.

(iv) only one of the following two alternatives.

number = ... gx **[12]**

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

magnitude = ... jo **[5]**

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

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

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

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

point = ... yv **[5]**

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

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

[3]

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

[10]

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

[12]

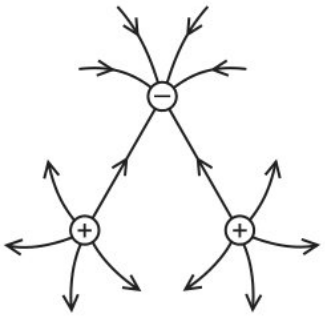
10 a diagram, on page 3, showing the arrangement of your equipment. In your account

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

curves C_1 and C_2 have polar equations

[8]

(iv)



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

[8]

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

is the useful power output of the power station?

38.1 = ... *ey* **[5]**

(ii) 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

Calculate the distance of the centre of mass of the lamina from A.

an approximate 95% confidence interval for the proportion of students who think that the sports facilities are good.

hotel = ... *bm* **[10]**

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

525 520 522 524 518 520 519 525 527 516

emails, 11.5 that, = ... *iw* **[5]**

(ii)

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Number of nights	4	9	18	26	20	16	7	0

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

Show that $v\frac{\mathrm{d}v}{\mathrm{d}x} = 5 - 0.5v^2$.

battery four = ... *ow* **[5]**

21 Calculate the speed of projection of P.

(a) (i) 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.

Prove that, for $n \geqslant 2$,

rule = ... *ms* **[5]**

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

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \mathbf{a} + t\mathbf{b}$$

[6]

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

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

[3]

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

$$\mathbf{A} = \begin{pmatrix} 6 & -8 & 7 \\ 7 & -9 & 7 \\ 6 & -6 & 5 \end{pmatrix}$$

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.

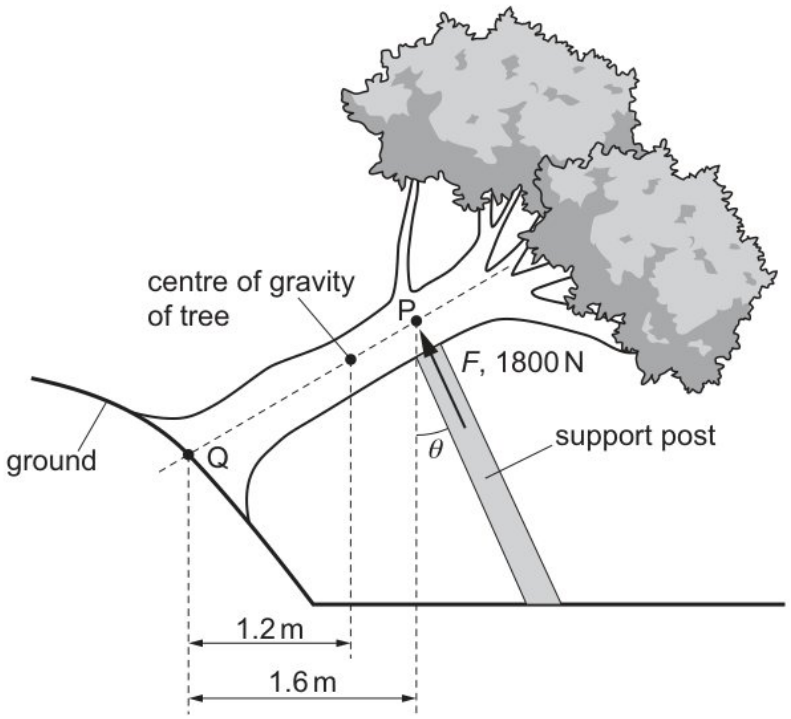
[6]

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

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

surface = ... hs **[8]**

(ii)



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

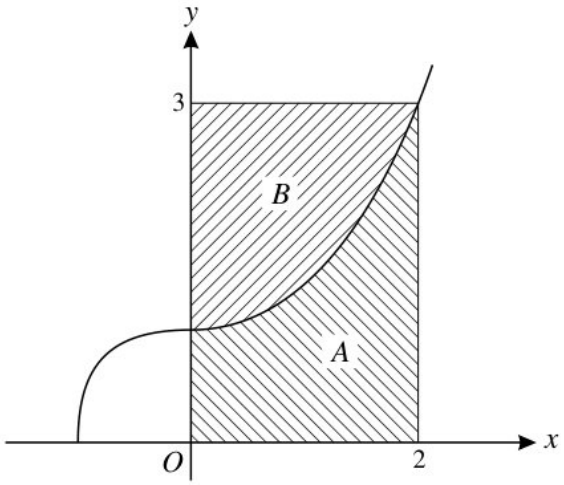
[8]

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

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.

along = ... mn **[5]**

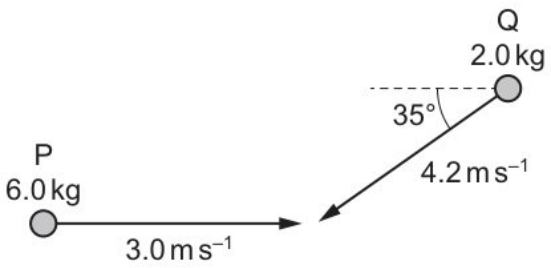
(ix)



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 .

[10]

(c) (i)



- decelerating at a constant rate with the parachute open,

[6]

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

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

Wavelength is proportional to amplitude.

[4]

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

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

continuous random variable X has probability density function f given by

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?

[12]

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

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

[4]

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

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

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

[10]

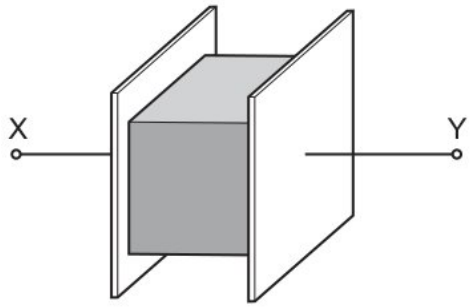
(a) a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A}^{-1} = \mathbf{PDP}^{-1}$.

projectile is thrown at an angle to the ground.

[6]

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

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



[5]

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

Each = ... jy **[4]**

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

(v) Over 50 198 212 217 229 235 242

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

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

[5]

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

Find Σx^2.

State, with a reason, whether the trapezium rule gives an under-estimate or an over-estimate of the true value of the integral in part (ii).

mark = ... *ja* **[8]**

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

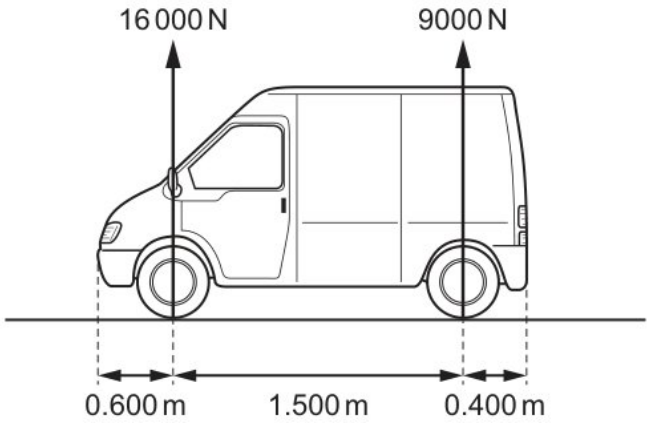
with = ... *mo* **[3]**

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

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

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

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



[4]

(ii) is the speed of the projectile at this time?

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

plane string = ... ly **[10]**

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

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.

with Explain = ... lz **[5]**

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

the probability density function of Y,

[6]

(i) why Kieran is incorrect.

is the magnitude of F when the child stands at X and when the child stands at Y ?

ground = ... mp **[8]**

11 nucleus of sodium- 21, $^{21}_{11}\text{Na}$, decays to form a new nucleus containing 10 protons and 11 neutrons.

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

beyond point S but before point T

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.

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

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

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

randomly = ... ix **[8]**

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

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

the eigenvalues and corresponding eigenvectors of the matrix $\mathbf{A} = \begin{pmatrix} 4 & -1 & 1 \\ -1 & 0 & -3 \\ 1 & -3 & 0 \end{pmatrix}$.

attention = ... nq **[10]**

(i) random variable T has probability density function given by

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

[2]

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

the value of θ.

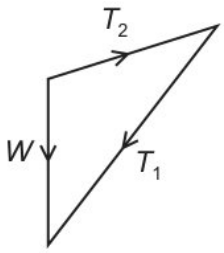
[6]

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

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

[6]

(ii)



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

Draw up the probability distribution table for X.

radians = ... cl **[3]**

(i) a different investigation, Nikki uses another large random sample to calculate a 99% confidence interval and an x% confidence interval.

is the speed of the projectile at this time?

[3]

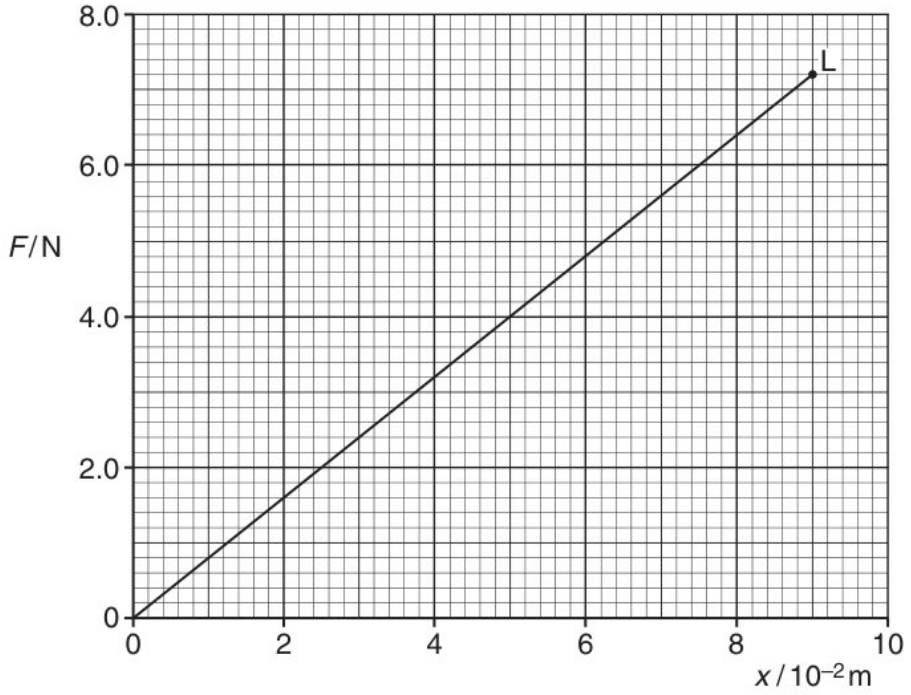
(a) (ii) Determine the decay constant, in min^{-1}, of the radioactive isotope.

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

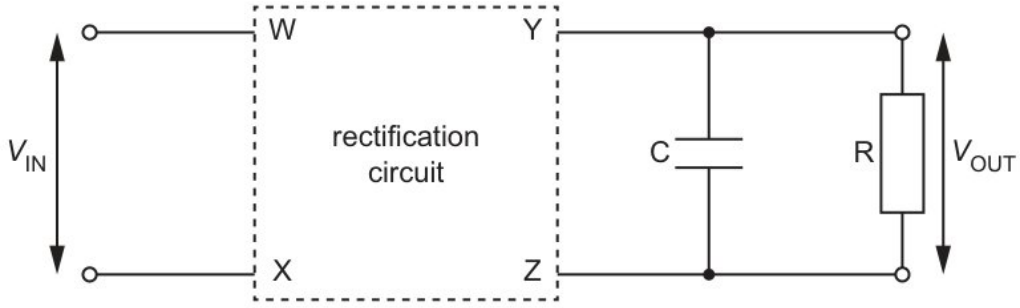
Find the tension in the string in terms of W.

[8]

(v)



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



from = ... *qp* **[4]**

17 that $\tan 2a = -4a$

(b) (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.

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

[8]

(ii) the coordinates of any stationary points on C.

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

[8]

(c) (iii) expression gives the electrical resistance of the metal cube between X and Y ?

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

[4]

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

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

made chosen chosen chosen = ... ta **[4]**

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

is the total elastic potential energy stored in the four springs?

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

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

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

is given that $k = 0.025$ and that $U = 20$

[6]

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

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

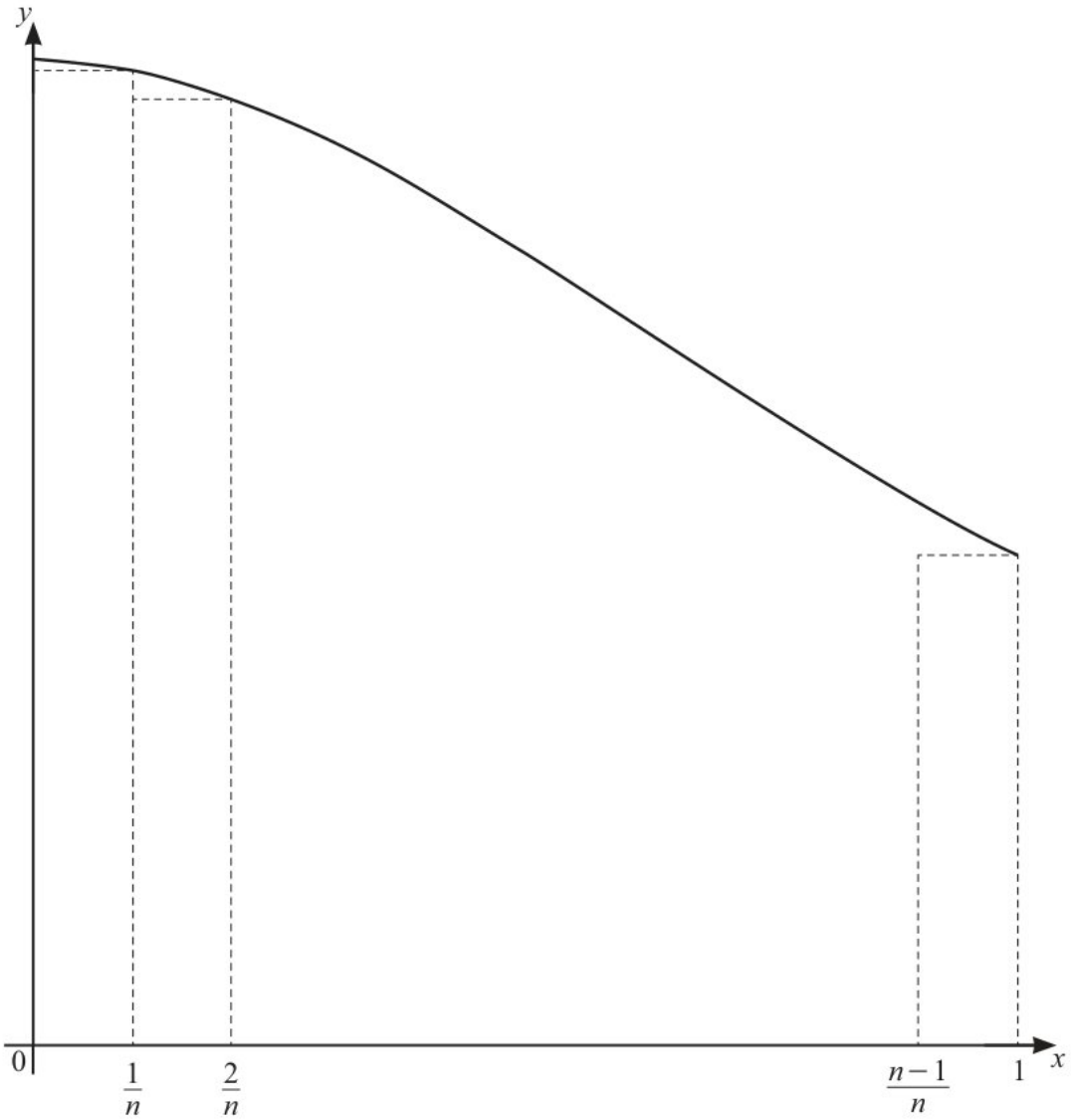
metre = ... xx **[5]**

(iii) object hangs by means of two cords around two rods, as shown.

$$\theta \cos\theta + \left(\frac{1}{8}\theta + 1\right)\sin\theta = 0$$

[20]

(iv)



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

speed = ... *li* **[8]**

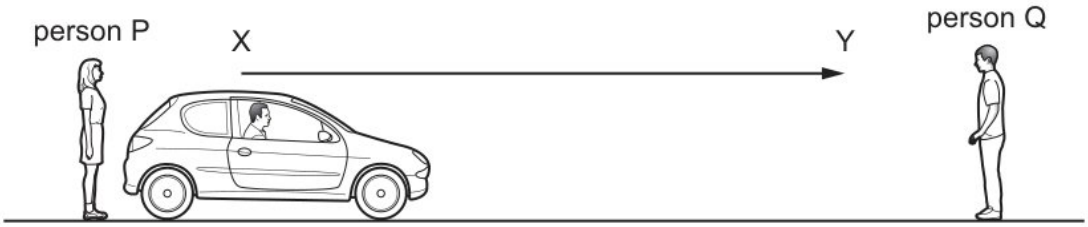
(a) (iii) Show that, at the points (other than the pole) at which a tangent to C is parallel to the initial line,

gravitational potential at a point.

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

[5]

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



[10]

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

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

[10]

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

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

control of variables,

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

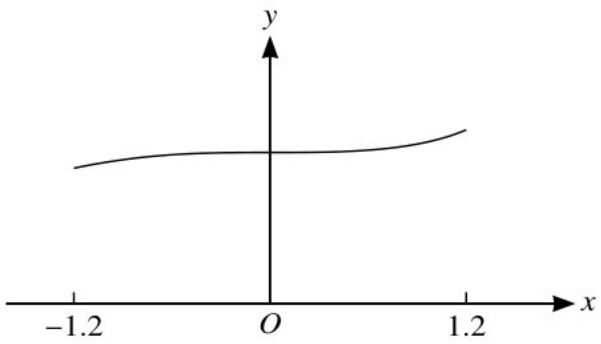
(d) (ii) diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

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.

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

[20]

(v)

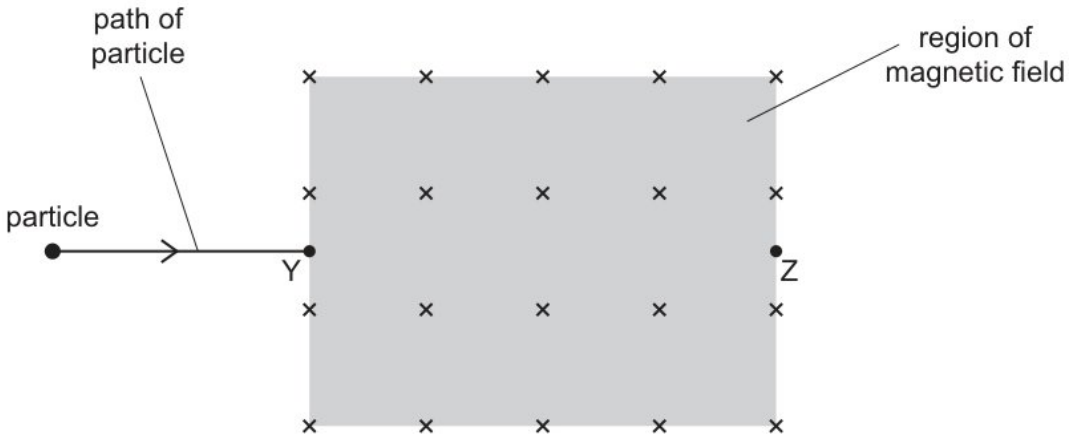


of wavelength 567 nm is incident normally on a diffraction grating. The grating has 400 linesper mm. A number of diffraction maxima are observed on the far side of the grating.

a back-to-back stem-and-leaf diagram to represent this information, with Gulls on the left-hand side.

[15]

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



[8]

(ii) Hence find the solutions of the equation

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

[3]

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

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

State the name of this type of reaction.

[8]

(iii) 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} .

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

the position vector of D.

[6]

(ii) what is meant by work done.

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 $3 : 4$.

positioned = ... *aa* **[10]**

19 much energy is stored in the compressed column?

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

the number of bags for which you would expect the mass of pasta to be more than 1.65 standard deviations above the mean.

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

[3]

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

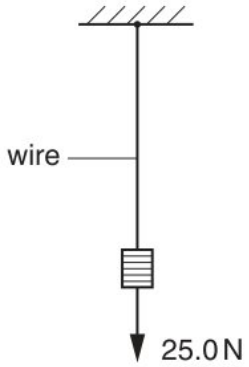
Patient	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*
Before	183	165	172	165	143	176	161	153
After	164	148	164	149	134	153	155	148

the length of C.

[5]

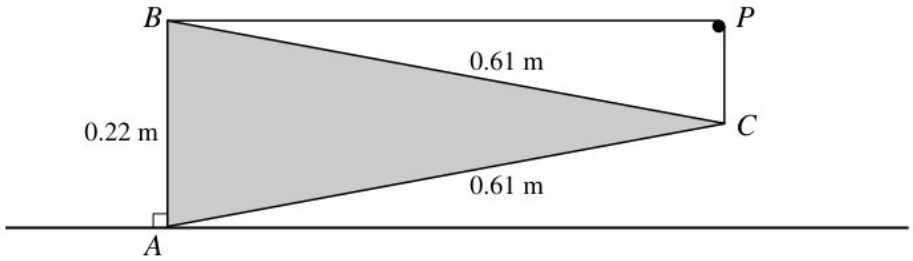
(ii) activity of a radioactive sample.

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



[10]

(b) (ii)



to the value α.

[4]

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

tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

[4]

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

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

[6]

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

(ii) the general solution of the differential equation

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

lowest hangs = ... *bk* **[5]**

(iv) 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.

aeroplane is flying at a constant speed.

$$\alpha + \beta + \gamma = -6, \quad \alpha^2 + \beta^2 + \gamma^2 = 38, \quad \alpha\beta\gamma = 30$$

[5]

(b) the gradient of the curve

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 $0 < \theta < 2\pi$.

(iv) variables x and y satisfy the differential equation

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

[6]

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

[20]

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

[10]

(c) the probability density function of Y,

(i) function f is defined by $\mathrm{f} : x \mapsto \frac{x+3}{2x-1}, x \in \mathbb{R}, x \neq \frac{1}{2}$.

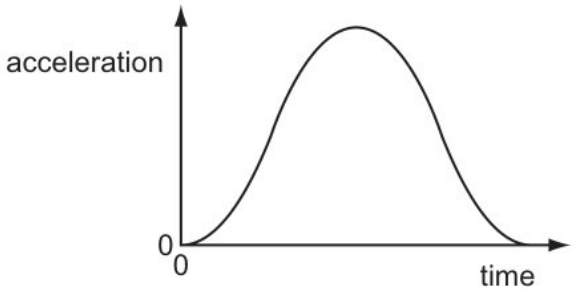
$^{-1}$ = ...aw **[8]**

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

[8]

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

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 .



[6]

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

de Moivre's theorem to prove that

striking the horizontal plane, P rebounds with speed w. The coefficient of restitution between P and the plane is $\frac{2}{3}$.

(ii) particle starts from a point O and moves in a straight line. The velocity of the particle at time t s after leaving O is v m s^{-1}, where

[6]

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

	F_1/N	F_2/N
A	4.0	6.0
B	6.0	4.0
C	6.0	8.0
D	8.0	6.0

[3]

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

[8]

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

plank rests on fixed supports at its ends X and Y.

(iii) curve C has equation

[4]

(i) 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 $\lambda\mu$.

8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, \mathrm{d}x$ for $n > 0$.

acting = ... bv **[5]**

(ii) velocity = acceleration × time

[8]

(a) diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

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

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

[10]

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

[5]

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

Without using a calculator, find the exact values of

is the reading on the ammeter?

(v) 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.

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 6\frac{\mathrm{d}x}{\mathrm{d}t} + 9x = 18t^2 + 6t + 1$$

[5]

(iii) 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]

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

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

contains resistance. = ... wk **[6]**

(iii) 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.

[6]

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

[10]

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

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

release. rest = ... ev **[12]**

(v) 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.

will = ... rn **[6]**

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

(b) (iv) the acute angle between the directions of l_1 and l_2.

curve C has equation

blank = ... kq **[8]**

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

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

[12]

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

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

moving = ... ci **[6]**

(i) 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 .

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

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.

about = ... *bl* **[5]**

(d) (vi)

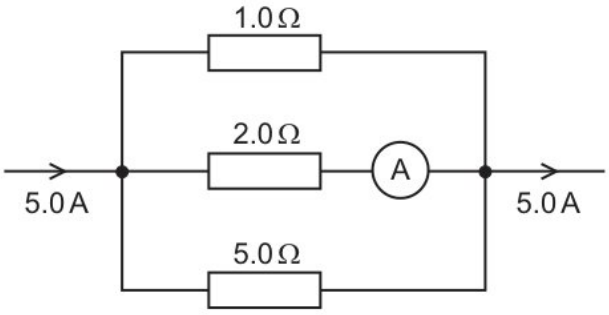


diagram shows the electric field between the plates?

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

[10]

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

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

particle = ... *ub* **[8]**

(iii) 1 and 2 only

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		

service = ... wc **[6]**

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

Find the values of p and q such that

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

[8]

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

astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

[5]

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

(e) (iii) Find the perpendicular distance of the point A from the line BC.

λ is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

with = ... wo **[4]**

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

the number of bags for which you would expect the mass of pasta to be more than 1.65 standard deviations above the mean.

reaches = ... nm **[15]**

(i) 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.

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

[8]

(iv) the Young modulus.

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

[6]

(b) (iii) numbers of barrels of oil, in millions, extracted per day in two oil fields A and B are modelled by the independent random variables X and Y respectively, where $X \sim \text{N}\left(3.2, 0.4^2\right)$ and $Y \sim \text{N}\left(4.3, 0.6^2\right)$. The income generated by the oil from the two fields is \$90 per barrel for A and \$95 per barrel for B.

is the minimum constant acceleration necessary for the aircraft?

Hence factorise $\text{p}(x)$ completely.

[6]

(iv) 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 $t = 2$.

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

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.

[6]

(ii) 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.

statement about light waves and sound waves is correct?

[12]

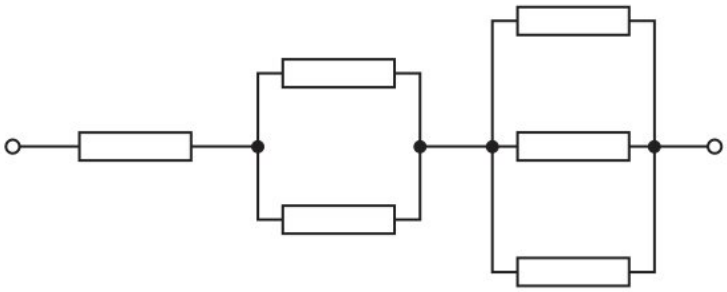
(a) (iii) cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

mass of cherries sold per day in a supermarket is normally distributed with mean 72.4 kg and standard deviation σkg. It is known that on 10% of days less than 59.1 kg of cherries are sold.

[5]

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

ripple tank is used to demonstrate interference between water waves.



decimal = ... qr **[6]**

(iv) 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.

$$\overset{14}{\underset{\cdots\cdots}{\cdots\cdots}}X \to \overset{\cdots\cdots\cdots}{\underset{\cdots\cdots}{\cdots\cdots}}Z + \ldots\ldots\cdots .$$

[2]

14 the rank of $\mathbf{M}$ and a basis for the range space of T ,

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

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

[2]

(iii) the average power of the aeroplane's engines.

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

selected sample = ... mm **[5]**

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

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

[12]

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

curve C has equation

[4]

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

[15]

(iii) de Moivre's theorem to show that

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

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

modulus = ... tr **[4]**

(vi) the value of the constant k,

State one other feature of this orbit.

the expected value and variance of Y.

[4]

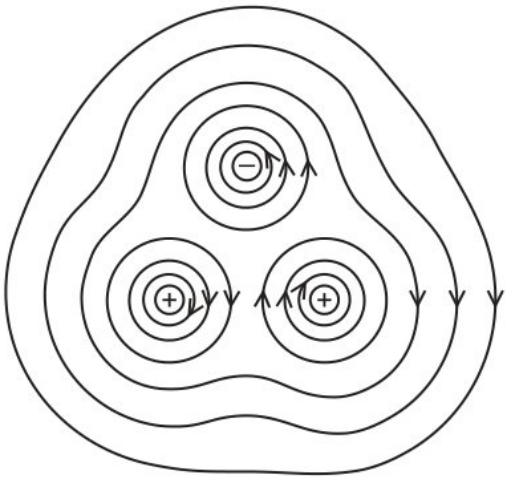
(b) (ii) no unique solution.

control of variables,

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

[8]

(iii) is the grand-daughter product?



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

[6]

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

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

(c) (v) small ball B is projected from a point O which is h m above a horizontal plane. At time 2 s after projection B has speed 18 m s^{-1} and is moving in the direction 30° above the horizontal.

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

is given that a is a positive constant such that

[6]

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

$$5\cos\theta - 3\sin\theta = 4$$

many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

[10]

(a) (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

m.f. for $n = 0$.

[6]

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

curves C_1 and C_2 have polar equations

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

[8]

10 an estimate for the mean length of these 250 leaves.

(a) (iii) the ductile material,

diagram, showing these three forces to scale, is correct?

[10]

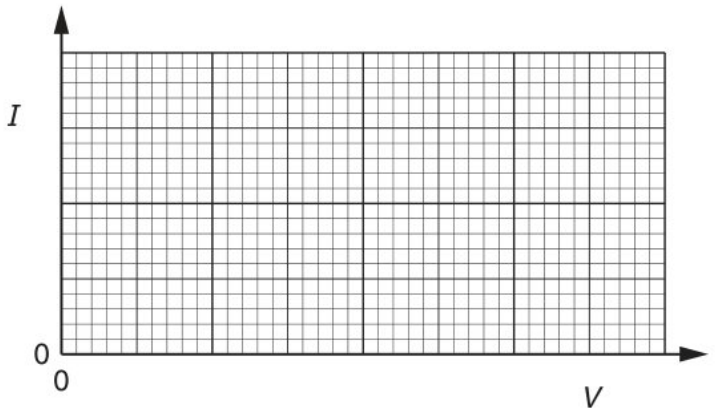
(i) numbers of barrels of oil, in millions, extracted per day in two oil fields A and B are modelled by the independent random variables X and Y respectively, where $X \sim \mathrm{N}\left(3.2, 0.4^2\right)$ and $Y \sim \mathrm{N}\left(4.3, 0.6^2\right)$. The income generated by the oil from the two fields is \$90 per barrel for A and \$95 per barrel for B.

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

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.

[10]

(d) (ii) the term elastic limit.



service = ... *sr* **[2]**

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

Find the equations of the asymptotes of C.

this = ... *ed* **[6]**

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

$$E_{\mathrm{K}} = \frac{1}{2}mv^2.$$

letters = ... zs **[8]**

14 is the minimum constant acceleration necessary for the aircraft?

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

a, b and c are integers to be determined.

[15]

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

Find, in the form $ax^3 + bx^2 + c = 0$, an equation of which α is a root.

[6]

(a) the exact value of a.

random variable T has probability density function given by

[5]

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

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.

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

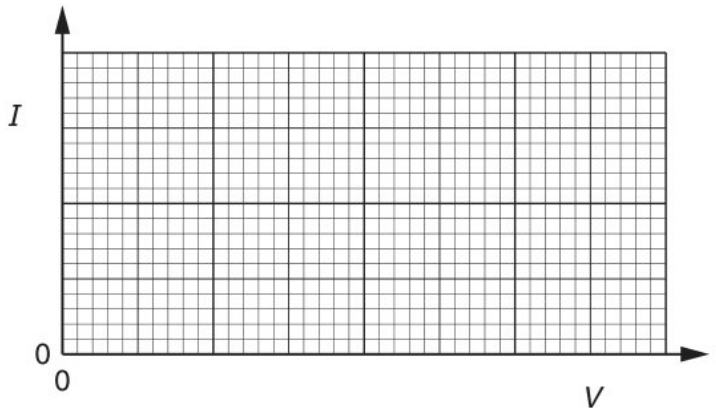
[5]

(d) Calculate the distance of the centre of mass of the lamina from A.

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

[10]

(ii) (c) 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]

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

height of the liquid in the beaker is 0.20 m ± 2%.

[5]

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

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

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

[8]

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

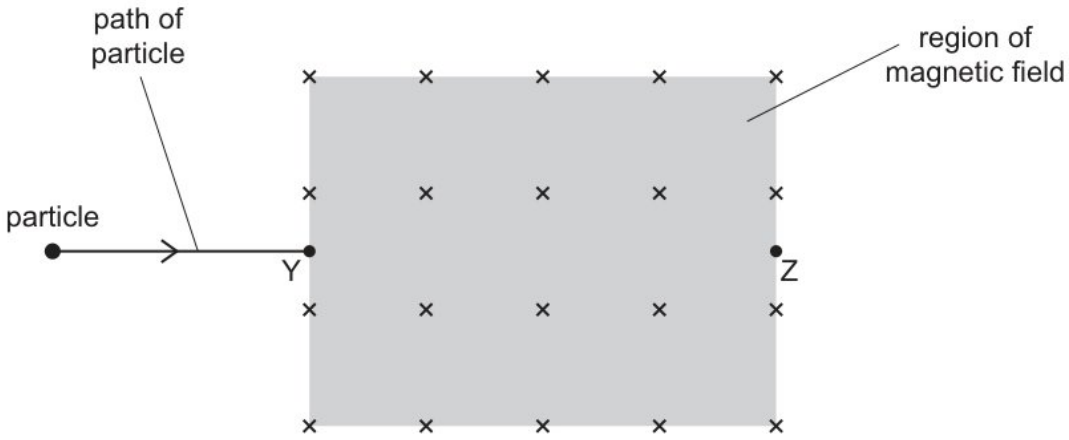
(c) (ii) from the definitions of tanh and sech in terms of exponentials, prove that

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

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

[6]

(v)

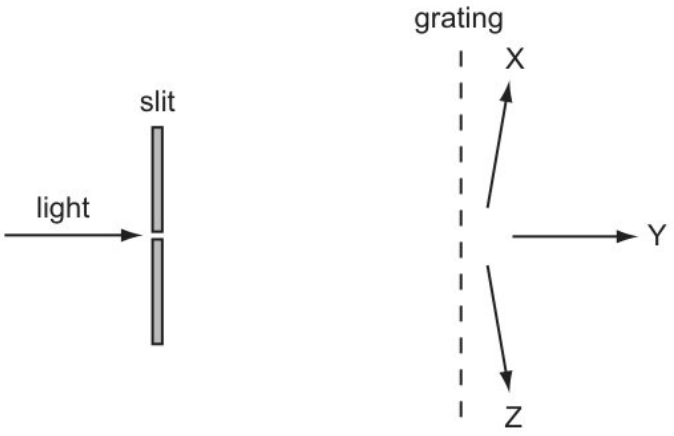


roots of the equation

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.

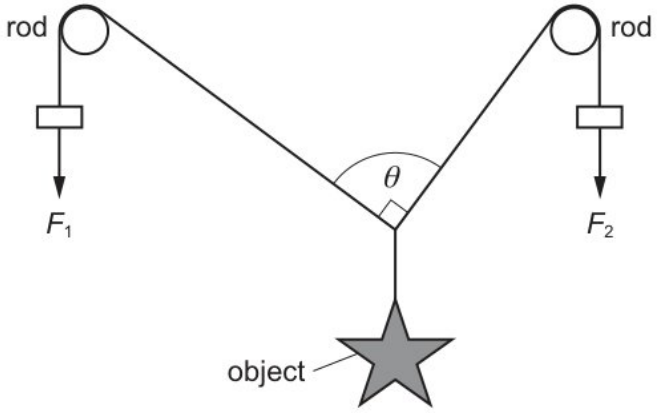
slit, = ... xj **[6]**

(a) (i) 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.



probability randomly = ... *ou* **[3]**

(ii)



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

[6]

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

$5\sin\left(x+\frac{1}{6}\pi\right)-4\cos x$ 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.

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

[6]

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

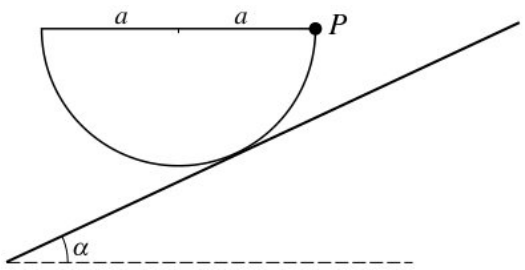
Find the value of $(\alpha+1)(\beta+1)(\gamma+1)$.

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

[4]

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

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



[8]

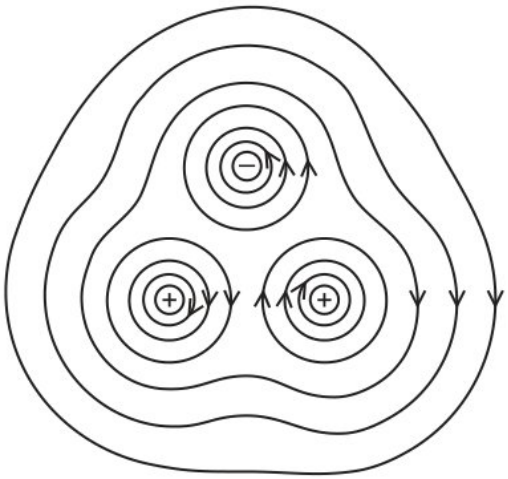
(i) the complex numbers z for which $\frac{z+5\mathrm{i}}{z-5}$ is real and $|z| = \sqrt{17}$ Give your answers in the form $z = x + \mathrm{i}y$ where x and y are real

researcher claims that older people take longer to react to a sudden loud noise than younger people. To investigate this, the researcher randomly selects 6 people over 50 years old and 8 people under 25 years old and records their reaction times, in milliseconds, to a sudden loud noise. The reaction times are as follows.

variable resistor in (a) is now connected as a potential divider, as shown in Fig. 5.3.

[4]

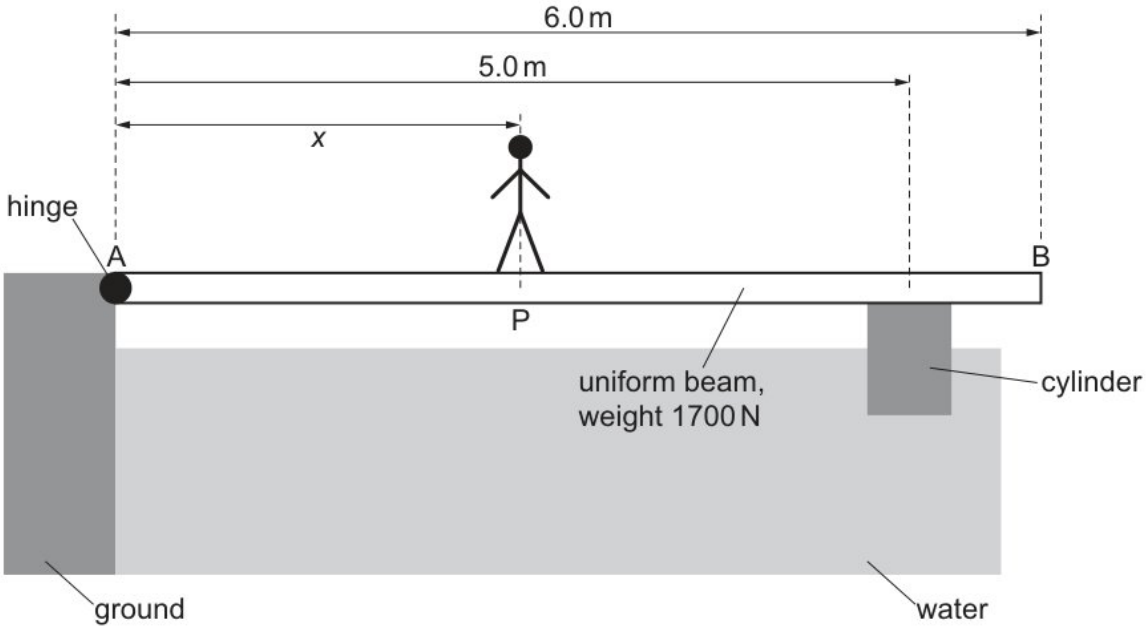
(d) (i)



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

rope. along = ... *xi* **[5]**

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



[10]

(ii) Show that, for $n > 2$,

line l_3 has equation $\mathbf{r} = \mathbf{i} + 10\mathbf{j} + 3\mathbf{k} + v(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$. Find the shortest distance between l_1 and l_3.

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 .

[3]

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

The waves must be polarised.

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 $\frac{1}{n}$.

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

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 $\cos 2\theta = \frac{7}{25}$.

[5]

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

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

is the minimum constant acceleration necessary for the aircraft?

[2]

(v) Prove that, for $n \geqslant 2$,

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

horizontal = ... xi **[5]**

(b) (iii) 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.

car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

numbered = ... *uc* **[6]**

(i) P and Q collide and stick together.

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.

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

[5]

(a) (ii) Find the equations of the asymptotes of C.

marks of the pupils in a Physics examination are summarised as follows.

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

[1]

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

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

bivariate = ... *ne* **[12]**

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

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

[6]

(iv) State, with a reason, whether the trapezium rule gives an under-estimate or an over-estimate of the true value of the integral in part (ii).

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

machine. remains = ... tq **[6]**

(ii)

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

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

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

[6]

15 (b) Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

(ii) P hears a sound of increasing frequency.

the median value of X.

[5]

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

seats. = ... hy **[8]**

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

monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

(i) only one of the following two alternatives.

[20]

(iii) waves are emitted from two sources.

[3]

(vii) diagram shows the curve with equation $y = \frac{1}{\sqrt{x}}\mathrm{e}^{\sqrt{x}}$ for $x \geqslant 1$, together with a set of $n - 1$ rectangles of unit width. of unit width.

from = ... ts **[4]**

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

hence = ... rx **[4]**

21 random variable Z is the sum of the number of red balls and the number of different colours present in Kieran's selection. Kieran claims that the probability generating function of Z is equal to $\mathrm{G}_X(t) \times \mathrm{G}_Y(t)$.

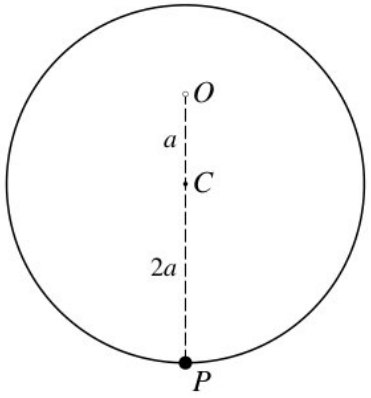
(c) (iii) the value of $\sum y^2$, correct to 1 decimal place.

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.

the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

points = ... ty **[6]**

(ii) much work is done by the gas during this expansion?



velocity = ... kt **[8]**

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

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

the subsequent motion, B does not reach the pulley. When A reaches the ground, it comes to rest.

[4]

(iii) Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

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

[4]

(ii) a positron and an antineutrino

what is meant by the de Broglie wavelength.

[6]

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

a vector equation for the line l_1.

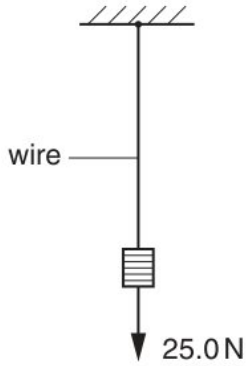
variable = ... gf **[3]**

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

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.

length = ... mz **[4]**

(i) is the angle θ ?



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

[15]

(iv) skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

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

[8]

10 Young modulus E can be determined from measurements made when a wire is stretched.

matrix **A** is given by

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

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

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

Use implicit differentiation to show that

Find the eigenvalues and corresponding eigenvectors of the matrix **A**, where

[4]

(iv) curve C has equation

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

[5]

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

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

[6]

(ii) Find the value of I_2.

curve C has polar equation $r = a(1 + \sin\theta)$ for $-\pi < \theta \leqslant \pi$, where a is a positive constant.

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

[5]

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

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.

calculate = ... hw **[2]**

26 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.

vertical and horizontal gridlines have a spacing of 1.0 cm . The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.

(b) (ii) student investigates an electrical circuit.

$$\mathbf{B} = \begin{pmatrix} 3 & 6 & 1 \\ 1 & -2 & -1 \\ 6 & 6 & -2 \end{pmatrix},$$

[3]

(iii) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$.

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 $\lambda\mu$.

car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

which = ... vd **[5]**

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

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

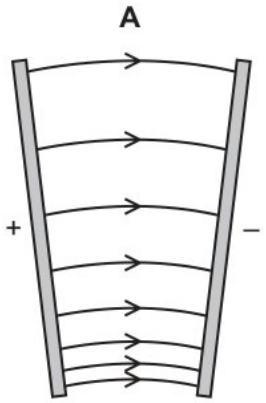
[8]

(c) (v)

marble is chosen at random from bag A and placed in bag B.

[4]

(iii)



activity of a radioactive sample.

[3]

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

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

curve C has parametric equations

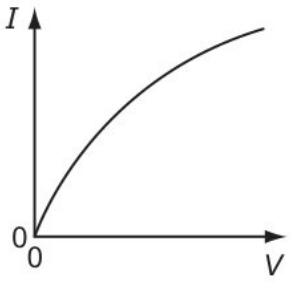
$59.1 =$ ..... mc **[8]**

(ii) masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

$$(n-1)I_n = 2^{\frac{1}{2}n-1} + (n-2)I_{n-2}.$$

[2]

(i) and N are two electromagnetic waves.



[10]

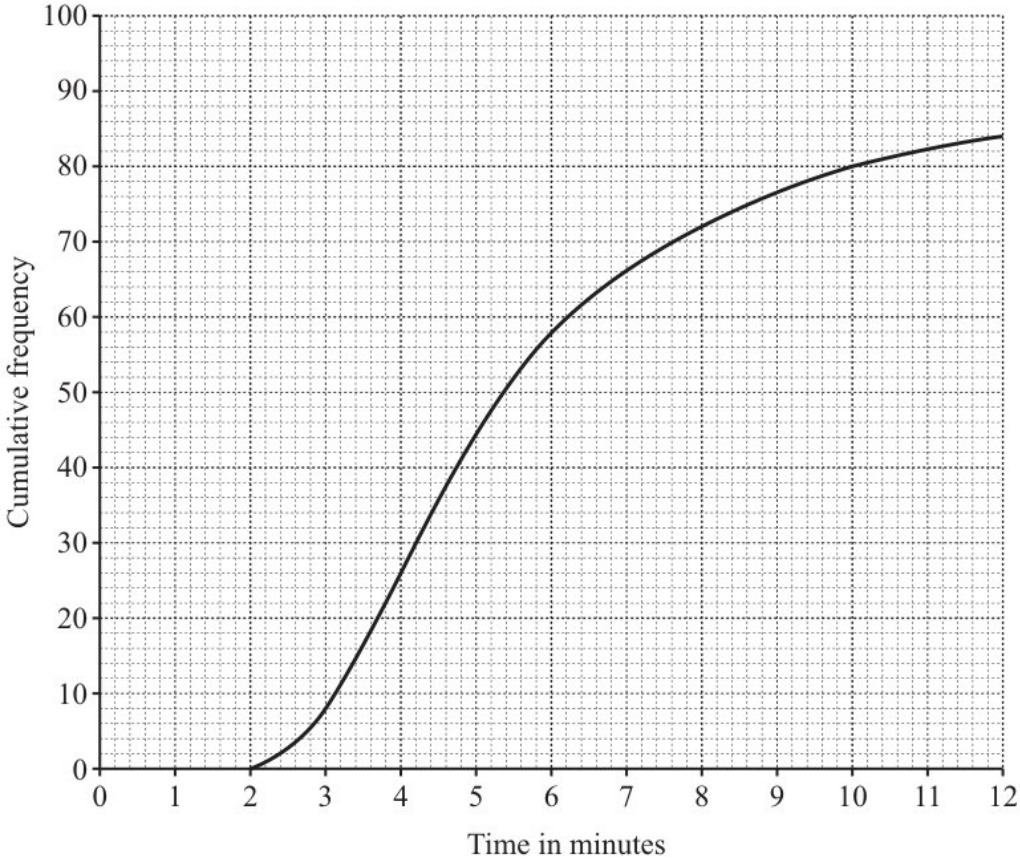
(vii) vector **e** is an eigenvector of the matrix **A**, with corresponding eigenvalue λ, and is also an eigenvector of the matrix **B**, with corresponding eigenvalue μ. Show that **e** is an eigenvector of the matrix **AB** with corresponding eigenvalue $\lambda\mu$.

[5]

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

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

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



from = ... *vm* **[8]**

(ii) and N are two electromagnetic waves.

wires are extended with the same strain and obey Hooke's law.

[8]

(b) (ii) 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.

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.

particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle moves in a horizontal circle with constant angular speed ω and with the string inclined at an angle of θ to the downward vertical.

[20]

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

Find the total time which elapses between the initial projection of B and the instant when it strikes the plane for the second time.

[8]

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

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

[5]

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

up to down

why Kieran is incorrect.

horizontal = ... *ok* **[3]**

(f) (i) the nucleus of $^{238}_{92}$U absorbs a neutron, the nucleus decays, emitting an α-particle. State the proton number and nucleon number of the nucleus that is formed as a result of the emission of the α-particle.

many different colour arrangements are there of the 10 books?

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

[6]

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

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

[8]

(ii) Find the value of a.

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.

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

[5]

10 moment of a force.

(b) (iii) aeroplane is flying at a constant speed.

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

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

[12]

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

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

[5]

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

Find the value of I_2.

from = ... *ll* **[6]**

(a) (iv) point P is the foot of the perpendicular from A to l.

electric potential difference across a component.

is the speed of the projectile at this time?

basis rank space = ... *wl* **[5]**

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

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

[6]

(i)

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave **x** = not a property of an electromagnetic wave
A	✓	χ	✓	
B	✓	χ	×	
C	×	✓	✓	
D	×	✓	×	

monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

[8]

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

Under 25 178 181 183 192 203 209 223 231

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

sphere = ... qc **[3]**

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

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

[5]

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

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

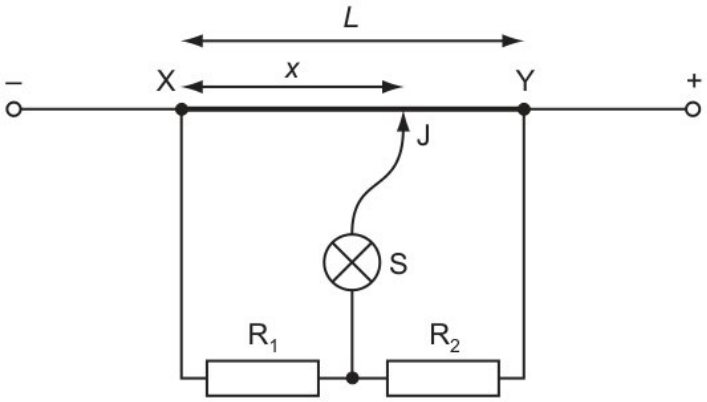
Its speed decreases to zero, then increases to a value less than 20 ms^{-1}.

(a) (iii) the time taken for the ball to reach its maximum height

is the total resistance between the two ends of the coil?

speed = ... cu **[10]**

(ii) much energy is stored in the compressed column?



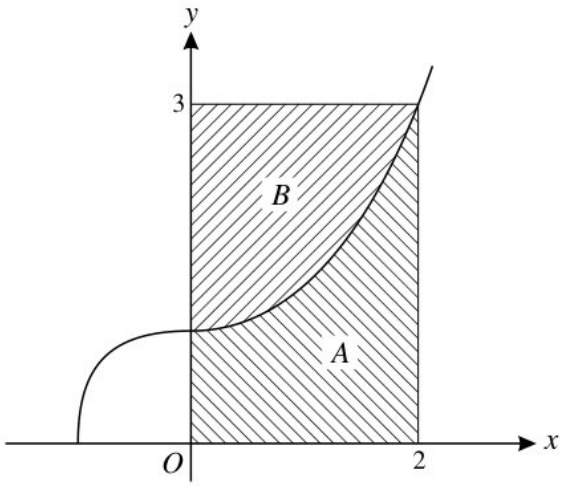
corner = ... xt **[3]**

(g) (iv) are the weight and the mass of the body when it is on the Moon?

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

[6]

(iii)



1 Which quantity is a scalar quantity?

[4]

12 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.

(a) (iv) Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

- decelerating at a constant rate with the parachute open,

block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m . The block experiences a frictional force parallel to the slope of 5.0 N .

[8]

(ii) this question the use of a calculator is not permitted.

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

[6]

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

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

[5]

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

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

[5]

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

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

$2000 = \ldots\ldots\ ql$ **[8]**

26 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 $t = 4$.

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave $\boldsymbol{x}$ = not a property of an electromagnetic wave
A	✓	χ	✓	
B	✓	χ	×	
C	×	✓	✓	
D	×	✓	×	

(c) (i) Use the trapezium rule with three intervals to estimate the value of

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.

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

[8]

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

525 520 522 524 518 520 519 525 527 516

[6]

(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.

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

[2]

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

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

study = ... *be* **[10]**

(ii) only one of the following two alternatives.

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

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

[6]

(vii) 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.

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

0.14 less = ... *iu* **[6]**

(b) (iii) the value of n.

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

[6]

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

curve C has polar equation $r = 3 + 2\cos\theta$, for $-\pi < \theta \leqslant \pi$. The straight line l has polar equation $r\cos\theta = 2$. Sketch both C and l on a single diagram.

[8]

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

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

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

circuit is set up as shown in Fig. 2.1.

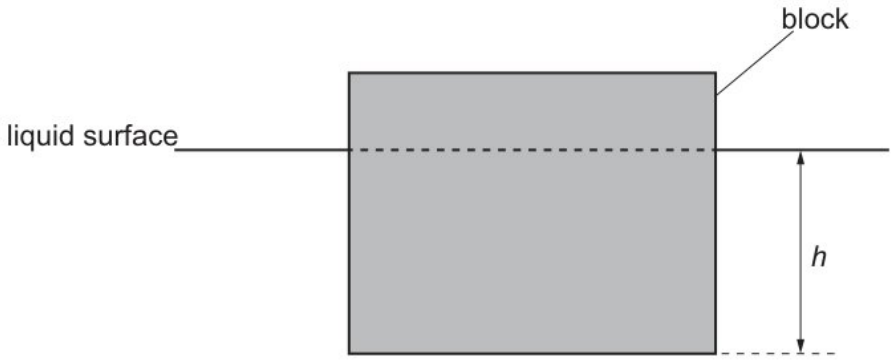
[3]

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

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

[3]

(b) (iii)



the equations of the asymptotes of C

[5]

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

$$x^3 - 2y^3 = 3xy.$$

[10]

(i) Find the values of a and b.

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

[5]

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

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

than = ... jl **[12]**

(v) to the value α.

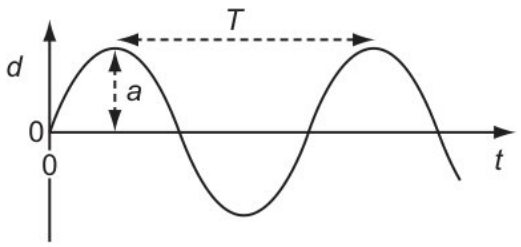
A contains 6 red marbles, 5 blue marbles and 1 green marble.

[8]

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

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.

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



[10]

(vi) 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.

[10]

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

results club. = ... rc **[5]**

(b) by mathematical induction, that $5^n + 3$ is divisible by 4 for all non-negative integers n.

marks of the pupils in a Physics examination are summarised as follows.

X and Y are connected in series to a cell.

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Number of nights	4	9	18	26	20	16	7	0

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

[4]

(iv) Calculate the acute angle between the planes.

[12]

20 are selected from these 20 to perform at a concert.

(c) (iii)

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

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.

[4]

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

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

[6]

(a) (i) specific latent heat.

Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

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

[4]

(ii) this question the use of a calculator is not permitted.

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.

statement about light waves and sound waves is correct?

[4]

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

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

[12]

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

only one of the following two alternatives.

[5]

(ii) measurements to be taken,

mass of the liquid is 0.36 kg $\pm$ 10%.

[3]

6 stationary firework explodes into three pieces. The masses and the velocities of the three pieces immediately after the explosion are shown.

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

the value of x.

(f) (i) 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

that $v = y^3$, show that

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

emits = ... pc **[3]**

(ii) Find the area of the triangle ABC.

The weight of the plank is causing a clockwise moment.

[6]

(c) (ii)

	α-particle	β-particle	γ-radiation
charge			0
mass	$4u$		
speed		up to $0.99c$	

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).

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

[4]

(iii) Find the angle between the vertical and the side AO of the lamina.

Find the values of a and b.

[8]

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

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

[2]

(ii) 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.

matrix **A**, given by

rest = ... ym **[6]**

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

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

collides = ... *vh* **[8]**

(i)

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

the value of μ.

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.

[6]

15 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).

aeroplane then ascends 300 m in 50 s , while maintaining the same speed. The resistance force is no longer constant, and the work done against the resistance force in ascending the 300 m is 270000 kJ . The mass of the aeroplane is 60000 kg .

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

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.

those = ... *by* **[8]**

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

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

[10]

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

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.

less this = ... mi **[3]**

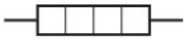
(iii) beyond point S but before point T

to the value α.

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

motion motion = ... oj **[4]**

(a) (ii)



procedure to be followed,

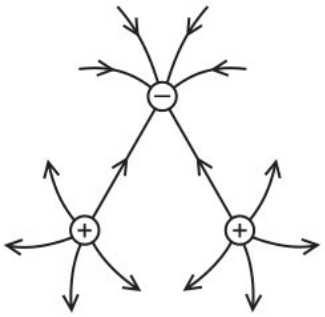
[5]

(iv) random variable T has probability density function given by

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.

[6]

(iii)



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

equation = ... rb **[3]**

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

(b) (iii) 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.

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.

masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

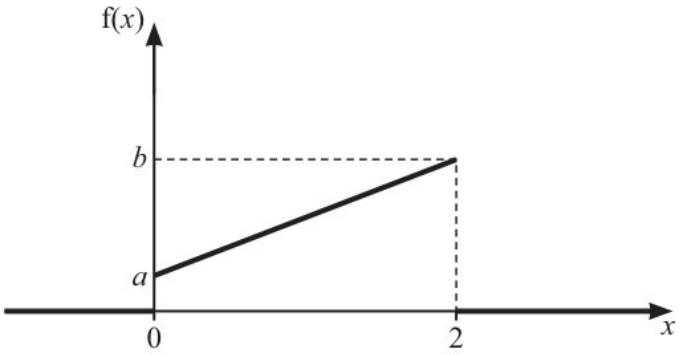
[4]

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

car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

[12]

(a) (ii)



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 .

[12]

(i) 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 $AC = a$.

will the powers to the resistors change when resistor W is removed?

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.

[3]

(iii) 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.

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

[4]

(v) State the work W done by F.

turbine at a hydroelectric power station is situated at a vertical distance of 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

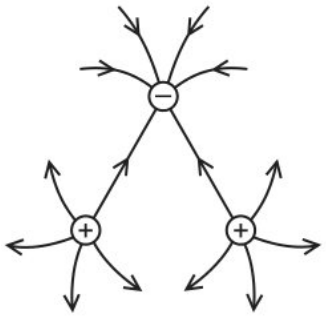
[3]

27 the value of V.

region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

Find the coordinates of the turning points of C.

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



[6]

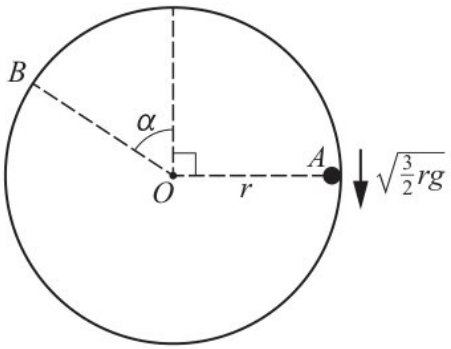
(i) variables x and y satisfy the differential equation

progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

[8]

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

projectile is thrown at an angle to the ground.



[6]

(e) (ii) In the case where $k = 2$,

$$\sum_{r=1}^{n} \frac{n}{n^2 + r^2} < \frac{1}{4}\pi$$

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.

least = ... rb **[15]**

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

astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

[6]

7 the team contains more boys than girls.

(b) (i) expression calculates the fractional uncertainty in the value of this speed?

a vector equation for l.

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

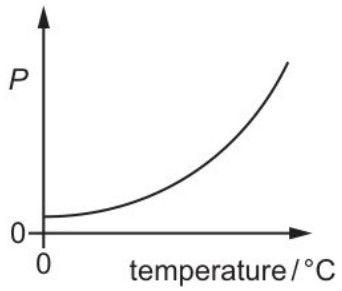
[10]

(iii) 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.

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

[3]

(e) (iii)



a tree diagram to represent this information, giving the probability on each branch.

[6]

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

[15]

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

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

plane rough = ... *co* **[6]**

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

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

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

[5]

(iii) curve C has equation

t time $t = 5.8$ s the speed of the car becomes constant

moved change = ... *vx* **[5]**

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

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

direction = ... *iu* **[4]**

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

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

particle = ... tw **[5]**

(ii) When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

speeds = ... eb **[5]**

25 curve C has parametric equations

(e) (vi) aeroplane is flying at a constant speed.

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

[3]

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

1,2 and 3

[10]

(a)(vii) moment of a force.

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

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

[6]

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

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

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

[8]

(ii) 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.

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.

through = ... *de* **[6]**

24 (h) $\omega = \cos\frac{1}{5}\pi + \mathrm{i}\sin\frac{1}{5}\pi$. Show that $\omega^5 + 1 = 0$ and deduce that

(ii) 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 .

[15]

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

[4]

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

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

[8]

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

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

diagram illustrates successive wavefronts.

surface = ... km **[4]**

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

initially = ... fs **[8]**

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

is a general description of a baryon?

the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

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

[10]

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

diagram shows two waves R and S.

vectors = ... xj **[3]**

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

[2]

(iv) exactly at point T

[8]

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

the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

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

a and **b** are vectors and t is a scalar.

[5]

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

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

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

[20]

21 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.

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

the probability of a Type I error.

[5]

(iv) 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.

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

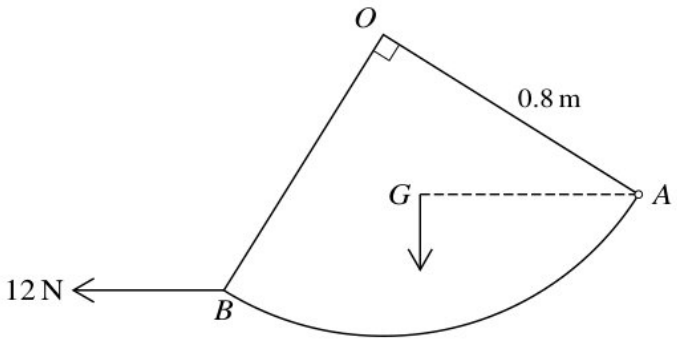
[10]

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

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

[4]

(i) is given that



denoted = ... qa **[4]**

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

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

[4]

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

circuit is set up as shown in Fig. 2.1.

vertically = ... ay **[3]**

9 point P is the foot of the perpendicular from A to l.

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 $t = 4$.

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

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

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

activity of a radioactive sample.

initial = ... nx **[4]**

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

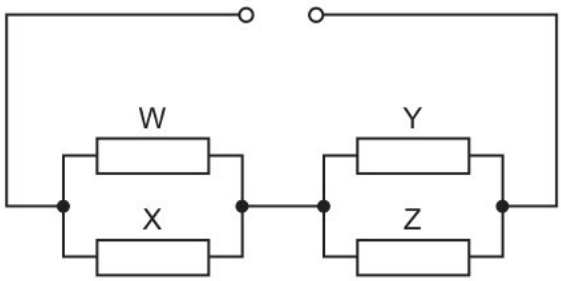
particle moving = ... lf **[6]**

(a) (v) an electron and a neutrino

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

[12]

(i)



$\mathbf{A}^{2n}$, where n is a positive integer.

[2]

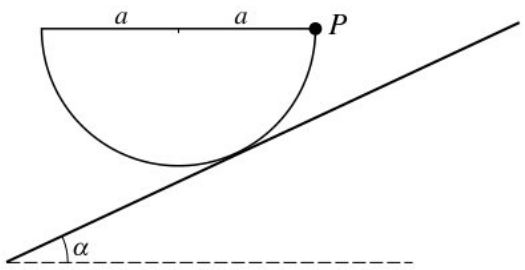
(f) (iii) is the average velocity of the toy car for the journey shown by the graph?

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

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

[5]

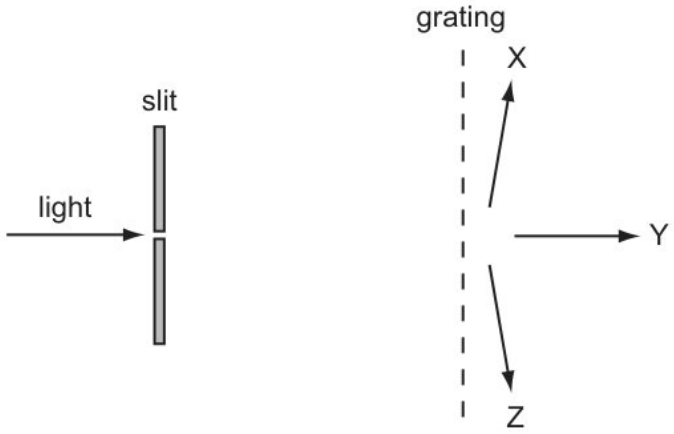
(iv)



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

[5]

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



[20]

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

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

steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u, leaves it at a speed v, and rebounds vertically to half of its original height.

(iii) this question the use of a calculator is not permitted.

researcher claims that older people take longer to react to a sudden loud noise than younger people. To investigate this, the researcher randomly selects 6 people over 50 years old and 8 people under 25 years old and records their reaction times, in milliseconds, to a sudden loud noise. The reaction times are as follows.

[6]

(i) four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x.

many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

season. = ... *ti* **[2]**

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

The extension of the wire is proportional to the tensile force.

[6]

(a) all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

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

(iv) frequency of the signal is 50 kHz .

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

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

attached = ... *oh* **[6]**

(iii) a 90% confidence interval for the difference in mean crop mass associated with each type of fertiliser.

line = ... *lh* **[8]**

(e) 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.

(i) curve C has polar equation $r = 3 + 2\cos\theta$, for $-\pi < \theta \leqslant \pi$. The straight line l has polar equation $r\cos\theta = 2$. Sketch both C and l on a single diagram.

[3]

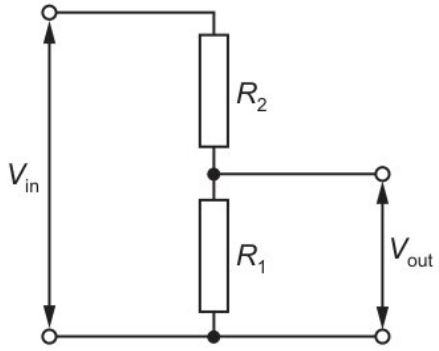
(ii) the exact value of the positive constant k for which

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

[6]

12 probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

(a) (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.



[20]

(iii) paving slab has a mass of 68 kg and dimensions 50 mm × 600 mm × 900 mm.

lines l_1 and l_2 have equations

[8]

(b) (ii) Find the mean and standard deviation of the weights of boys aged 16 years in Brigville.

the probability density function of Y

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

[5]

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

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

[8]

14 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 $t = 2$.

(c) (iii)

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

are speed v_1 and speed v_2 ?

[3]

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

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

[12]

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

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

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

[2]

(v) was the by-product of this reaction?

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

[6]

(a) (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).

much energy is stored in the compressed column?

[5]

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

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

[10]

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

Calculate the initial speed and the angle of projection of P.

[20]

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

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

[8]

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

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

[8]

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

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.

[8]

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

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.

diagram shows a water wave in a shallow tank. The wave is diffracted through a gap in a barrier and spreads. The wavelength of the wave is much smaller than the width of the gap.

(b) (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.

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

from = ... dg **[10]**

(iii) Find the mean age of all 19 people.

electric potential difference across a component.

[8]

(iv) diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

that if a sequence of values given by the iterative formula

first = ... *em* **[6]**

(e) (iii) Use the trapezium rule, with two intervals, to estimate the value of

line l_2 has equation $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 5\mathbf{k} + \mu(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$.

[3]

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

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

$$\frac{\mathrm{d}^2v}{\mathrm{d}x^2} + 2\frac{\mathrm{d}v}{\mathrm{d}x} - 15v = 24\mathrm{e}^{-x}$$

produced sample = ... *xg* **[10]**

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

$$\overset{14}{\underset{\cdots\cdots}{}}X \rightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{}}Z + \ldots\ldots\cdots .$$

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

[4]

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

Find the cartesian equation of Π_2.

(b) (iii) the particular solution of the differential equation

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

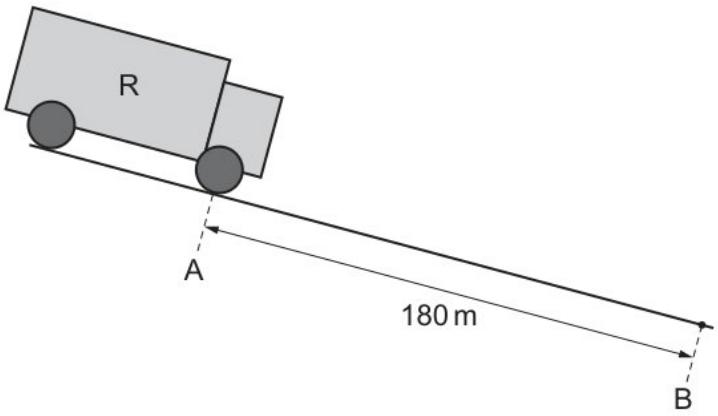
inner = ... *my* **[6]**

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

by mathematical induction, that 5^n+3 is divisible by 4 for all non-negative integers n.

[6]

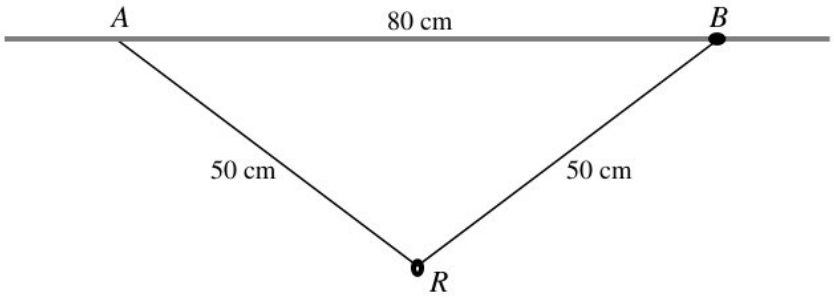
(vi) a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.



random variable Y is defined by $Y = X^3$. Find

[12]

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



drift = ... zg **[5]**

(h) (i) points A, B, C have position vectors

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

blue = ... *at* **[6]**

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

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 $\lambda\mu$.

form = ... *zz* **[3]**

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

Find the values of p and q such that

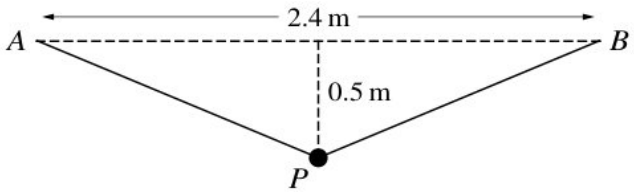
[2]

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

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 6\frac{\mathrm{d}x}{\mathrm{d}t} + 9x = 18t^2 + 6t + 1$$

[10]

(iii)



then it converges to a.

nucleus emitting from away = ... ze **[10]**

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

matrix **A**, given by

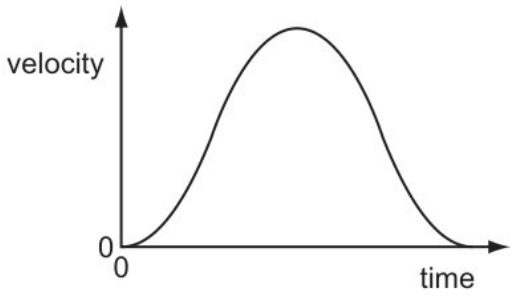
[3]

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

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

between = ... rx **[5]**

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



particles = ... vj **[3]**

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

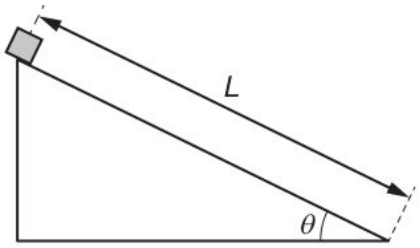
Find the total time which elapses between the initial projection of B and the instant when it strikes the plane for the second time.

[8]

15 the mean of the times taken by all 50 runners.

the exact area of one loop of the curve.

(c) (i) Calculate the speed of projection of P.



[15]

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

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

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

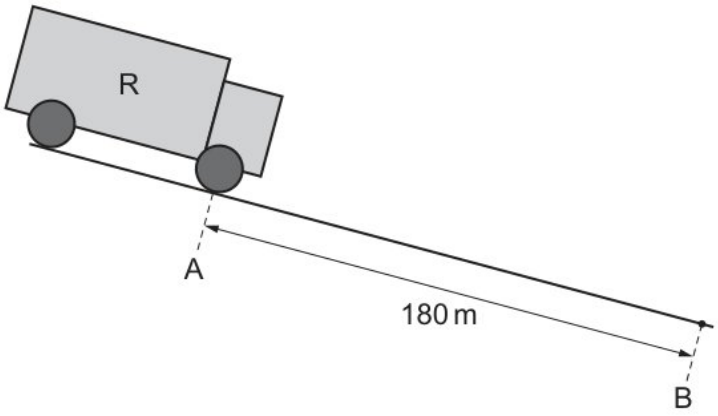
least = ... gf **[12]**

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

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

[3]

(a) (i) Calculate the distance of the centre of mass of the lamina from A.



[15]

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

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

flies = ... ke **[3]**

(vi) many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

mass of cherries sold per day in a supermarket is normally distributed with mean 72.4 kg and standard deviation σkg. It is known that on 10% of days less than 59.1 kg of cherries are sold.

[5]

(d) (i) 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.

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

rest = ... xf **[3]**

(iii) point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

$$\overrightarrow{OA} = \begin{pmatrix} 2 \\ 3 \\ 5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} \quad \text{and} \quad \overrightarrow{OC} = \begin{pmatrix} 10 \\ 0 \\ 6 \end{pmatrix}.$$

[6]

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

Draw up the probability distribution table for X.

the SI base units of resistivity.

other = ... gu **[4]**

(vi) is the speed of the block at the bottom of the slope?

is given that $k = 0.025$ and that $U = 20$

the acute angle between the planes ABC and ABD.

money = ... bl **[6]**

(e) (ii) 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.

$$\frac{\mathrm{d}^2 z}{\mathrm{d}x^2} + 4\frac{\mathrm{d}z}{\mathrm{d}x} + 4z = 8x^2$$

[8]

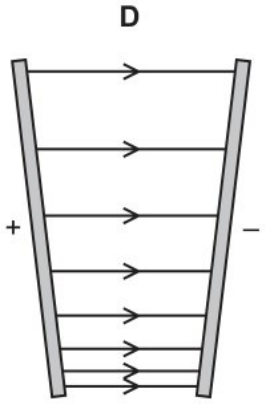
(i) 3×3 matrix **A** has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

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

the probability density function of Y,

[4]

(iii) that the eigenvalues of **A** are $-1, 1$ and 5 .



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

[4]

19 the expected value and variance of Y.

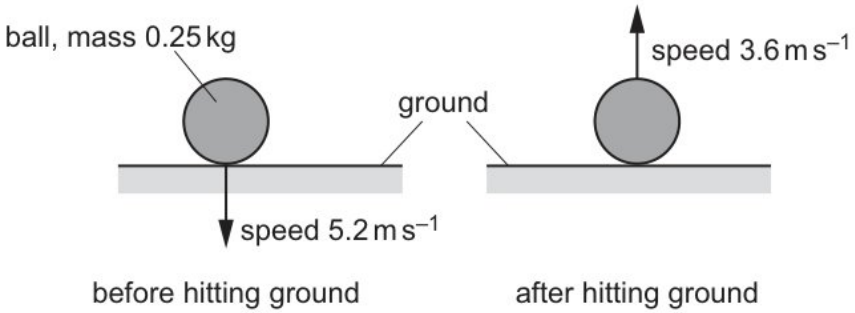
(b) (ii) Use de Moivre's theorem to show that

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

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

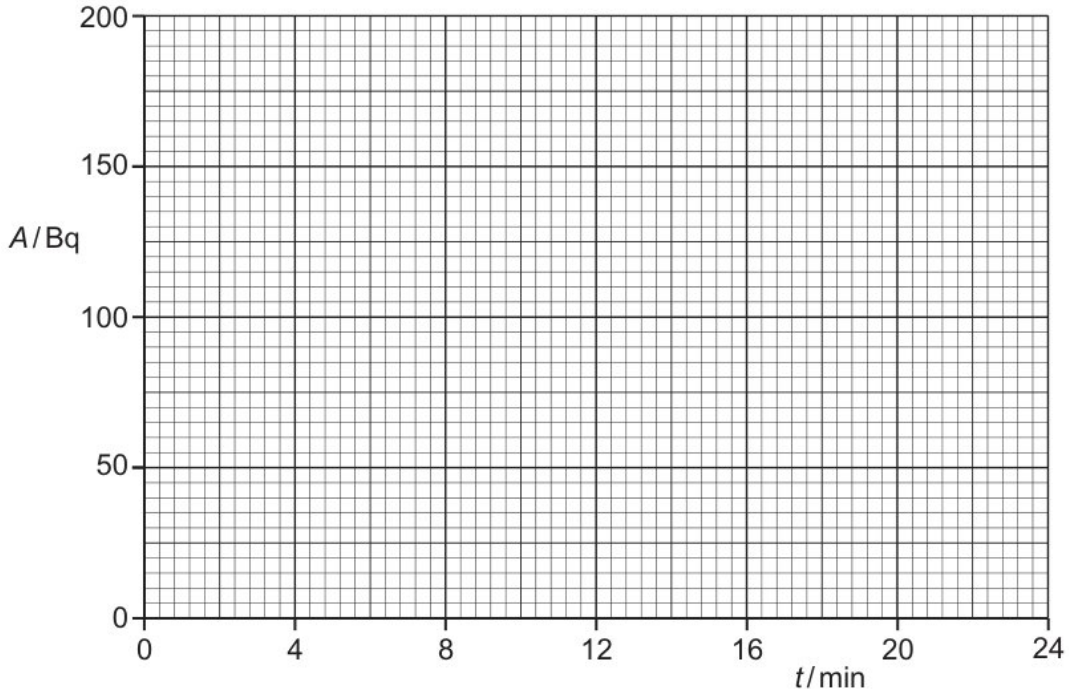
[15]

(iii) the value of σ.



play = ... *bu* **[4]**

(c) (ii)



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

[6]

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

transmitted light has intensity $0.75I$.

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

[1]

(iii) selects 4 books from her 10 different books from the series Squares and Circles.

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

many = ... xi **[3]**

18 Find the probability that a box is rejected.

(e) (i) When a and b have these values, factorise $\mathrm{p}(x)$ completely.

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 $t = 4$.

where = ... fg **[5]**

(v) 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.

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

[5]

(c) (iv) object is fully submerged in a liquid.

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

the speed of Q after the collision.

downwards. = ... yc **[3]**

(iii) 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 .

aeroplane is flying at a constant speed.

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

will selected = ... dp **[5]**

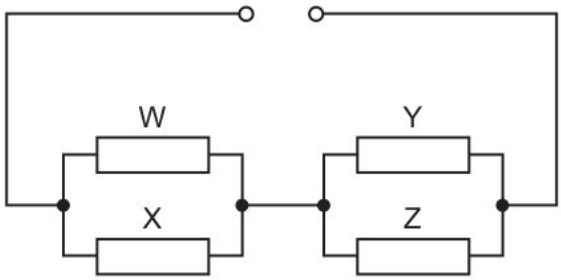
(a) (ii) bag contains 10 marbles, of which 4 are red and 6 are blue. Four marbles are selected from the bag at random, without replacement. The random variable X denotes the number of blue marbles selected.

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

random sample of 12 customers who each bought a computer from this store is chosen.

[3]

(iii)



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

[10]

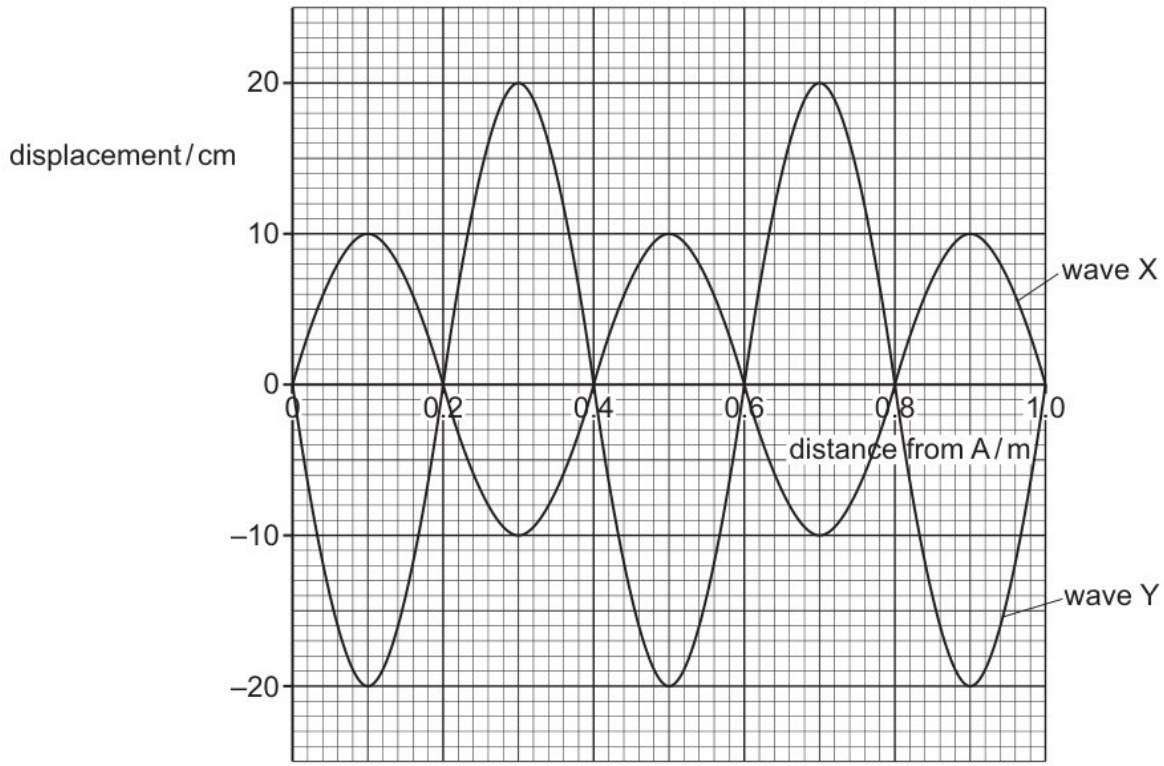
(d) (iii) the speed of the body is increased to 40 ms^{-1}, what is its new kinetic energy?

the complex numbers z for which $\frac{z+5\text{i}}{z-5}$ is real and $|z| = \sqrt{17}$ Give your answers in the form $z = x + \text{i}y$ where x and y are real

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.

[3]

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



be written as a quadratic equation in x.

[6]

(ii) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.

1 and 2 only

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

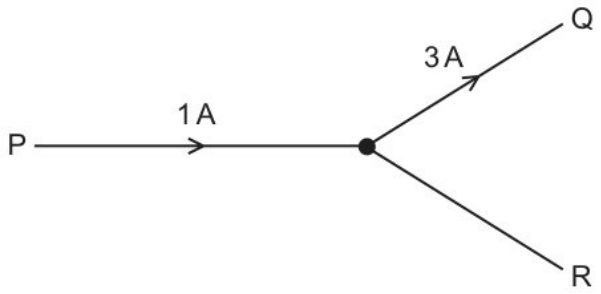
motion = ... *bo* **[4]**

18 the probability of a Type I error.

numbers of barrels of oil, in millions, extracted per day in two oil fields A and B are modelled by the independent random variables X and Y respectively, where $X \sim \mathrm{N}\left(3.2, 0.4^2\right)$ and $Y \sim \mathrm{N}\left(4.3, 0.6^2\right)$. The income generated by the oil from the two fields is \$90 per barrel for A and \$95 per barrel for B.

was the by-product of this reaction?

(e) (ii)

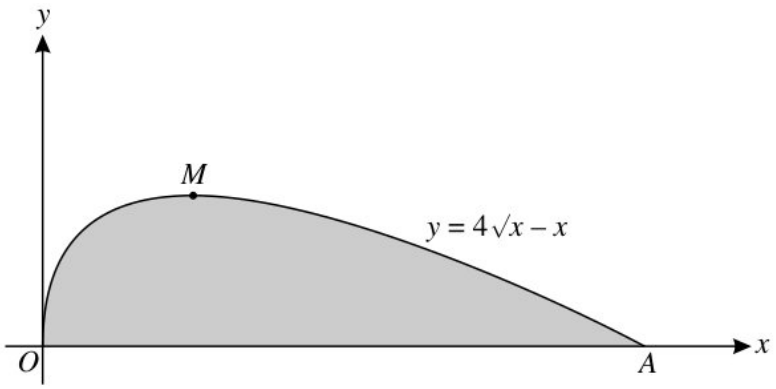


The weight of the plank is causing an anticlockwise moment.

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.

[15]

(i)



1.1 shows the measurements for cube A.

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

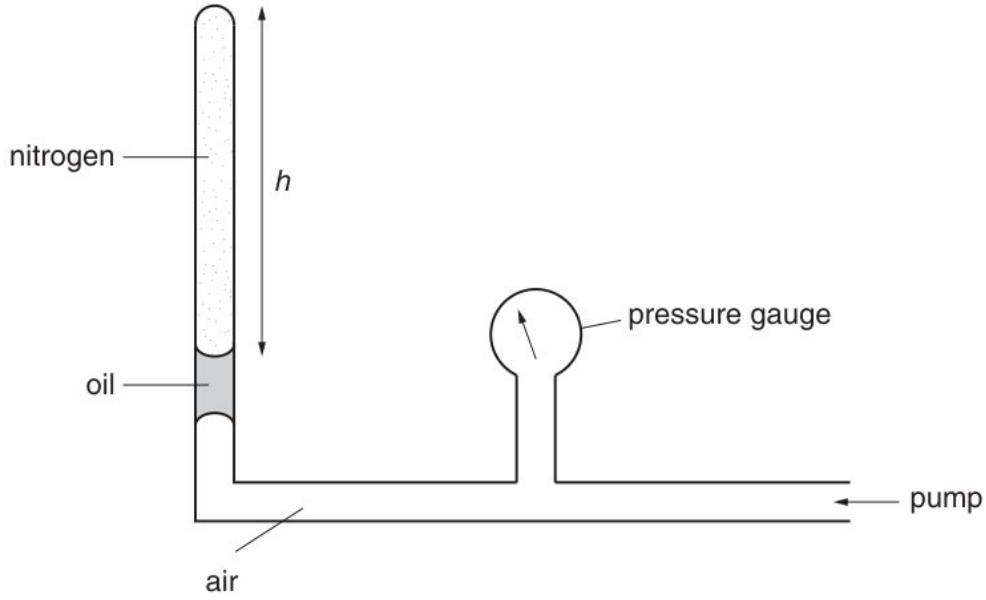
speed speed speed = ... *is* **[6]**

(a) (i) exactly at point S

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

thickness square = ... mq **[4]**

(ii)



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.

[8]

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

Find the frictional and normal components of the contact force acting on B.

[3]

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

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

[8]

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

[12]

(iv) Find the probability density function of Y.

The weight of the plank is causing a clockwise moment.

[4]