15 The total momentum is conserved only in elastic collisions.

(d) (iv) coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

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

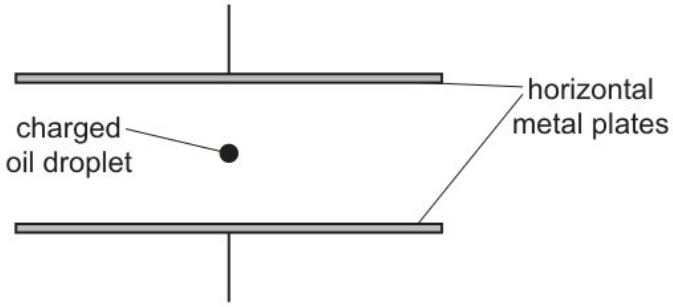
[6]

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

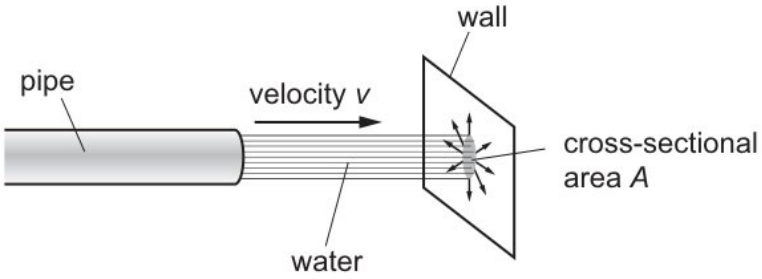
complex number u is defined by $u = \frac{5}{a+2\mathrm{i}}$, where the constant a is real.

[6]

(v)



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



[6]

(a) (ii) the position vector of P.

$$(3 + 2n)I_n = 2nI_{n-1}.$$

how the pattern of interfering waves may be observed.

[8]

(v) 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.

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

[2]

22 the probability of a Type I error.

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

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.

$a =$ ……..

$b =$ ……..

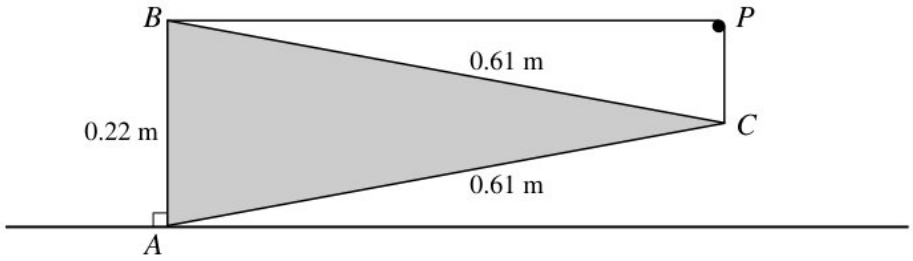
$x =$ ……..

$y =$ ……..……..

[3]

[6]

(ii)



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

[5]

(c) (i) 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.

Find the coordinates of the turning points of C.

[10]

(iii) Find a set of corresponding eigenvectors.

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

[6]

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

	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

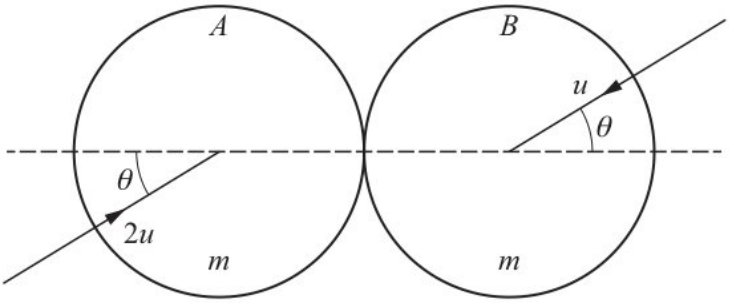
[4]

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

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

[3]

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



[12]

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

(c) (ii) people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

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.

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.

[4]

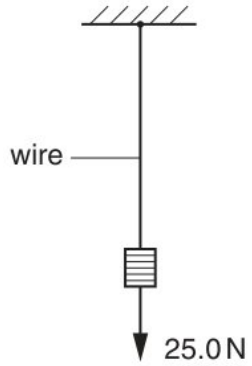
(i) the exact area of one loop of the curve.

a vector equation for l.

progressive water waves X and Y travel along a straight line from point A to point B. The variation of displacement of the waves with distance from A at an instant in time is shown in Fig. 3.1.

[4]

(a) (i)



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

[15]

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

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

[5]

(d) (iv) isolated stationary nucleus Q decays into nucleus R and an α-particle. The α-particle has speed 1.5×10^7 ms^{-1}.

the past, the population mean time was 62.4 seconds.

[5]

(iii) diagram shows a semicircle ACB with centre O and radius r. The tangent at C meets AB produced at T. The angle BOC is x radians. The area of the shaded region is equal to the area of the semicircle.

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

[4]

(b) (iv) Hence factorise p(x) completely.

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.

It consists of three quarks that must all be the same flavour.

sold. = ... wy **[5]**

(ii) row of the table gives an angle θ of 90° ?

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

boys = ... gq **[6]**

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

(b) (ii) the ductile material,

The matrix $\mathbf{B}$, where

[5]

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

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

[4]

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

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

will the powers to the resistors change when resistor W is removed?

[8]

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

curve C has parametric equations

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

[10]

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

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

[15]

(ii) diagram shows part of the curve

resistors of equal value are connected as shown.

[8]

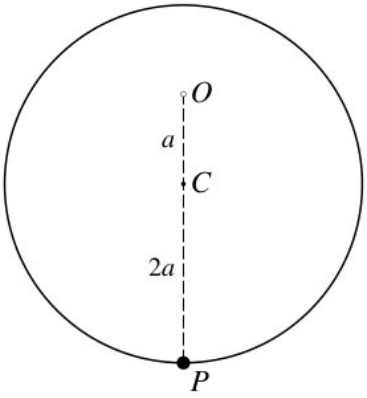
(a) (i) order to test the effect of a drug, a researcher monitors the concentration, X, of a certain protein in the blood stream of patients. For patients who are not taking the drug the mean value of X is 0.185 . A random sample of 150 patients taking the drug was selected and the values of X were found.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

only one of the following two alternatives.

is given that $y=2$ when $x=2$.

[12]

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



[5]

(iv) Express v in terms of x.

m.f. for $n = 0$.

[5]

14 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.

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

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 $t = 2$.

$$y = \frac{x^2 + \lambda x - 6\lambda^2}{x + 3}$$

[4]

(iii) Find the values of a and b.

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.

[5]

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

the probability density function of Y

Find angle ABC.

[5]

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

Show that $\frac{\mathrm{d}s}{\mathrm{d}x} = \frac{1}{2}(e^x + e^{-x})$, 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.

work = ... *be* **[12]**

20 It limits the range of values obtained in repeated measurements.

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?

(d) (ii) the exact volume of the solid generated

is the current in the load resistor?

[4]

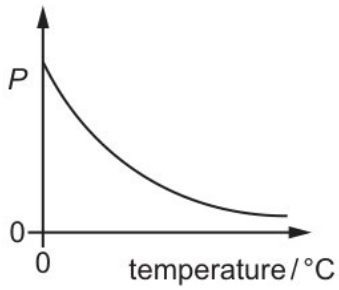
(iii) Hence solve the equation $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4$, for $0° \leqslant \theta \leqslant 360°$.

is the effect of a systematic error on the measurement of a physical quantity?

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

[6]

(a) (iii)



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

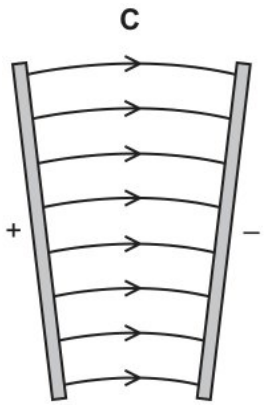
[8]

(i) Find the area of the triangle ABC.

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.

[5]

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



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.

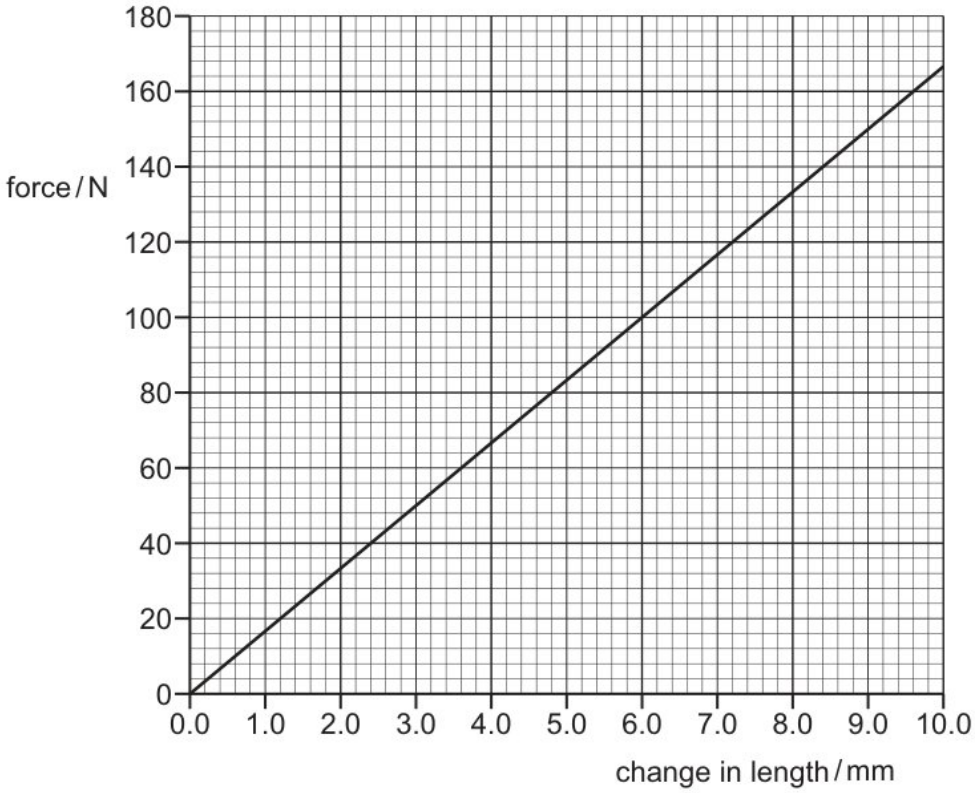
[4]

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

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).

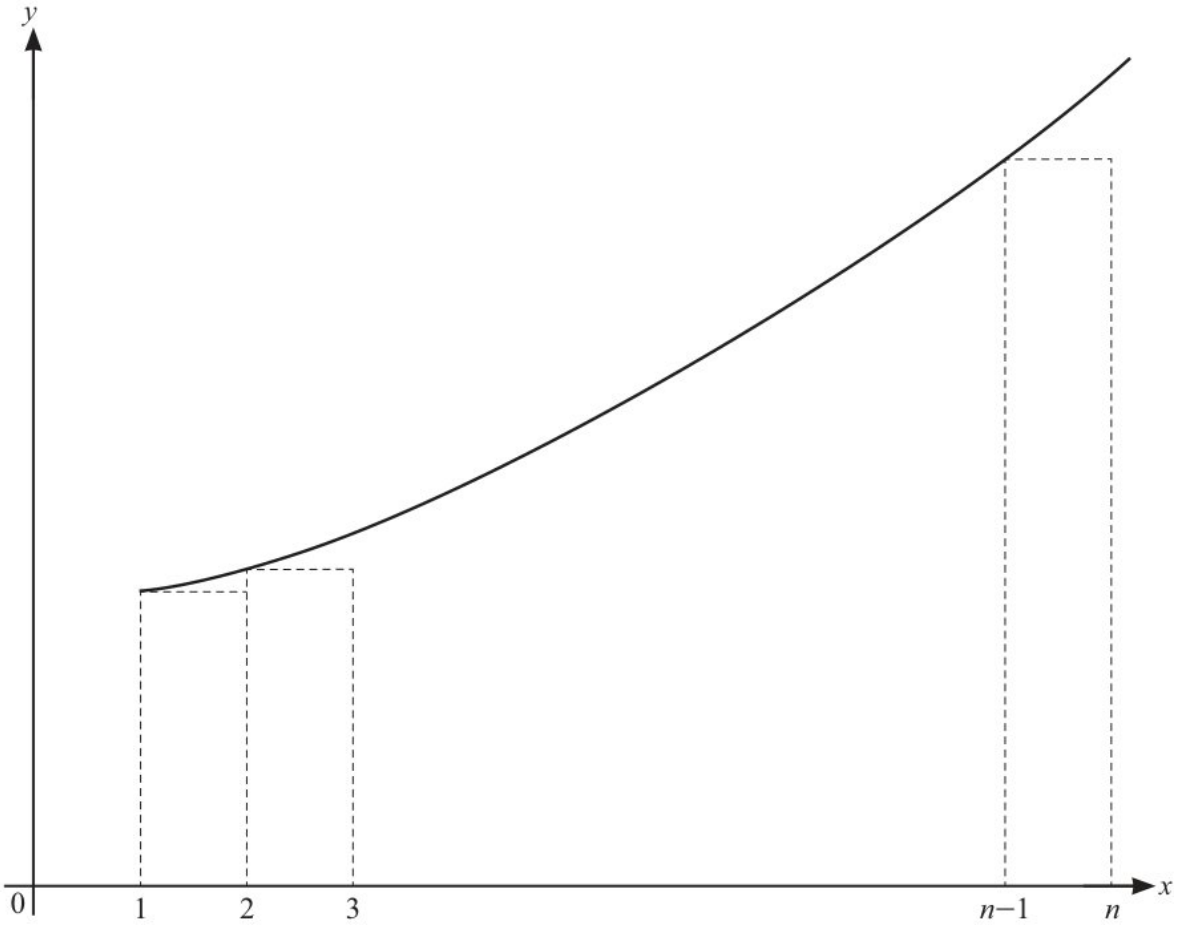
[4]

(i) Find the equation of the tangent to the curve at P.



[10]

12 the solution of the differential equation

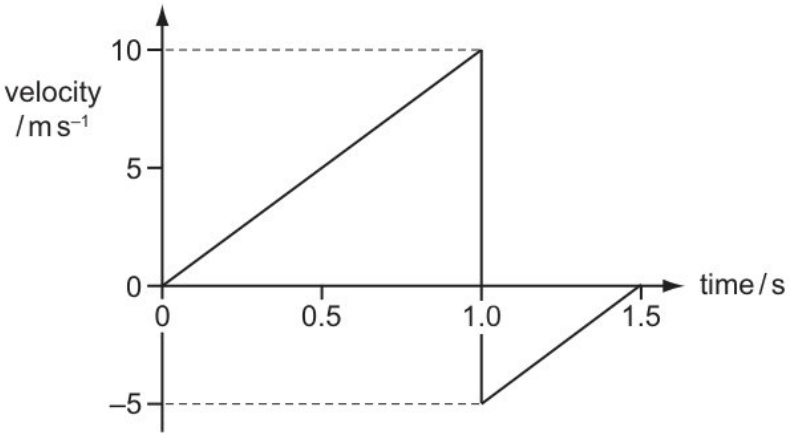


(e) (iii) what is meant by a fundamental particle.

the value of x.

[5]

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



[3]

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

the coordinates of any stationary points on C.

[4]

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

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

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.

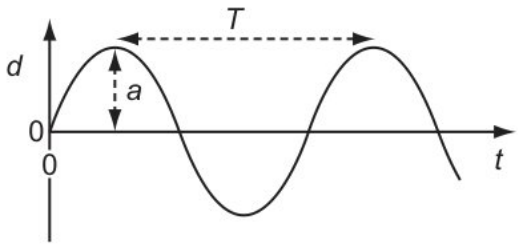
[4]

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

eigenvalues $1, -1$ and -2 .

[5]

(iv)



Find the standard deviation of the weights of the letters.

[6]

(vi)

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

weight of the parachutist is 850 N .

[5]

(i) random sample of 12 customers who each bought a computer from this store is chosen.

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

[5]

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

up the probability distribution table for X.

[8]

(iii) Hence solve the equation

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

[8]

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

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

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

[5]

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

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

[6]

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

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

- falling with constant speed with the parachute open,

[6]

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

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

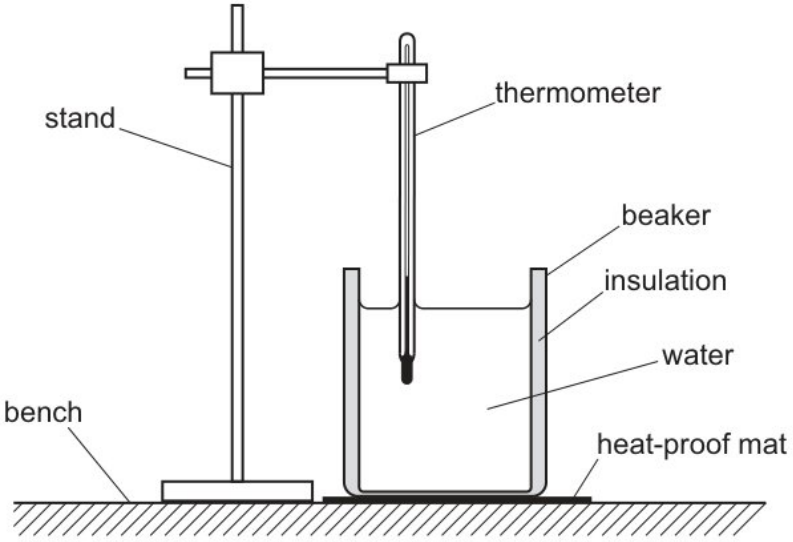
[5]

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

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

[8]

(b) (v) 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} .



find = ... lw **[5]**

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

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.

[10]

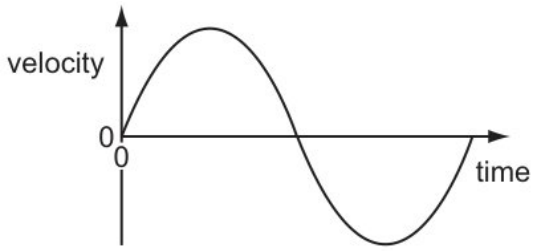
16 the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

(b) (v) in either order the value of μ and the value of σ

Find the value of I_2.

[6]

(iii)



the equation $2\ln(2x) - \ln(x+3) = \ln(3x+5)$.

[8]

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

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

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

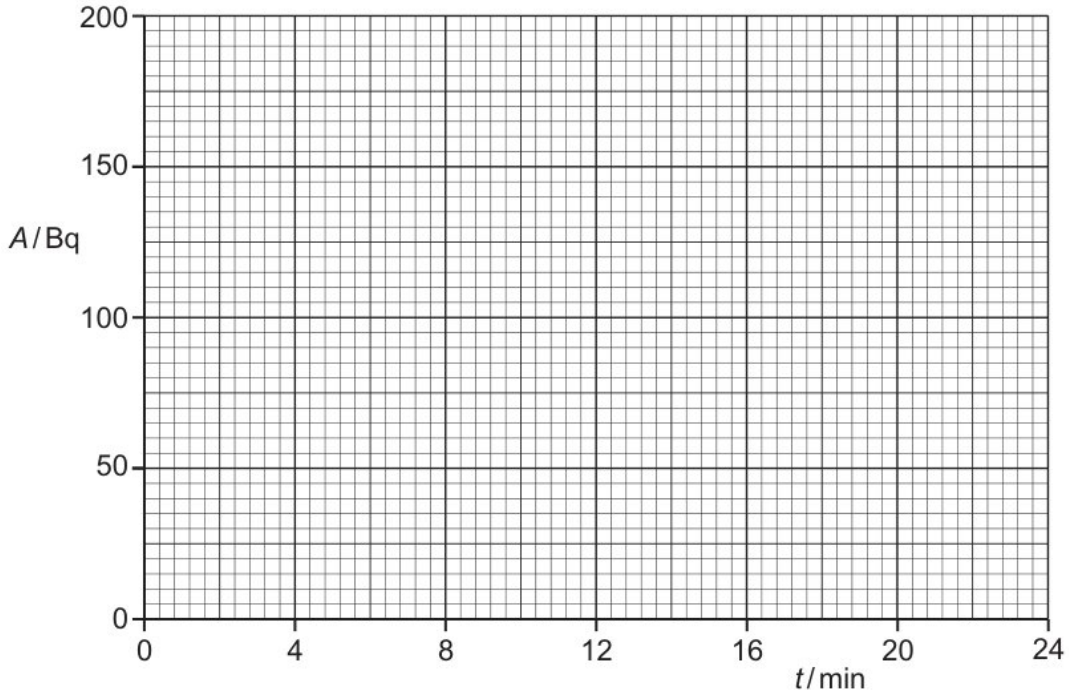
[3]

(a) (i) is the speed of the block after falling this distance?

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.

[5]

(iii)

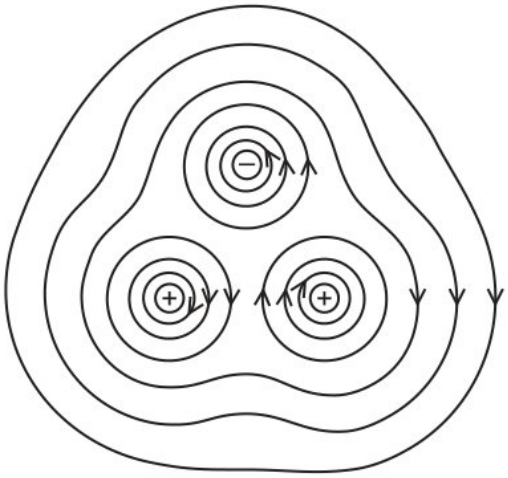


find the variance of the number of 4 s obtained in 30 throws,

[4]

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

(e) (i) Use implicit differentiation to show that



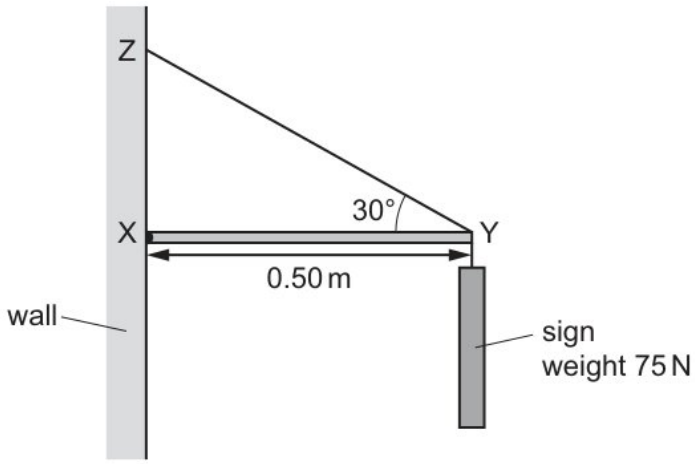
[8]

(ii) resistors of equal value are connected as shown.

to the value α.

[10]

(v)



Given that $v = 2.5$, find x.

kinetic energy $= 1/2 \times$ mass $\times$ (speed $)^2$.

[5]

(iii) curve C has equation

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

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

[3]

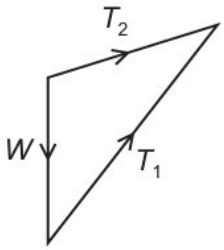
(b) (iv) of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

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

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.

[3]

(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.

[3]

(g) (iv) Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

student investigates an electrical circuit.

[12]

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

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

[5]

(i) waves are emitted from two sources.

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

cubic polynomial $\mathrm{p}(x)$ is defined by

[8]

(v) 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.

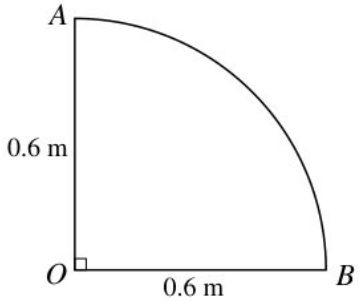
the median and the interquartile range of the times of the runners from the Gulls.

[6]

16 radius of the circle in which P moves and the radius of the circle in which Q moves,

the significance level of the test.

(d) (i)



is given that

[6]

(ii) diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

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

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.

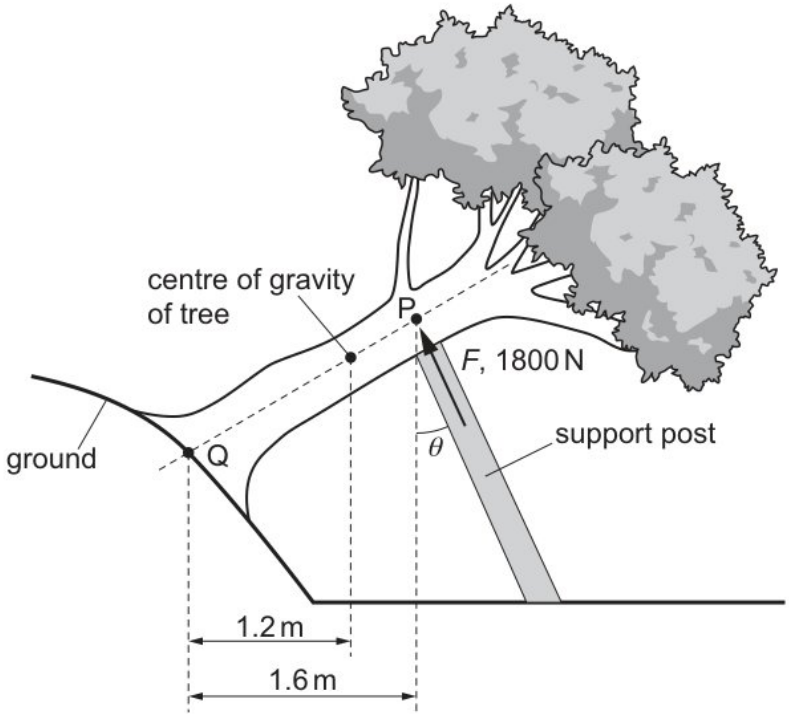
[5]

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

is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

[5]

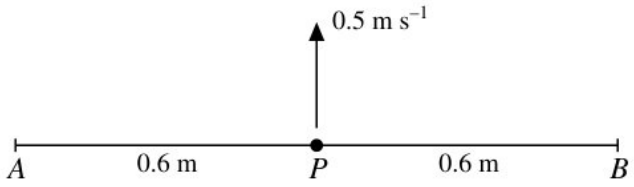
(i) mass of the liquid is 0.36 kg ± 10%.



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

[3]

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



[12]

(ii)

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

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

Find the value of k for which the set of linear equations

[6]

(i) up to antidown

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.

t time $t = 5.8$ s the speed of the car becomes constant

[6]

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

is the ratio $\frac{\text{stress at } Y}{\text{stress at } X}$?

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

[5]

(ii) cable has tensions T_1 and T_2 as shown.

[5]

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

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

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

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

[12]

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

[5]

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

[6]

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

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

[6]

(iv) curve C has parametric equations

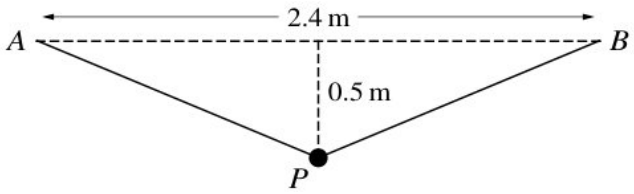
[2]

14 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, $f(x) = 0$.

Given that exactly two of the selected balls have the same number, find the probability that they are both numbered 2 .

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

(a) (i)



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

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

[6]

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

Find the equations of the asymptotes of C.

Show that the equation

[6]

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

The weight of the plank is causing an anticlockwise moment.

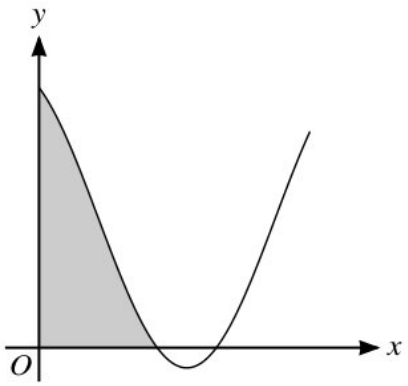
[8]

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

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

[3]

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



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

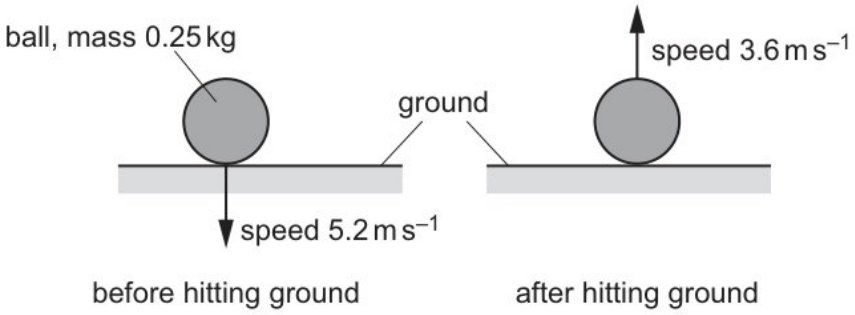
[4]

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

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

[2]

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



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

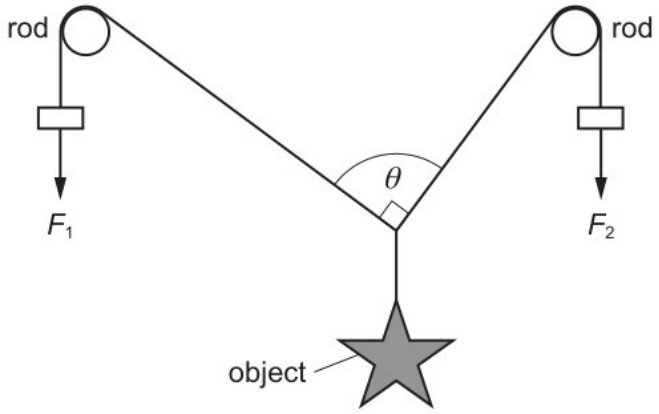
[2]

(f) (i) by calculation that $0.9 < a < 0.95$.

control of variables,

[10]

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



[12]

(ii) not have a unique solution.

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

$$(3 + 2n)I_n = 2nI_{n-1}.$$

[3]

(iii) what is meant by work done.

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

[6]

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

flows out of a pipe and hits a wall.

[4]

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

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

[4]

(i) it is given that $y = 2$ when $x = 1$. Solve the differential equation and obtain an expression for y in terms of x.

$$x = \tanh^{-1} t \quad \text{and} \quad y = t \operatorname{sech}^{-1} t, \quad \text{for } 0 < t < 1$$

[5]

11 number of cars sold per day at another showroom has the independent distribution Po(0.6). Assume that the distribution for the first showroom is still Po(0.7).

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.

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

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]

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

procedure to be followed,

[15]

(a) (iv) diagram, showing these three forces to scale, is correct?

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

[6]

(i) Find the exact area of the shaded region.

	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

[5]

(vi) thermistor is connected to a cell with negligible internal resistance.

Using these values of p and q, find the value of the constant r for which the equation $x^2 + px + q + r = 0$ has equal roots.

[6]

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

supermarket is open 7 days a week.

[3]

(vi) Show that $m = 0.9$.

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

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

[5]

20 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.

Potential difference is energy per unit current.

(c) (i) 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.

$$y = 2\cos 2x \cos\left(2x + \frac{1}{6}\pi\right)$$

wire Young = ... *pe* **[10]**

(ii) t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the amplitude $\propto$ intensity

[6]

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

constant potential difference is applied between two horizontal metal plates. A charged oil droplet is held stationary by the electric field between the plates.

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

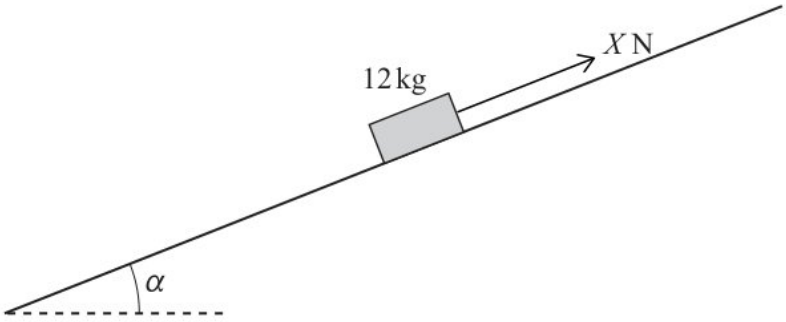
[12]

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

Find the speed of P when it passes through L.

[15]

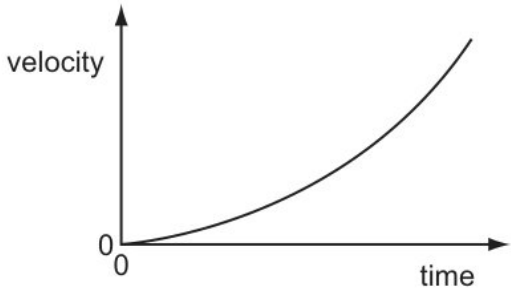
(i)



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

[10]

(iv)



displacement = velocity × time

[10]

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

only one of the following two alternatives.

[10]

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

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

Find the values of p and q.

[4]

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

the exact area of one loop of the curve.

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

statement about the weight of the plank is correct?

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

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

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

[10]

(ii) 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 $\lambda\mu$.

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

[6]

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

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

[6]

(ii) 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.

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

[5]

(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.

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

[12]

15 small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

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

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

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

[2]

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

the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.

[2]

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

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

[6]

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

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

[5]

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

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

[2]

(i) 100 nm to 400 nm

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

[3]

15 (g) Find $\frac{\mathrm{d}y}{\mathrm{d}x}$ and deduce that if C has two stationary points then $-\frac{3}{2}<\lambda<1$.

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

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.

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

[10]

(ix) 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

[3]

(b) 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.

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

the period of small oscillations,

[6]

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

[4]

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

[6]

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

(c) (iii) When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

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

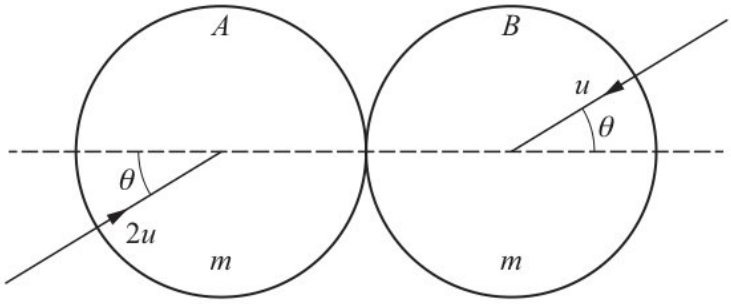
[4]

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

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.

[5]

(e) (ii)



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

[4]

(i) is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

the exact value of the positive constant k for which

is given that

straight acting length = ... js **[6]**

(iii) aeroplane is flying horizontally. The aeroplane's engines are producing a constant power of 5500 kW , and the aeroplane experiences a constant horizontal resistance force of 25 kN .

is the average useful power at which he is working?

[6]

(b) (iii) state the corresponding eigenvalue.

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

[5]

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

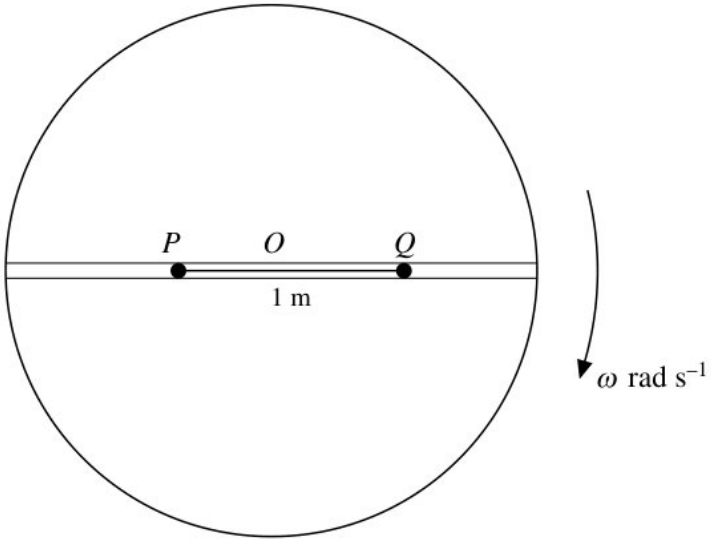
matrix $\mathbf{M}$ represents a sequence of two geometrical transformations in the $x - y$ plane

[4]

10 eigenvalues $1, -1$ and -2 .

(i) (f) weight of the parachutist is 850 N .

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



[4]

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

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.

[8]

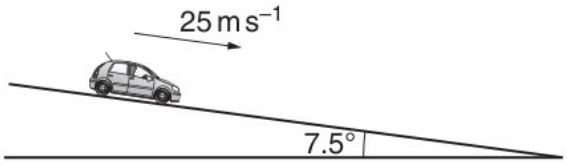
(iii) (f) that $rp^3 = q^3$.

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

expression gives the electrical resistance of the metal cube between X and Y ?

[5]

(c)



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

[4]

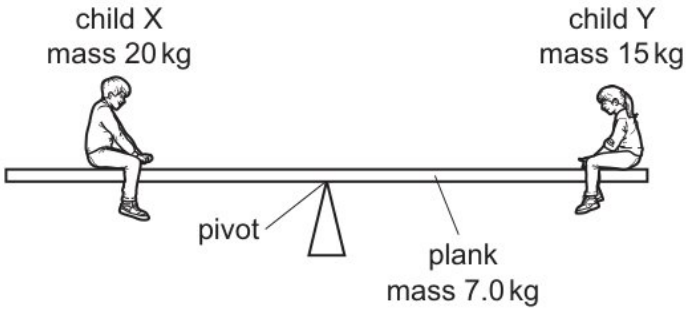
(b) Find the coordinates of any intersections with the coordinate axes.

The waves must not be polarised.

Find the value of a.

[8]

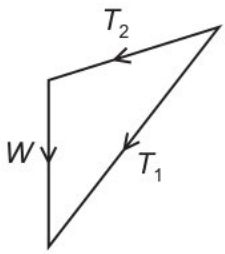
(vi) (e) the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.



aeroplane is flying horizontally. The aeroplane's engines are producing a constant power of 5500 kW , and the aeroplane experiences a constant horizontal resistance force of 25 kN .

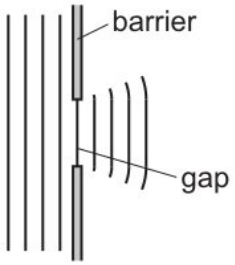
[6]

(f) people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.



[8]

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



[6]

15 measurements to be taken,

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

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

[10]

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

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

[12]

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

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

[20]

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

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

down to up

[8]

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

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

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

[4]

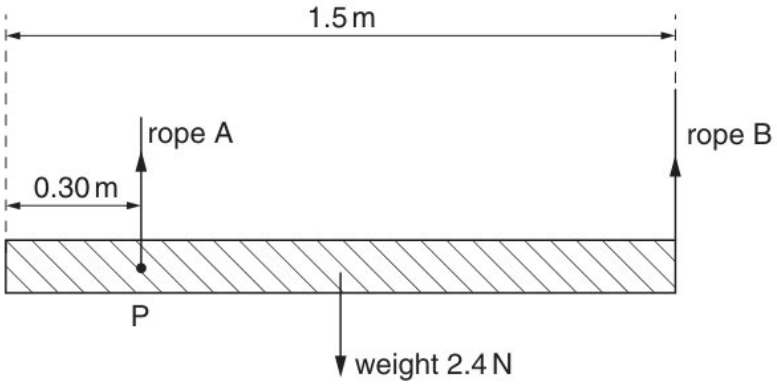
(c) (iv) Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

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

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

[6]

(ii)

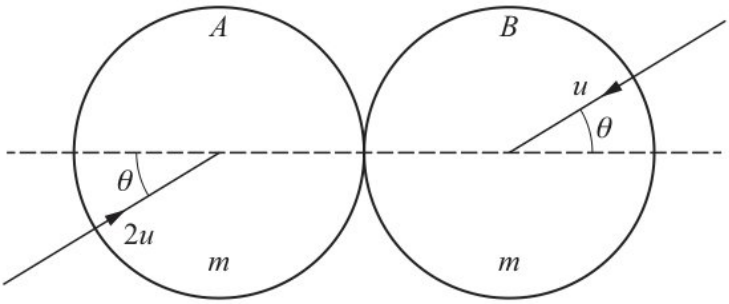


acceleration of free fall on Pluto is 0.66 m s^{-2}.

[8]

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

(a) (iii)



is meant by elastic deformation?

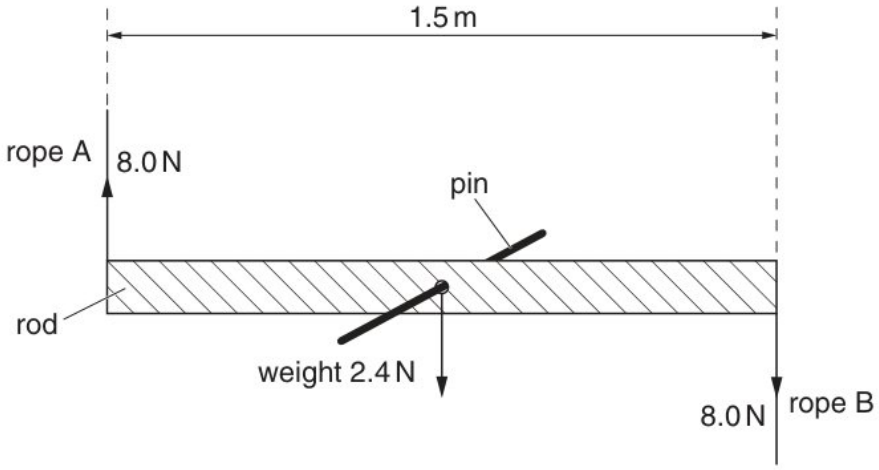
[2]

(v) mean, $\bar{x}$, is 28.325 .

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

[4]

(c) (iv)



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

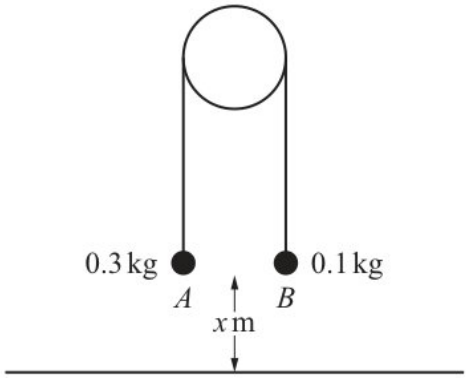
[6]

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

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

[10]

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



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

[6]

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

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

$$y = 2\cos 2x \cos\left(2x + \frac{1}{6}\pi\right)$$

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

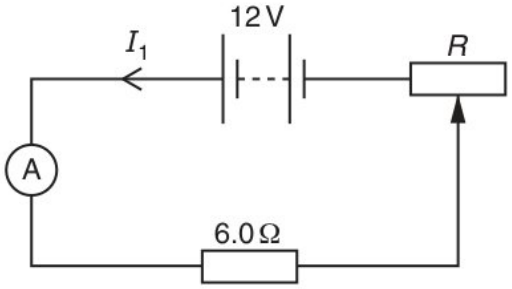
(a) (ii) Lee asserts that boys are slower than girls at completing a particular mathematical puzzle. In order to test his assertion, a random sample of 40 boys and a random sample of 60 girls are selected from a large group of students who attempted the puzzle. The times taken by the boys, b minutes,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

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

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

[4]

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



directions = ... fu **[6]**

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

an antinode, what could be the ratio $\frac{\text{displacement of the incident wave}}{\text{displacement of the reflected wave}}$ at any instant?

[3]

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

is the effect of a systematic error on the measurement of a physical quantity?

[6]

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

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

[5]

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

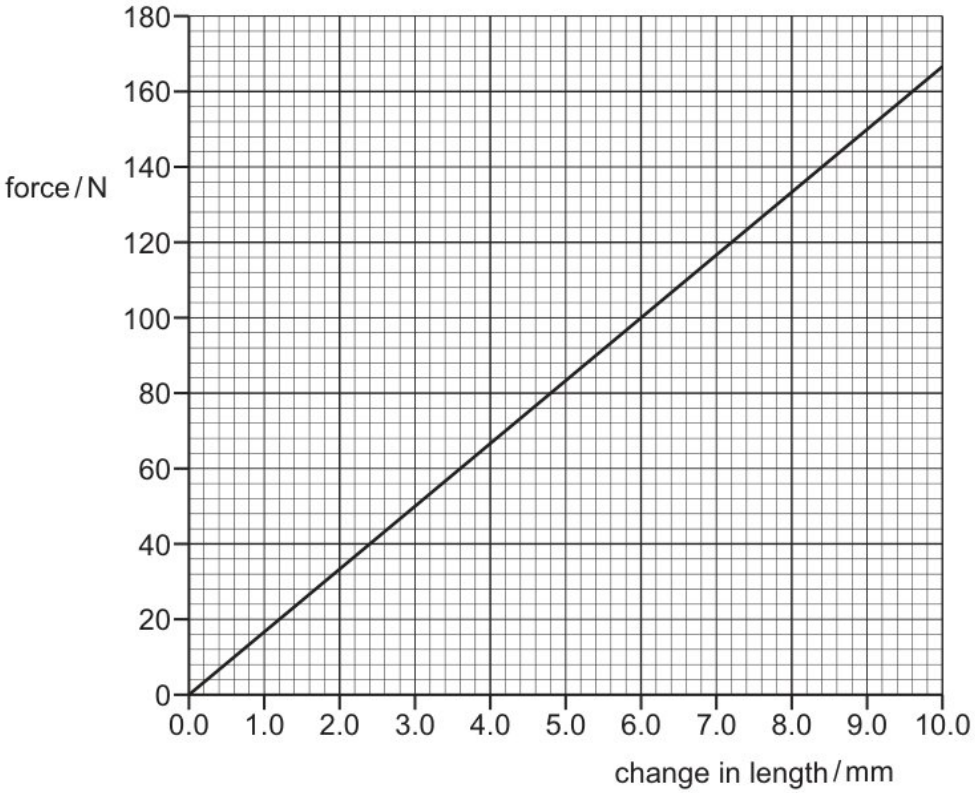
Given that the total number of cars sold during the 5 days is 5 , carry out the test.

Find the value of t when the particle is instantaneously at rest.

[12]

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

your answer correct to 2 decimal places.



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

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

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

[5]

(i) 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.

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]

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

$$\mathrm{F}(x) = \begin{cases} 0 & x \leqslant 0, \\ \frac{1}{3}x^2 & 0 < x \leqslant 1, \\ x - \frac{1}{2} - \frac{1}{6}x^2 & 1 < x \leqslant 3, \\ 1 & x > 3. \end{cases}$$

basis = ... mj **[6]**

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

a tree diagram to represent this information, giving the probability on each branch.

[10]

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

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

[4]

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

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

[3]

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

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

[6]

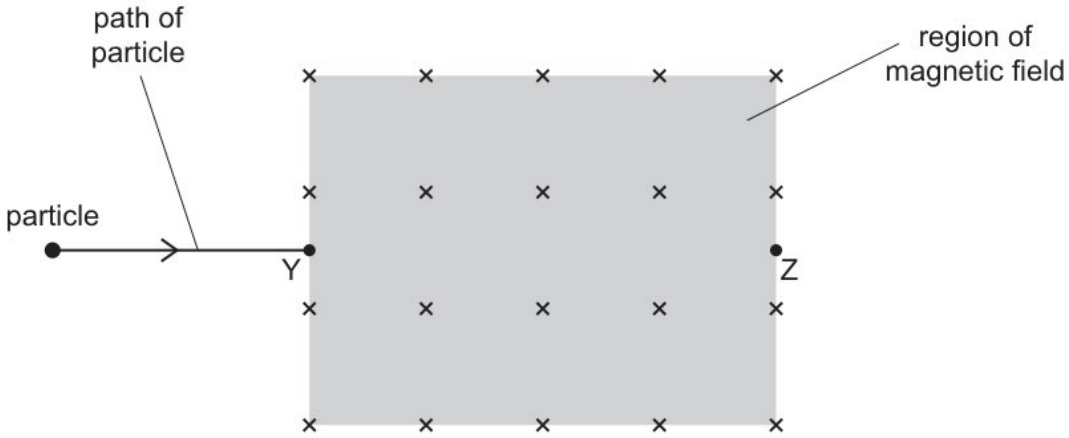
(iii) the distribution function of X.

weight, in grams, of pineapples is denoted by the random variable X which has a normal distribution with mean 500 and standard deviation 91.5. Pineapples weighing over 570 grams are classified as 'large'. Those weighing under 390 grams are classified as 'small' and the rest are classified as 'medium'.

[4]

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

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



[6]

18 a basis for the null space of T .

(d) (ix) diagram correctly represents the forces acting at point P ?

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

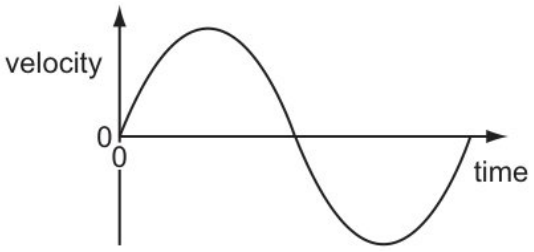
[12]

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

the equation $2\ln(2x) - \ln(x+3) = \ln(3x+5)$.

[6]

(b) (iii) is the angle between the second-order maximum and the third-order maximum?



[10]

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

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

the particular solution of the differential equation

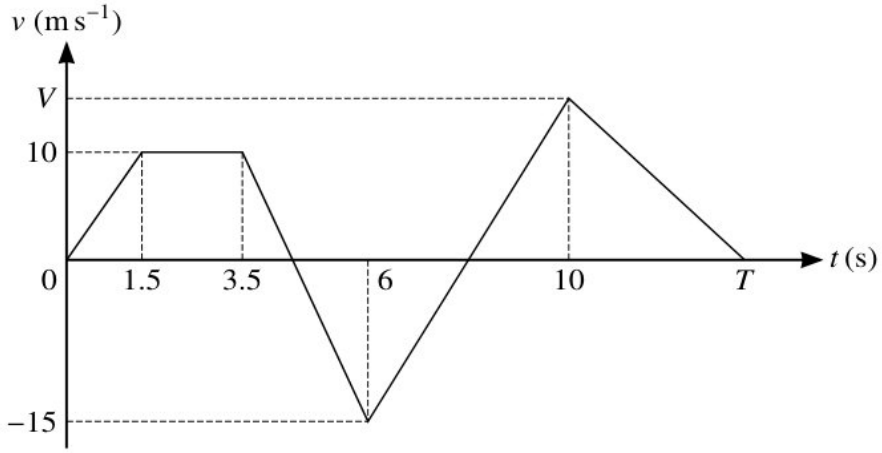
[4]

(c) (iii) the value of n.

as shown in Fig. 2.1.

[5]

(i)



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

[15]

(ii) what is meant by a fundamental particle.

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

no digit can be repeated,

[6]

12 (d) 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.

(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 .

the average power of the aeroplane's engines.

[6]

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

[10]

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

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

same = ... vx **[10]**

(i) control of variables,

[12]

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

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

Find the tension in the string.

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

[6]

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

the range of f,

[10]

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

[5]

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

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

the rank of the matrix

(a) (ii) 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.

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

[8]

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

Find the values of p and q such that

[5]

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

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

[4]

(v) The waves must be coherent.

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

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

[3]

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

Find the equations of the asymptotes of C.

[10]

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

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 $\lambda\mu$.

[12]

(i) there are no restrictions,

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

[6]

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

- coming to rest instantaneously on hitting the ground.

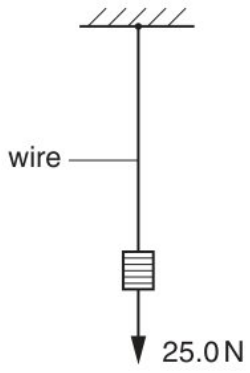
[6]

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

is meant by elastic deformation?

[6]

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



Amplitude is inversely proportional to velocity.

[8]

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

is the average useful power at which he is working?

[20]

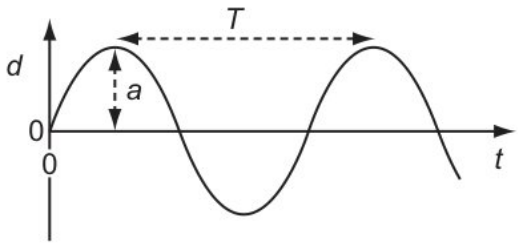
(iv) particle P is moving in simple harmonic motion with centre O. When P is 5 m from O its speed is V m s^{-1}, and when it is 9 m from O its speed is $\frac{3}{5}V$ m s^{-1}. Show that the amplitude of the motion is $\frac{15}{2}\sqrt{2}$ m.

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.

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

[3]

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



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

[20]

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

$$k_1(1 + \cos 4x) + k_2 \sin 4x$$

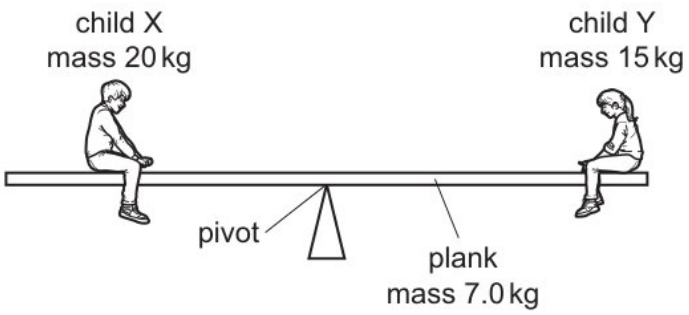
[4]

(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.

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

[5]

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



(c) (i) is given that

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

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

[12]

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

random variable Y is defined by $Y = X^3$. Find

[20]

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

parametric equations of a curve are

[12]

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

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

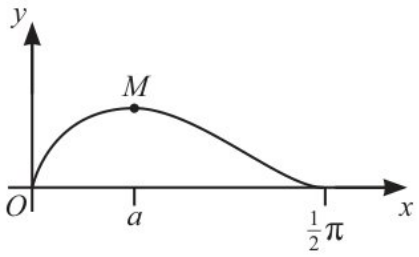
[4]

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

Prove that, for $n \geqslant 2$,

[8]

(f) (iii)



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

[6]

(iv)

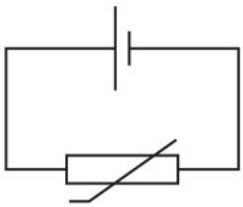


diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

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]

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

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

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]

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

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

is given that $z_1 = r_1 e^{i\theta_1}$ and $z_2 = r_2 e^{i\theta_2}$.

[12]

(a) 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 waves must have equal amplitudes.

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

[20]

(iv) (e) 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.

$$\mathbf{C} = \begin{pmatrix} -1 & -1 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 2 \end{pmatrix},$$

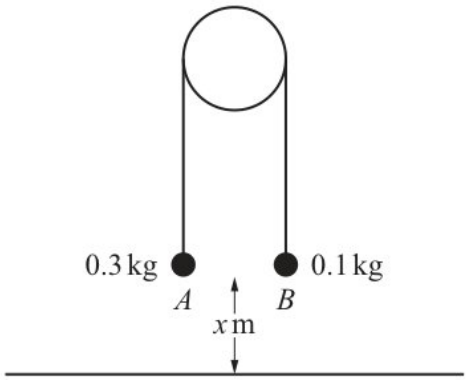
[3]

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

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

[6]

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



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 $0 < \theta < 2\pi$.

[4]

(d) Find the area of the triangle ABC.

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

[6]

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

$$\int_{-1.2}^{1.2} \frac{3}{\sqrt{(9-x^3)}} \mathrm{d}x$$

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

[1]

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

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

de Moivre's theorem to prove that

[4]

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

student is investigating a non-inverting operational amplifier (op-amp) circuit.

[2]

18 (c) 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.

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

[8]

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

Find the coordinates of A and M.

[5]

(i) Find the weight of the lamina.

[5]

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

(vi) 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 .

[1]

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

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

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

[10]

(iii) point D is the reflection of A in l.

[2]

(b) the solution of the differential equation

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

(iii) is a statement of the principle of conservation of momentum for a system?

[6]

(ii) - falling with constant speed with the parachute open,

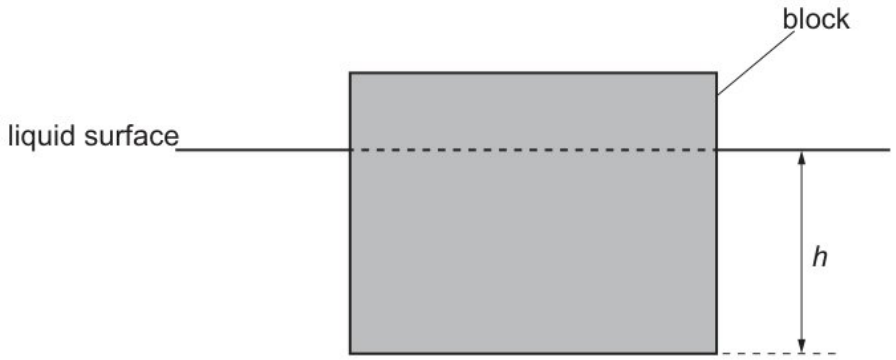
State what is meant by the internal energy of a system.

[3]

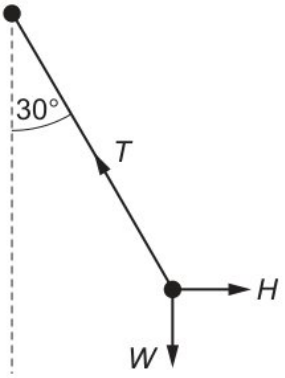
(iv) 8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, \mathrm{d}x$ for $n > 0$.

[5]

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



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



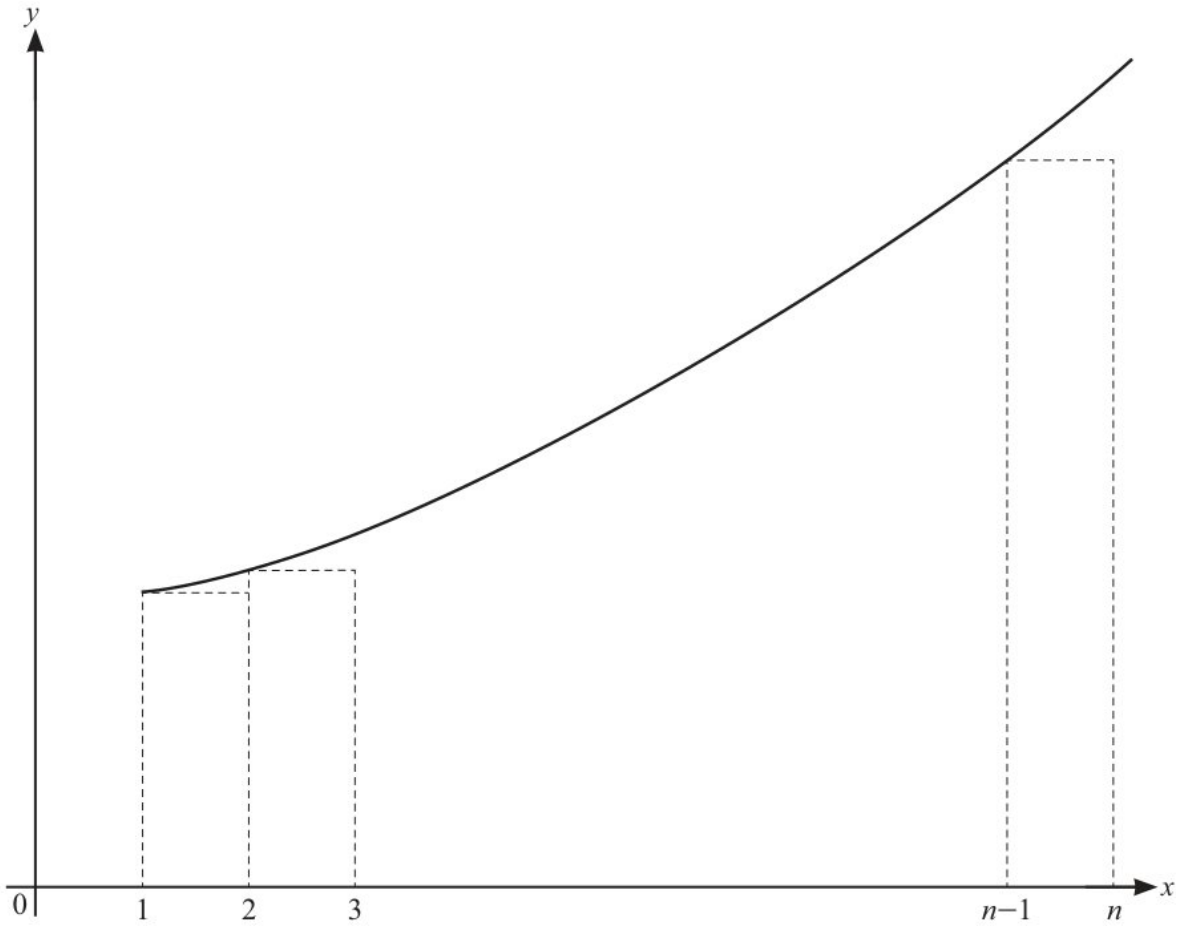
[12]

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

small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

[8]

(a) (iv)



the period of small oscillations,

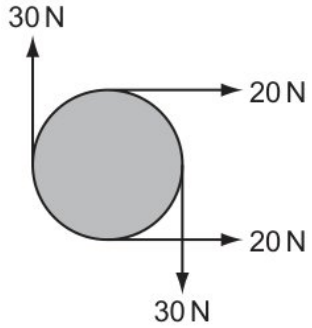
[3]

(ii) Show that the equation

$$2\tan\theta = -\tan 2\theta$$

[4]

(iii)



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

[6]

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

Use implicit differentiation to show that

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

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

[4]

(ii) what is meant by a fundamental particle.

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

[3]

(c) (i) 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.

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.

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

gamma-ray = ... qx **[5]**

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

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

[6]

(iv) Find the position vector of D.

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

[6]

(h) (iii) 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.

Over 50 198 212 217 229 235 242

[8]

(v) Find the weight of the lamina.

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

[4]

(i) the sum to infinity of the progression.

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

[3]

(d) (i) 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.

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

[8]

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

State the value of $\mathrm{E}(X)$.

[6]

(ii) parametric equations of a curve are

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

[10]

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

changes to R_1 and to R_2 will increase the value of V_{out} ?

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

[5]

(v) 1.1 shows the measurements for cube A.

525 520 522 524 518 520 519 525 527 516

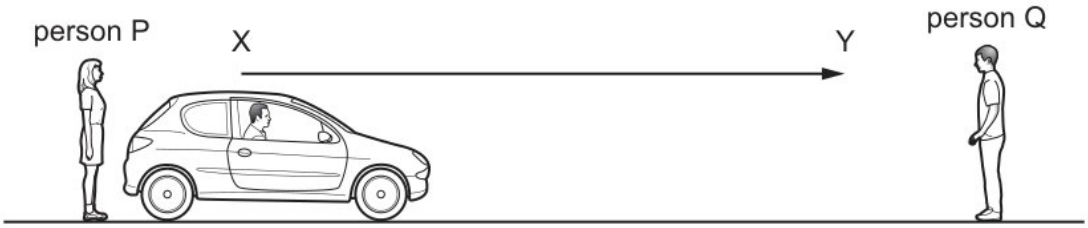
[2]

(b) (ii) 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 .

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

[6]

(iii)



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

[2]

14 the period of small oscillations,

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

$$\operatorname{cosec}^5\theta = \frac{a}{\sin 5\theta + b\sin 3\theta + c\sin\theta}$$

the probability that both marbles chosen are the same colour.

[12]

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

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

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.

[6]

(iv) (b) is the approximate range of wavelengths in free space for infrared radiation?

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

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

[5]

(d)

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

Find the speed of P when it passes through L.

The orbit has a period of 25 hours.

[6]

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

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

[5]

(a) the probability that at least 2 of the marbles chosen are blue, given that at least 1 red marble and at least 1 blue marble are chosen.

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

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

[15]

11 student investigates an electrical circuit.

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

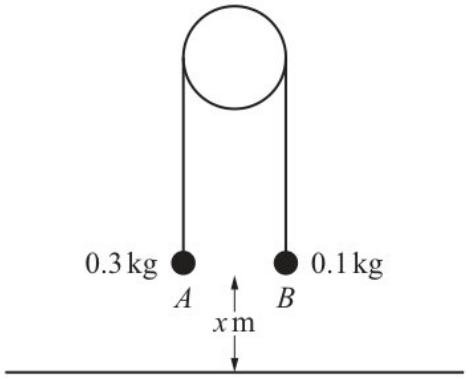
that, at the point $A(-1, 1)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -4$.

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.

[10]

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

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



[3]

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

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

such = ... zd **[12]**

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

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

[6]

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

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

parametric equations of a curve are

[6]

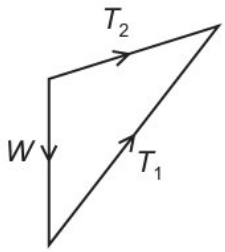
(ii) the time that it takes for the block to move 2 m down the plane from rest.

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

[4]

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

(c) (i)



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

[6]

(vi) an antinode, what could be the ratio $\frac{\text{displacement of the incident wave}}{\text{displacement of the reflected wave}}$ at any instant?

$$I_3 = \frac{3}{1024}\pi + \frac{1}{128}$$

[6]

(a) (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.

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

[1]

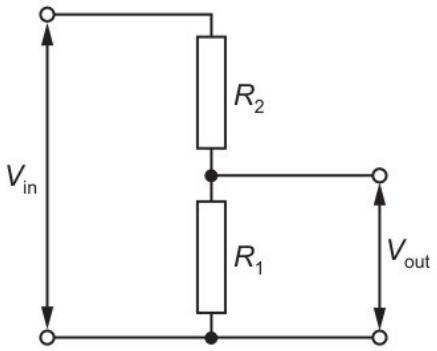
(i) particle P is projected from a point O on horizontal ground. 0.4 s after the instant of projection, P is 5 m above the ground and a horizontal distance of 12 m from O.

Find the exact value of the arc length of C.

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.

[8]

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



State the value of $\mathrm{E}(X)$.

(iv) (d) 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.

obtain the roots of the equation

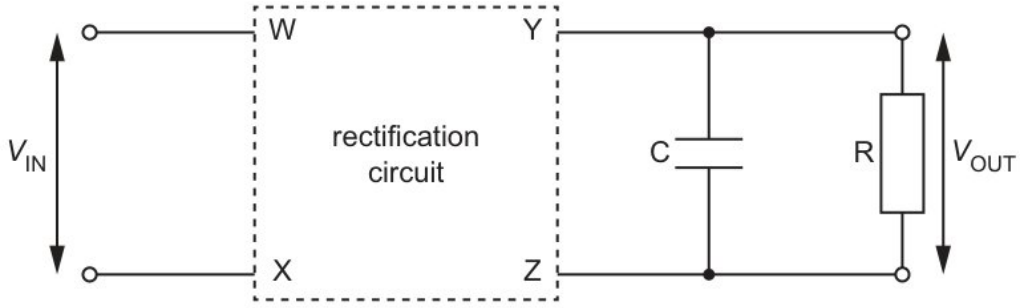
[6]

(c) the solution of the differential equation

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

[4]

(i) (c)



should pay particular attention to

[6]

(f) the value of σ.

Find the exact value of the arc length of C.

[5]

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

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

[8]

(ii) (h) When the tensile force is removed, the wire returns to its original length.

continuous random variable X has probability density function f given by

$$x = \tanh^{-1} t \quad \text{and} \quad y = t\,\mathrm{sech}^{-1} t, \quad \text{for } 0 < t < 1$$

[6]

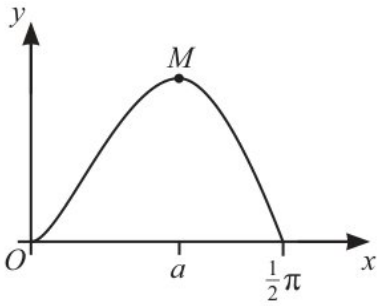
(c) a, b and c are integers to be determined.

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

[6]

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

(ii) (a)



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

no unique solution.

[6]

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

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

[4]

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

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

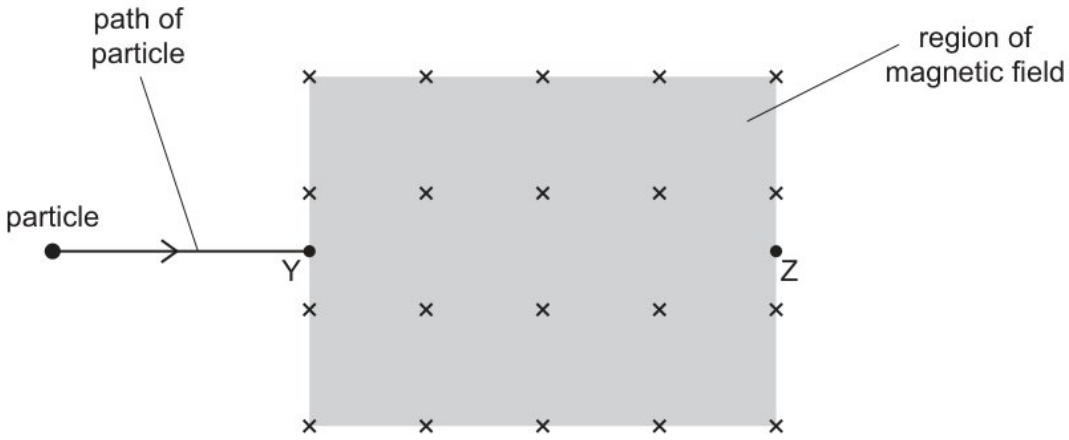
[4]

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

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

[8]

(d)



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

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

[5]

(a)

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

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

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.

[10]

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

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

continuous random variable X has probability density function f given by

[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 ?

current-carrying coil produces a magnetic field.

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.

[2]

(a) (v) up the probability distribution table for X.

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

[4]

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

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

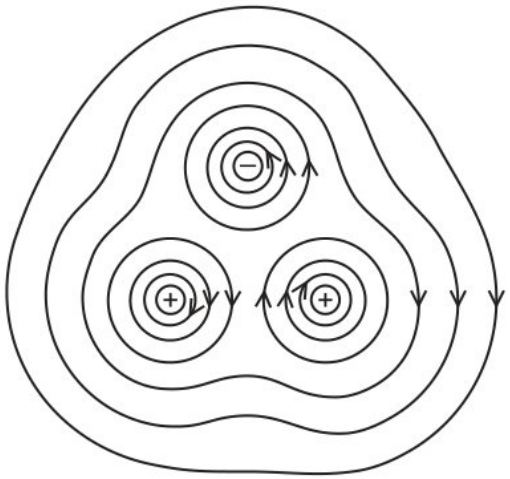
[6]

(iv) the solution of the differential equation

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

[6]

19 Find the period of the motion.



(c) (i) 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.

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

[4]

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

is the reading on the ammeter?

[6]

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

Q hears a sound of decreasing frequency.

[3]

(a) (ii) Show that the equation

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

[6]

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

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

[4]

(iii) observer views the slit through the grating at different angles, moving his head from X parallel to the grating, through Y , opposite the slit, to Z parallel to the grating on the opposite side.

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

[3]

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

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

[2]

(iii) an antinode, what could be the ratio $\frac{\text{displacement of the incident wave}}{\text{displacement of the reflected wave}}$ at any instant?

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

[6]

9 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.

(e) (iii) aeroplane is flying horizontally. The aeroplane's engines are producing a constant power of 5500 kW , and the aeroplane experiences a constant horizontal resistance force of 25 kN .

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

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

[6]

(i) curve C has equation

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

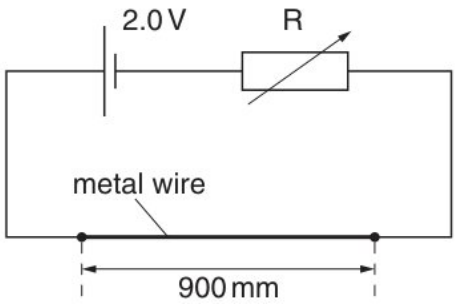
[6]

(b) (iv) Estimate the probability of throwing a 4.

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

[6]

(i)



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

[6]

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

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.

the probability of a Type I error.

[6]

(vi) frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m . Assume that the weights of the rods are negligible.

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

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

[8]

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

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

[2]

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

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

[8]

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

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?

[10]

18 radius of the circle in which P moves and the radius of the circle in which Q moves,

(c) (iii) 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.

the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.

[6]

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

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

[2]

(i)

matrix **A** is given by

[3]

(a) (ii) 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.

State one other feature of this orbit.

[5]

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

Carry out the test.

[12]

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

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]

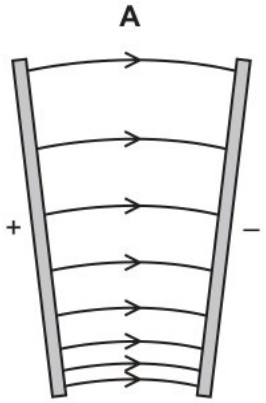
14 many competitors would you expect to have times within 1.2 minutes of the mean time?

(e) (ii) 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.

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

[8]

(i)

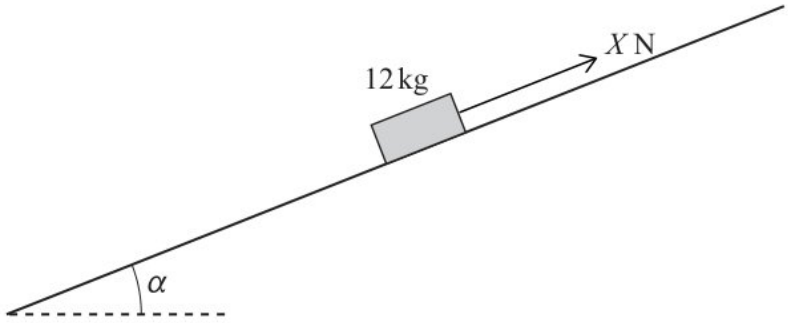


a back-to-back stem-and-leaf diagram to represent this information, with Gulls on the left-hand side.

[6]

(vi) 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 .

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



[4]

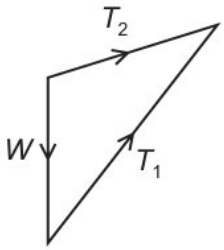
(iv) Show that $u^3 + 8 = 0$.

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

particle is not involved in the decay process?

[10]

(c) (iii) the ductile material,



Find the median of X.

[5]

(ii) Find the work done by the tension.

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

[6]

(i) The waves must be polarised.

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

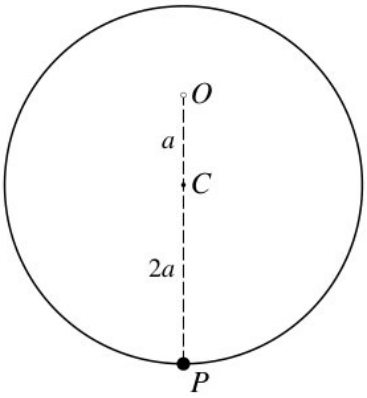
[4]

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

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

[4]

(i)



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

[2]

(v) the acute angle between the planes ABC and ABD.

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

[12]

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

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

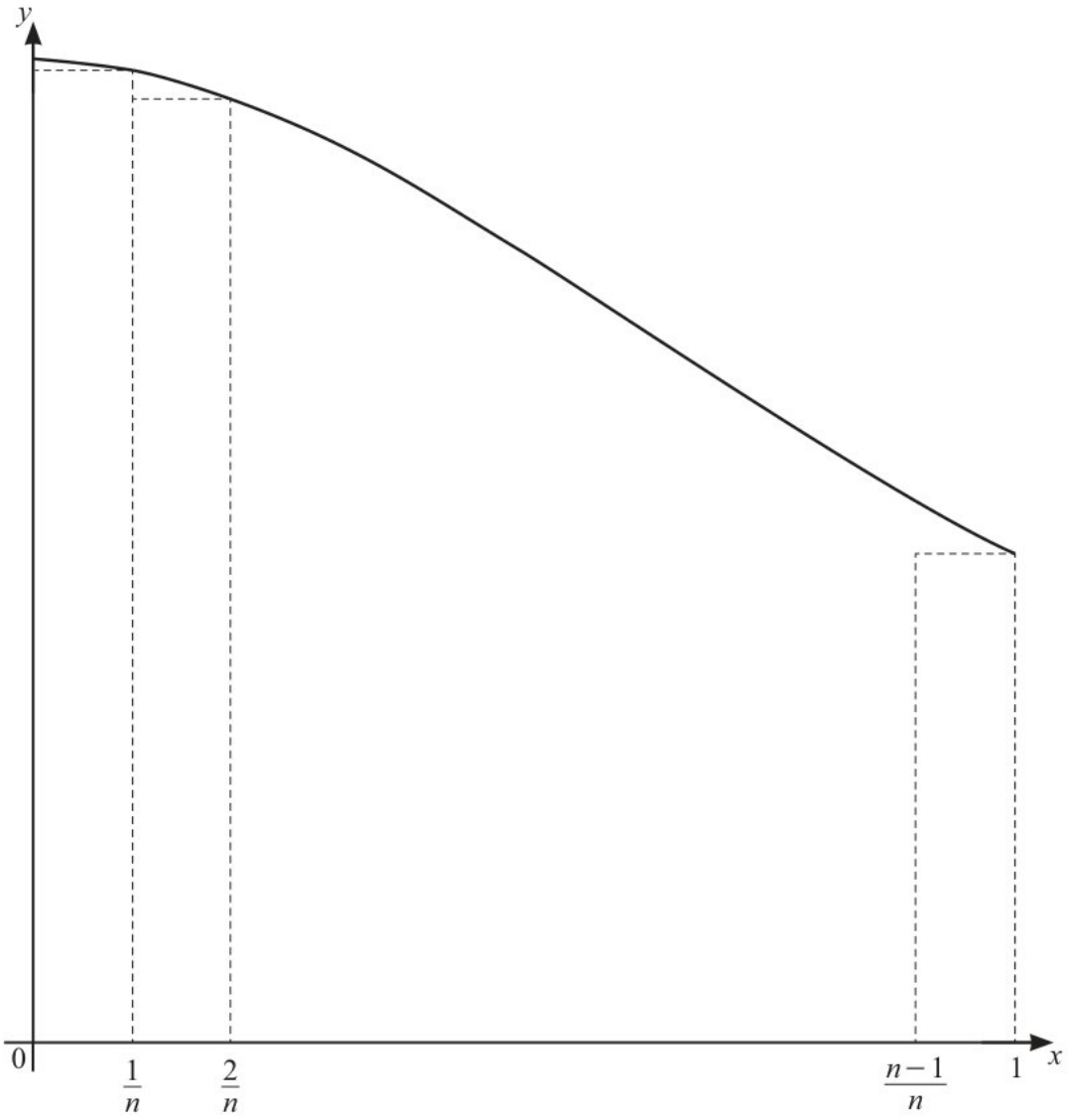
[10]

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

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

[4]

(v)



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

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

[12]

(iii) internal diameter of the beaker is 0.05 m ± 3%.

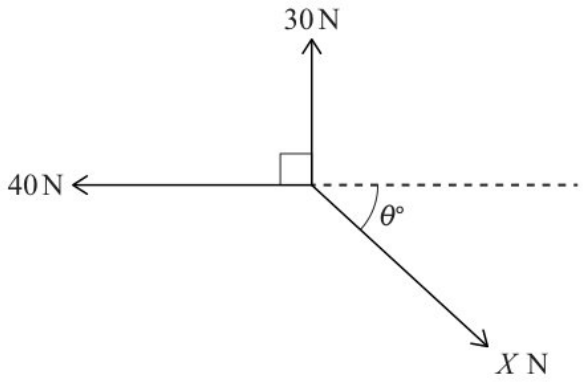
Carry out the test.

[6]

13 and N are two electromagnetic waves.

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

(f) (ii)



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

[2]

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

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

[12]

(d) (v) specific latent heat.

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

device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

[15]

(ii)

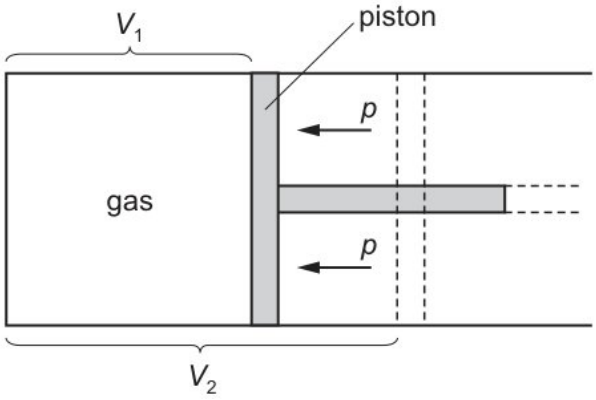


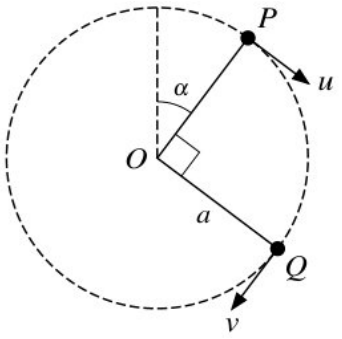
diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

[5]

9 only one of the following two alternatives.

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

(b) (iii)



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]

(iv) 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.

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

[3]

(f) (iii) Young modulus E can be determined from measurements made when a wire is stretched.

Find the period of the motion.

[3]

(i) width of the 99% confidence interval is double the width of the x% confidence interval.

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

[10]

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

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?

[8]

(ii) analysis of the data,

is the average useful power at which he is working?

function, = ... na **[6]**

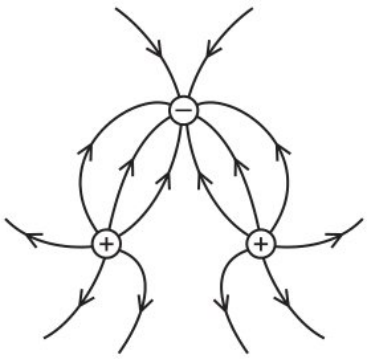
(iv) skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

complex number $1 - (\sqrt{3})$i is denoted by u.

[10]

17 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.

(b) (i)



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

[5]

(v) The total momentum is conserved provided that no external forces act.

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

[5]

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

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

[8]

(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.

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

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

[8]

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

statement about nuclei is correct?

[4]

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

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.

[4]

20 (i) diagram illustrates successive wavefronts.

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

[4]

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

[20]

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

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

[8]

(d) only one of the following two alternatives.

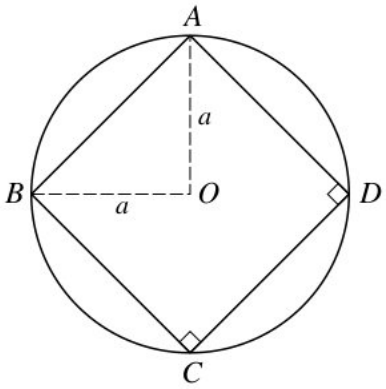
[12]

(a) 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 .

the exact volume of the solid generated

[4]

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



(d) there are no restrictions,

[15]

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

[4]

20 The matrix $\mathbf{B}$ is given by $\mathbf{B} = \mathbf{A} - 2\mathbf{I}$, where $\mathbf{I}$ is the 3×3 identity matrix. Write down the eigenvalues of $\mathbf{B}$, and state a set of corresponding eigenvectors.

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

measuring instrument should be used?

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

[4]

(iv) 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.

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

[6]

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

up the probability distribution table for X.

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

[2]

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

aeroplane is flying at a constant speed.

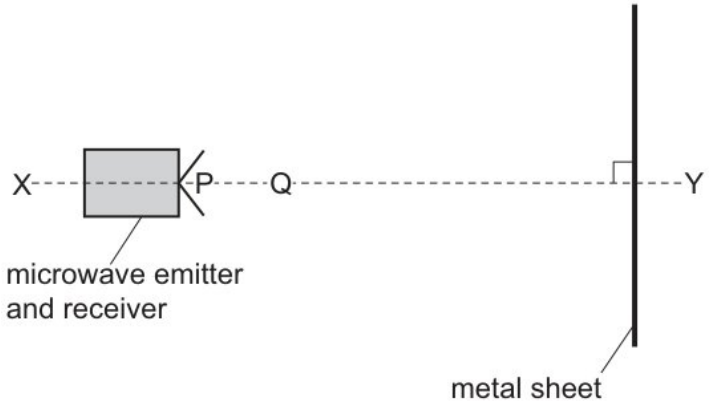
[6]

(i) 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.

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

[5]

(c) (ii)



is the force exerted on the wall by the water?

[6]

(i) Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

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

[6]

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

(h) (iv) 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.

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

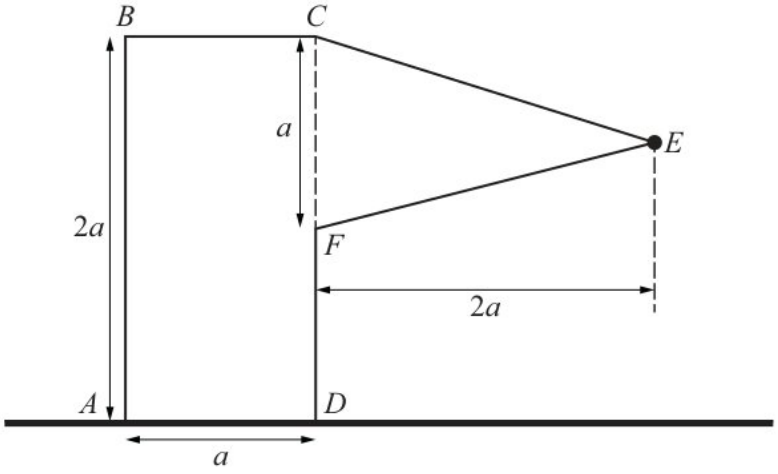
[3]

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

combined resistance is 66kΩ.

[4]

(g) (iii)



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

[2]

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

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

[12]

(iv) force = mass × acceleration

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

[5]

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

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

(i) (c) the value of α.

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.

[6]

(a) analysis of the data,

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.

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

[12]

(ii) (c) student takes measurements to calculate the density of a liquid in a beaker.

$$I_n = \int_0^{\frac{1}{2}\pi} \cos^n x \, \mathrm{d}x$$

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

[6]

(a) The potential difference across any component connected to the battery will be 9.0 V .

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

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

[6]

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

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 .

[6]

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

the significance level of the test.

[10]

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

statement about nuclei is correct?

[5]

(iv) (b) Deduce an approximation to the area of region B and explain why this approximation under- estimates the true area of region B.

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

[6]

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

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

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

[8]

17 two assumptions of the simple kinetic model of a gas.

(a) (ii) 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 $\lambda\mu$.

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

P has mass 6.0 kg and is moving at a speed of 3.0 ms^{-1}.

that = ... vq **[5]**

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

in either order the value of μ and the value of σ

[6]

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

Find a set of corresponding eigenvectors.

[15]

(b) (i)

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

three quantities that are conserved during the decay.

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

[12]

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

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.

[3]

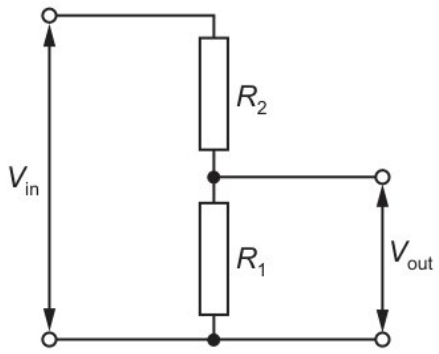
(ii) Find the equations of the asymptotes of C.

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.

[15]

23 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

(c) (i)



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

[6]

(iii) Find the equations of the asymptotes of C.

the equations of the asymptotes of C.

[3]

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

Find the probability density function of Y.

Find the tension in the string in terms of W.

[12]

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

the term interference.

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

[8]

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

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

[8]

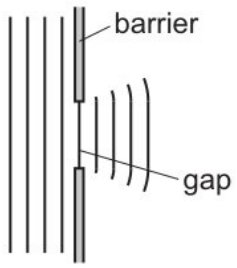
(ix)

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

then it converges to a.

[8]

(i)



show that $PQ = 13$,

a vector equation for l.

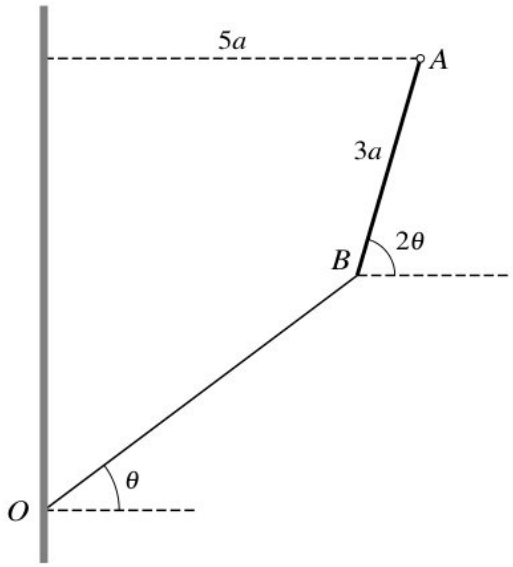
[6]

(e) (iv) the total time for which she is in motion from the instant that she passes O.

only one of the following two alternatives.

[4]

(i)



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

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

[6]

11 P hears a sound of increasing frequency.

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

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

(d) (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.

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

[10]

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

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

[6]

(g) (iii) that $rp^3 = q^3$.

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

[3]

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

far apart are two adjacent interference fringes that are formed on the laboratory wall?

$$\int_0^a \left(1 + 2x + 3\mathrm{e}^{3x}\right) \mathrm{d}x = 250$$

[8]

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

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

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

[5]

(i) curve C has equation

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.

than = ... ut **[6]**

(v) State one other feature of this orbit.

The waves must be coherent.

[10]

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

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

[12]

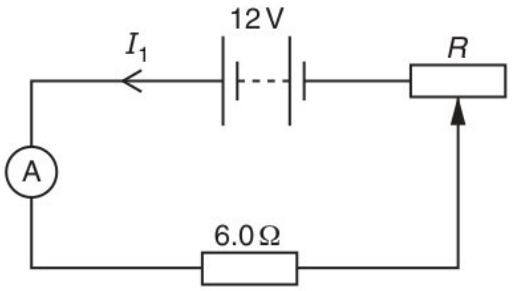
(i) marble is chosen at random from bag A and placed in bag B.

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

[8]

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

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



[1]

(d) (v) are the amplitude and the period of wave S ?

a and **b** are vectors and t is a scalar.

the probability density function of Y,

[4]

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

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

[5]

27 transmitted light has intensity I.

weight, in grams, of pineapples is denoted by the random variable X which has a normal distribution with mean 500 and standard deviation 91.5. Pineapples weighing over 570 grams are classified as 'large'. Those weighing under 390 grams are classified as 'small' and the rest are classified as 'medium'.

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

Show that the total distance fallen is 1048 m .

[8]

(i) Find the weight of the lamina.

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

[1]

(v) diagram correctly represents the forces acting at point P ?

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 .

[20]

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

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

[4]

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

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

[6]

(d) (i) 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.

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

[10]

(ii) curve C has parametric equations

matrix $\mathbf{A}$ is given by

[6]

(c) (iii) random variable Y is defined by $Y = X^3$. Find

the position vector of P.

[15]

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

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

[3]

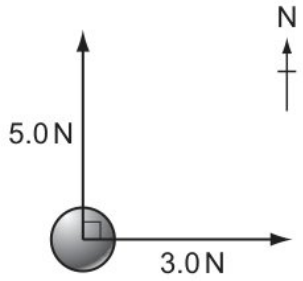
(i) Calculate the acute angle between the planes p and q.

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

[8]

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

(c) (ii)



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

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.

[2]

(i) all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

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.

[1]

(b) (iii) 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.

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

[15]

(i) Deduce that the cartesian equation of C is

are no resistive forces acting on the block.

[5]

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

There will always be 9.0 V across the battery terminals.

Find the values of a and b.

[1]

(iv) leptons are emitted from the sodium-21 nucleus during the decay?

Find the value of I_2.

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

[4]

(e) (i) small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

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

[5]

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

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

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

[4]

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

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

[2]

(a) (iii) is the density of the mixture with volume 2.0 m^3 ?

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.

is the useful power output of the power station?

[5]

(i) is the total resistance between the two ends of the coil?

a and **b** are vectors and t is a scalar.

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

[5]

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

cable has tensions T_1 and T_2 as shown.

[5]

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

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

original = ... *pm* **[10]**

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

is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

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

[5]

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

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

[4]

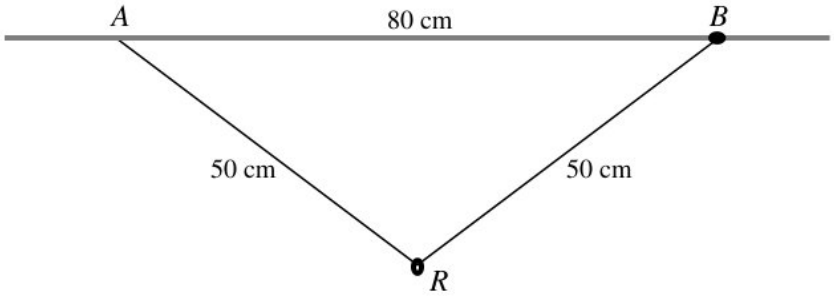
9 Show that $m = 0.9$.

(a) (iii) is given that $\sum_{r=1}^{n} u_r = n^2(2n+3)$, where n is a positive integer.

is given that a is a positive constant such that

[10]

(ii) source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by



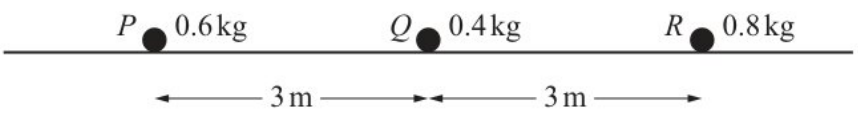
[5]

(f) (i) lowest mark was 17 and the highest mark was 74 .

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

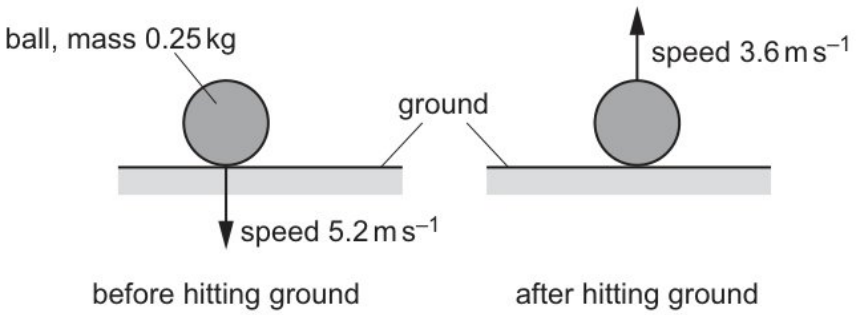
[4]

(iii) 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 .



[8]

(c) (iii)



Find the area of the triangle ABC.

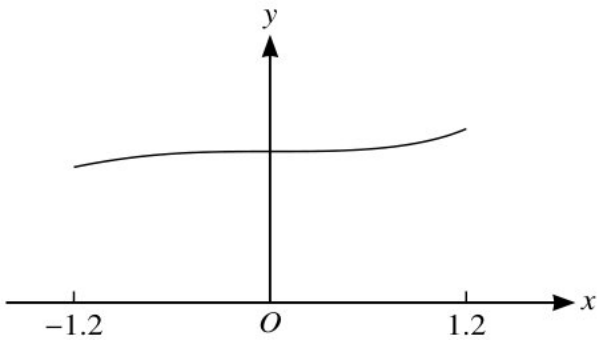
[20]

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

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

[10]

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



Prove that, for $n \geqslant 2$,

[4]

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

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.

[3]

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

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

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.

[5]

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

the value of x.

[4]

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

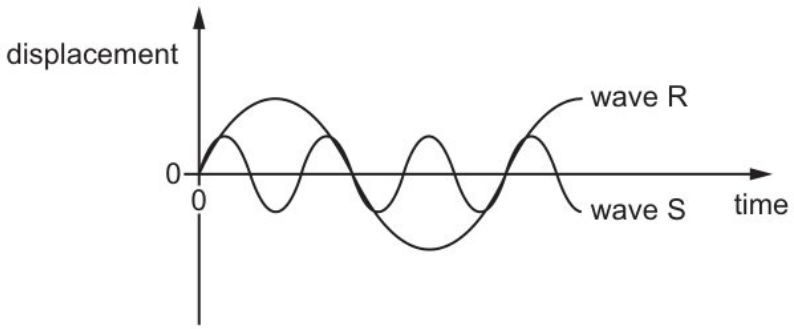
the probability that more than 7 study Art or Music.

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

[3]

19 Find the cartesian equation of Π_1.

(c) (ii) the number of different ways in which these three bands can be selected.



Hence solve the equation

[6]

(vii) Find the value of x.

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

[4]

(b) (ii) Find also the value of $\frac{1}{\alpha^2\beta^2} + \frac{1}{\beta^2\gamma^2} + \frac{1}{\gamma^2\alpha^2}$.

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

[4]

(vi) only one of the following two alternatives.

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.

[6]

(a) (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.

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

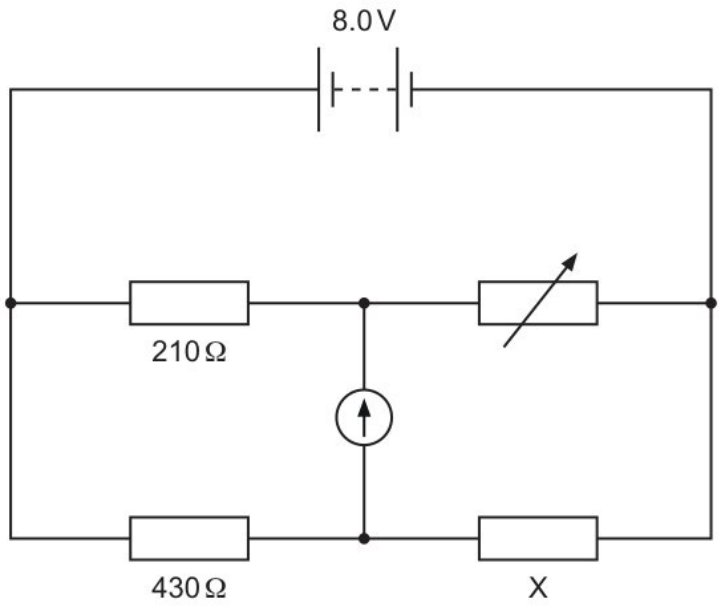
[6]

(v) the value of μ.

only one of the following two alternatives.

[6]

(iii)

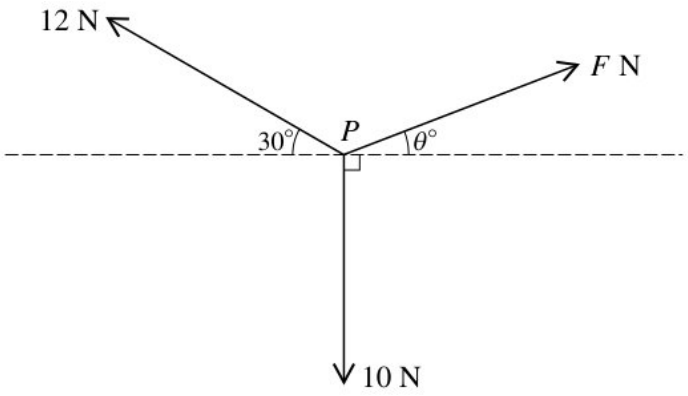


resistor of resistance 240Ω is now replaced by a new resistor X of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.

[8]

25 particle P is projected from a point O with speed U at an angle 45° above the horizontal and moves freely under gravity.

(d) (iv)



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

find the variance of the number of 4 s obtained in 30 throws,

[6]

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

is the average useful power at which he is working?

hollow = ... qg **[5]**

(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 $t = 4$.

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

[5]

(i) total energy input E_{in} in a process is partly transferred to useful energy output U and partly transfered to energy that is wasted W.

progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

[4]

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

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.

no unique solution.

[5]

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

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

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

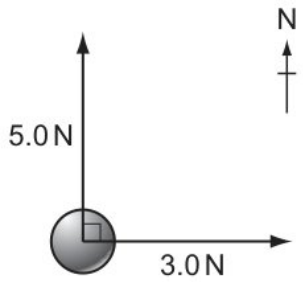
[2]

(a) (iv) Show that the tension in the string is 10 N .

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

[4]

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



[10]

(c) (ii) Show that $m = 0.9$.

waves are emitted from two sources.

[12]

(iv) observer views the slit through the grating at different angles, moving his head from X parallel to the grating, through Y , opposite the slit, to Z parallel to the grating on the opposite side.

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.

parallel = ... *py* **[3]**

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

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

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

[5]

(ii) statement about the weight of the plank is correct?

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.

[5]

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

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

[6]

(f) (ii) Find $\sum_{r=n+1}^{2n} u_r$.

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

[10]

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

student investigates an electrical circuit.

[8]

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

Speed is distance travelled per second.

[3]

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

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.

[5]

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

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

[15]

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

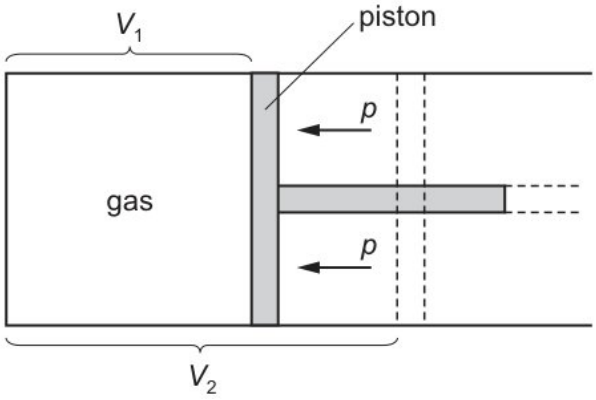
aeroplane then ascends 300 m in 50 s , while maintaining the same speed. The resistance force is no longer constant, and the work done against the resistance force in ascending the 300 m is 270000 kJ . The mass of the aeroplane is 60000 kg .

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

[2]

28 only one of the following two alternatives.

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



line l passes through B and C.

[3]

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

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

[5]

(i) curve C has equation

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

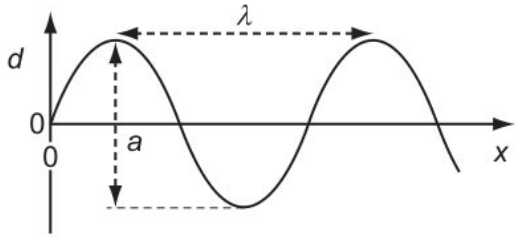
[3]

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

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

[8]

(ii)



the inequality $3x - 1 < |2x - 3|$.

a basis for the null space of T .

[8]

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

curve C has equation $y = \frac{1}{2}(e^x + e^{-x})$ for $0 \leqslant x \leqslant \ln 5$. Find

[5]

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

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

[6]

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

Find the tension in the string in terms of W.

[8]

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

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

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.

[12]

(d) (i) Prove by mathematical induction that, for all positive integers n,

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

the term interference.

[5]

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

- coming to rest instantaneously on hitting the ground.

[4]

35 Q hears a sound of decreasing frequency.

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

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

[12]

(ii) 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 ?

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

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

[5]

(d) (v) Given that $\mathrm{E}(X) = 1.2$, find the value of a.

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

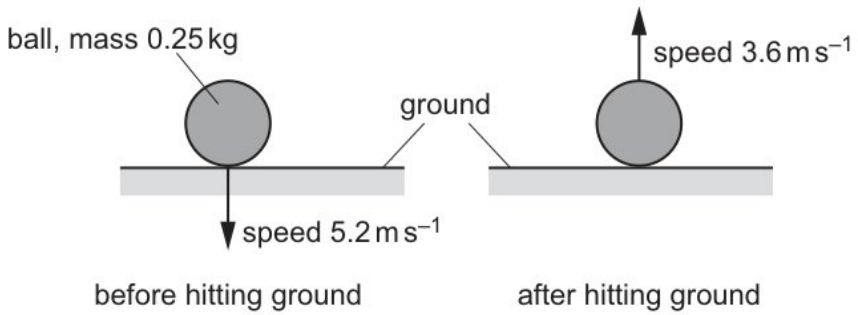
[6]

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

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

[5]

(iii)



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

[6]

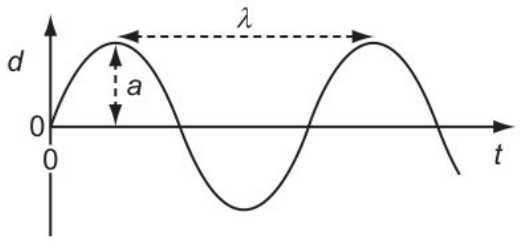
(i) shop sign weighing 75 N hangs from a frame attached to a vertical wall.

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.

[10]

11 Find the probability that the total number of cars sold in the two showrooms during 3 days is exactly 2 .

(b) (i)

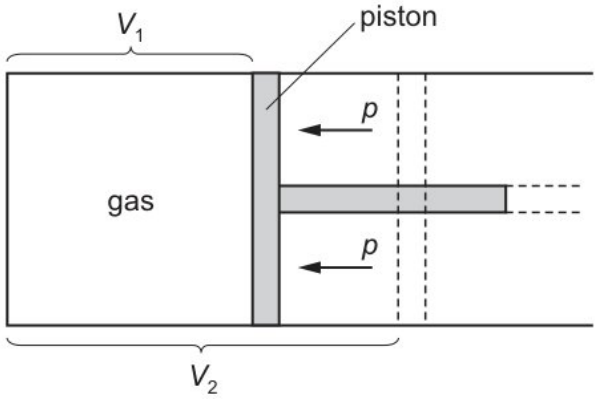


Its speed decreases to zero, then increases to a value less than 20 ms^{-1}.

[8]

(iii) lines l_1 and l_2 have equations

Given that $\text{E}(X) = 1.2$, find the value of a.



[3]

(ii) 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).

force = mass × acceleration

[15]

(a) (i)

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

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

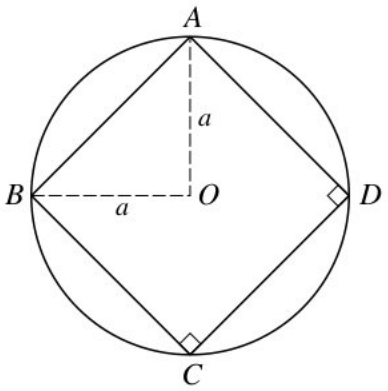
[5]

(iii) a positron and an antineutrino

Deduce an approximation to the area of region B and explain why this approximation under- estimates the true area of region B.

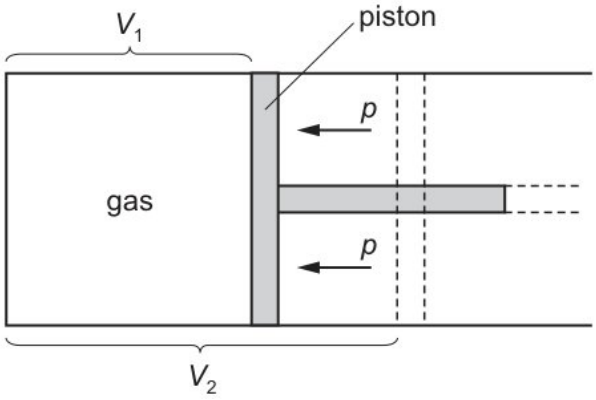
[5]

(vi) 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.



[5]

(d) (i)



Find the coordinates of any intersections with the coordinate axes.

[5]

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

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

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

[10]

(ii) Form two simultaneous equations and hence find x and v.

In the case where $k = 2$,

[4]

(c) (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.

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

[6]

(iii) changes to R_1 and to R_2 will increase the value of V_{out} ?

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.

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

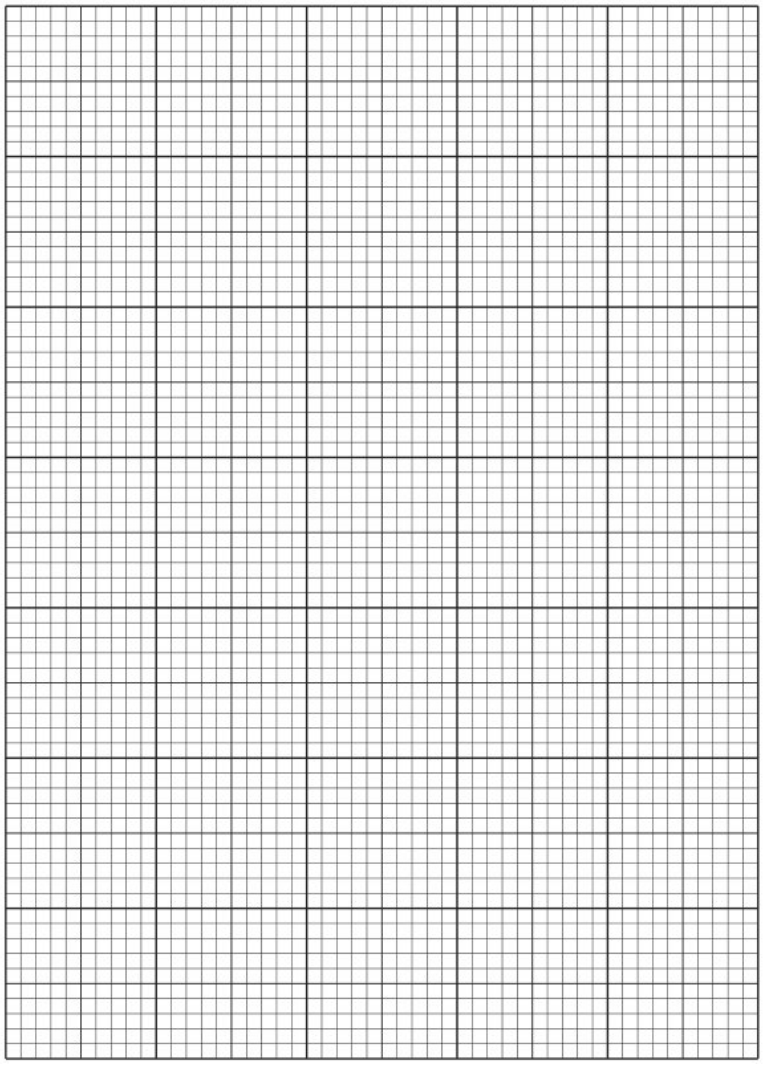
[6]

(v) frequency of the signal is 50 kHz .

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

[10]

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



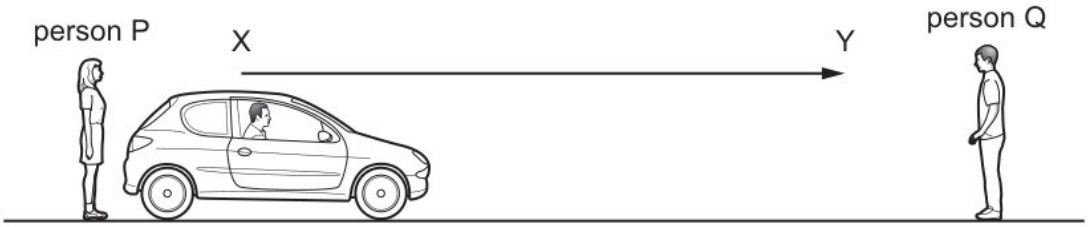
(d) (i)

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

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

[8]

(iii)



Show that the mass of P is 0.8 kg .

[8]

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

the acute angle between the planes ABC and ABD.

[5]

(vi)

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

[4]

(iii) 1 Which quantity is a scalar quantity?

the vertical and horizontal components of velocity at time t.

[15]

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

the equations of the asymptotes of C.

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

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

[1]

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

[6]

(vi) 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.

[10]

(b) potential difference is applied between two metal plates that are not parallel.

(vii) the de Broglie wavelength of an electron moving at a speed of 4.9×10^{7} m s^{-1}.

	amplitude /cm	period /ms
A	2	10
B	2	90
C	4	10
D	4	90

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

[12]

(iii) your answer correct to 2 decimal places.

[4]

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

$$x^3 - 2y^3 = 3xy.$$

In the case where $k = 1$,

(i) 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}.

the value of n.

[12]

(iv) the distribution function of X.

[4]

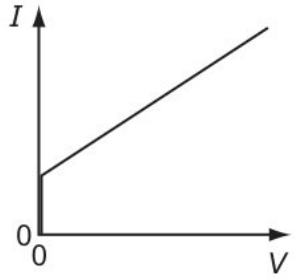
(ii) Find the value of $(\alpha+1)(\beta+1)(\gamma+1)$.

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

[2]

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

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



[8]

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

(ii) Given that, in fact, the mean concentration for patients taking the drug is 0.175 , find the probability of a Type II error occurring in the test.

$\mathbf{r} = 2\mathbf{i}-3\mathbf{j}+\mathbf{k}+\lambda(\mathbf{i}-2\mathbf{j}-\mathbf{k})$ and $\mathbf{r} = 2\mathbf{i}-3\mathbf{j}+\mathbf{k}+\mu(2\mathbf{i}+3\mathbf{j}-\mathbf{k})$.

[6]

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

[10]

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

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

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

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

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

[6]

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

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

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

perimeter = ... bd **[2]**

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

$$\text{cosec}^5\,\theta = \frac{a}{\sin 5\theta + b\sin 3\theta + c\sin\theta}$$

[3]

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

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

lamina is freely suspended at A and hangs in equilibrium.

[4]

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

greengrocer claims that his cabbages have a mean mass of more than 1.2 kg . In order to check his claim, he weighs 10 cabbages, chosen at random from his stock. The masses, in kg , are as follows.

[3]

(iii) Show that x satisfies the equation

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

[6]

14 random variable X is the number of heads obtained.

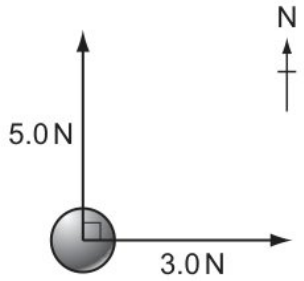
(a) (ii)

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

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

[3]

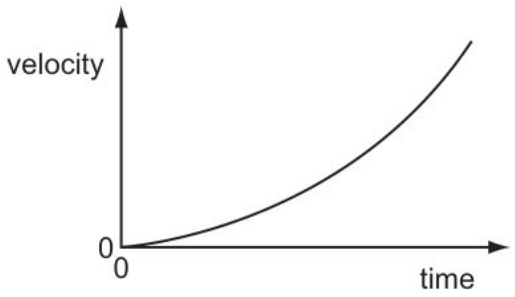
(i) Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.



the coordinates of C,

[8]

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



[10]

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

$$\overrightarrow{OA} = \mathbf{i} + 2\mathbf{j}, \quad \overrightarrow{OB} = \mathbf{i} + 3\mathbf{j} - 2\mathbf{k} \quad \text{and} \quad \overrightarrow{OC} = 2\mathbf{i} - \mathbf{j} + 3\mathbf{k}$$

[6]

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

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

row describes the horizontal and vertical components of its motion as it travels between the plates?

[3]

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

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

[12]

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

[10]

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

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

[3]

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

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

[4]

16 only one of the following two alternatives.

$$\mathrm{f}(x) = \begin{cases} 0 & x < 0 \\ a\mathrm{e}^{-x\ln 2} & x \geqslant 0 \end{cases}$$

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

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

(e) (iii) continuous random variable X takes values in the interval $0 \leqslant x \leqslant 3$ only. For $0 \leqslant x \leqslant 3$ the graph of its probability density function f consists of two straight line segments meeting at the point $(1, k)$, as shown in the diagram. Find k and hence show that the distribution function F is given by

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

[8]

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

the particular solution of the differential equation

[8]

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

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.

[5]

(v) curve C has equation

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

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

[6]

(a) (v)

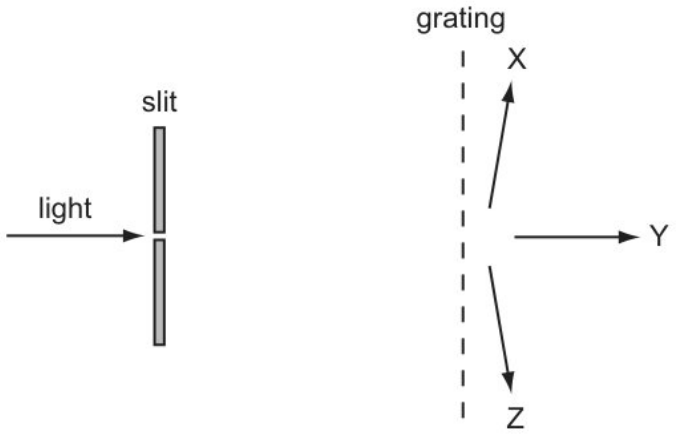


diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

[8]

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

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

[6]

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

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

[2]

(vi) 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 $0 < \theta < 2\pi$

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

that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - ye^x}{xe^x + 2y}$.

[4]

19 (b) is the magnitude of F when the child stands at X and when the child stands at Y ?

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

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.

continuous random variable X has probability density function f given by

[10]

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

$$\frac{\mathrm{d}^2 z}{\mathrm{d}x^2} + 4\frac{\mathrm{d}z}{\mathrm{d}x} + 4z = 8x^2$$

[4]

(i) procedure to be followed,

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

[3]

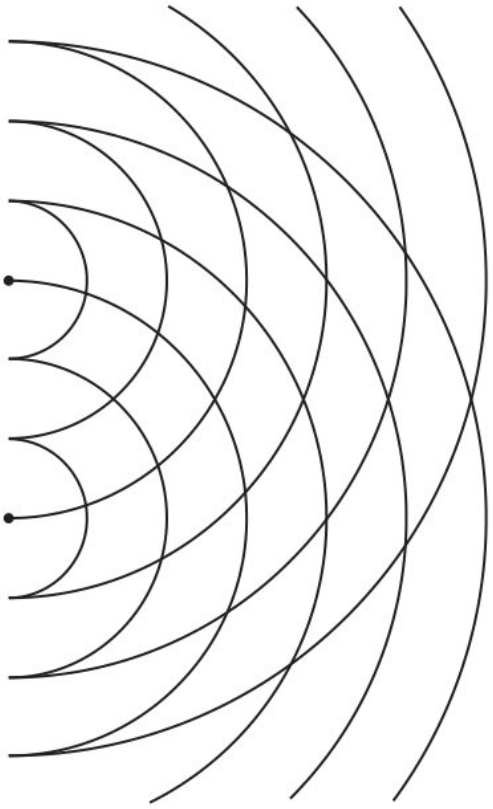
(d) a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.

a, b and c are integers to be determined.

the probability of a Type I error.

this compression, work W is done on the gas.

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



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.

[4]

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

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

[2]

(a) The matrix **B** is given by $\mathbf{B} = \mathbf{A} - 2\mathbf{I}$, where **I** is the 3×3 identity matrix. Write down the eigenvalues of **B**, and state a set of corresponding eigenvectors.

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

uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

[6]

(vi) the significance level of the test.

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

[4]

(iv) 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 $\frac{1}{n}$.

[4]

(f) student investigates an electrical circuit.

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

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

[10]

(iii) the solution of the differential equation

[4]

19 Calculate the acute angle between the planes.

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

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

[3]

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

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.

[3]

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

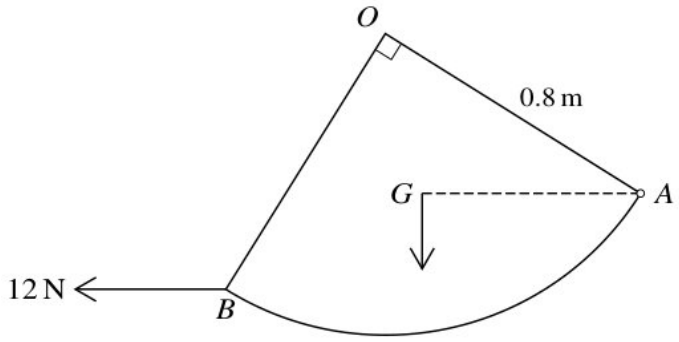


diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

[3]

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

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

[10]

(ii) gravitational potential at a point.

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

[5]

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

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

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

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

[6]

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

curves C_1 and C_2 have polar equations

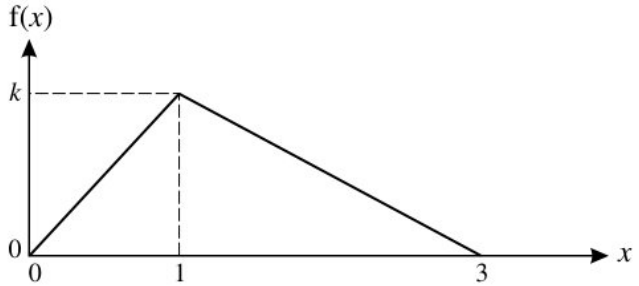
[8]

(b) (vi) Calculate the acute angle between the planes.

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

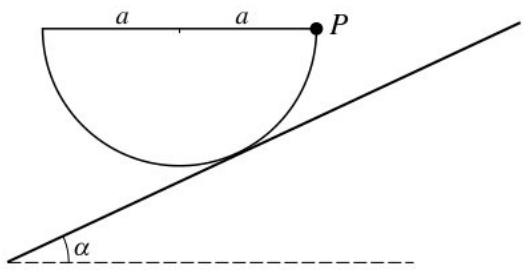
[6]

(iv) airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.



where = ... *ko* **[6]**

(ii)



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

[10]

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

P and Q collide and stick together.

[1]

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

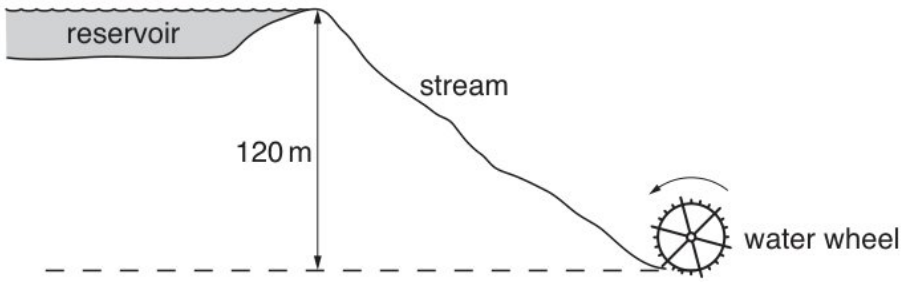
Express $\frac{dy}{dx}$ in terms of t.

Find the coordinates of the turning points of C.

[3]

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

(b) (ii)



Draw a fully labelled tree diagram to illustrate this situation.

[5]

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

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

[10]

(c) (i) 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?

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

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

[6]

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

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

[10]

(iii) 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.

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

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

[6]

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

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

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.

the exact area of one loop of the curve.

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.

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

Show that the mass of P is 0.8 kg .

[10]

(ii) V increases because there is a p.d. across R.

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

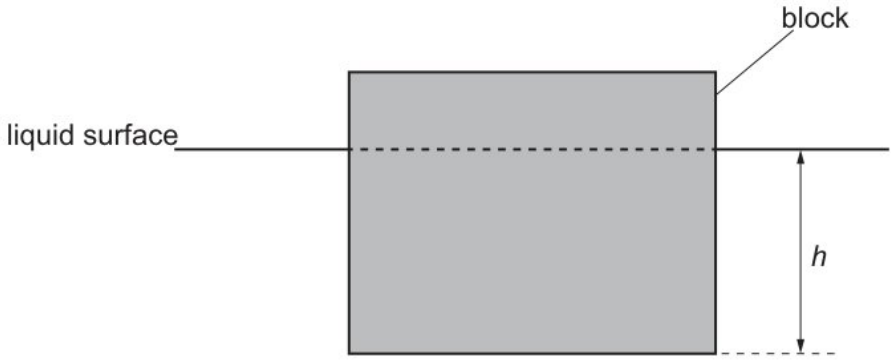
[8]

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

the value of the constant k,

[8]

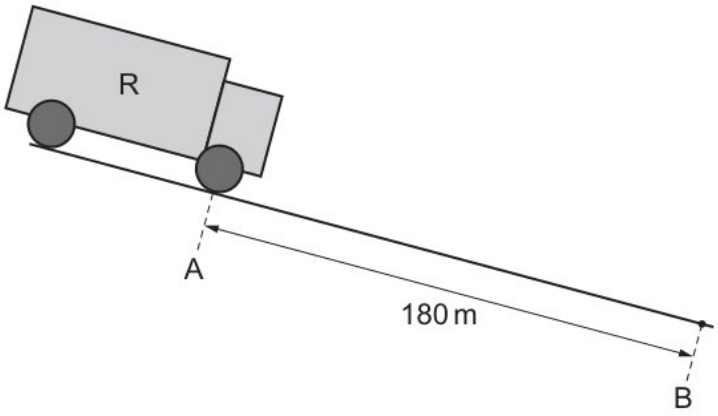
(v) The powers to X, Y and Z will all increase.



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

[2]

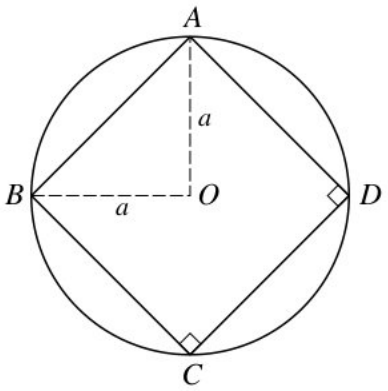
(ii)



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

[3]

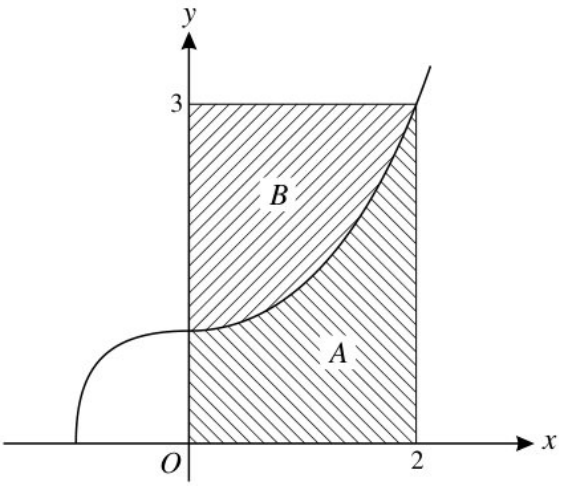
(c) (iv) particle P of mass m is placed at the point Q on the outer surface of a fixed smooth sphere with centre O and radius a. The acute angle between OQ and the upward vertical is α, where $\cos\alpha = \frac{9}{10}$. The particle is released from rest and begins to move in a vertical circle on the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



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

[12]

(iii)



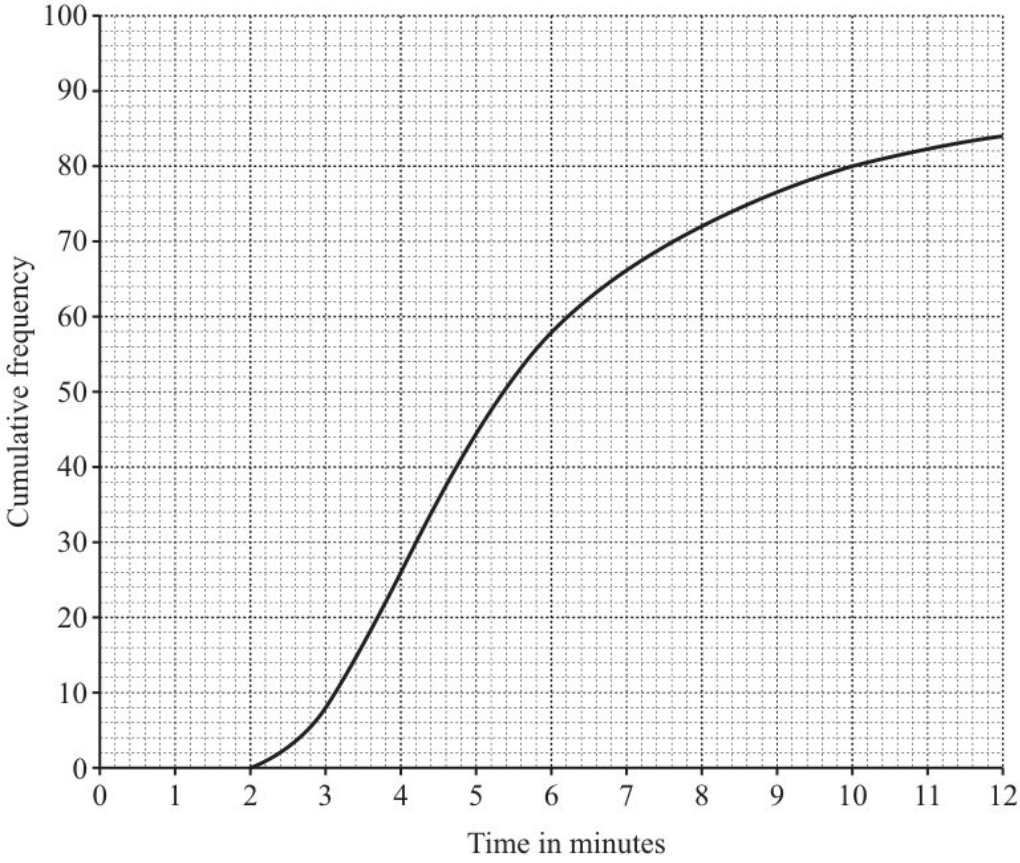
people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

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

[12]

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

(e) (ii)



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

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

[1]

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

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

[6]

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

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

[6]

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

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

[4]

(d) (i)

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

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

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

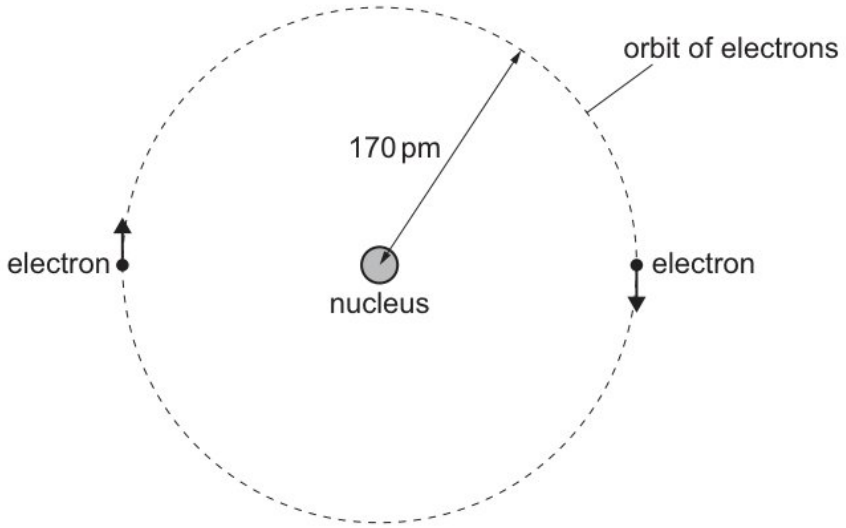
[3]

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

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.

[4]

(v)



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

[4]

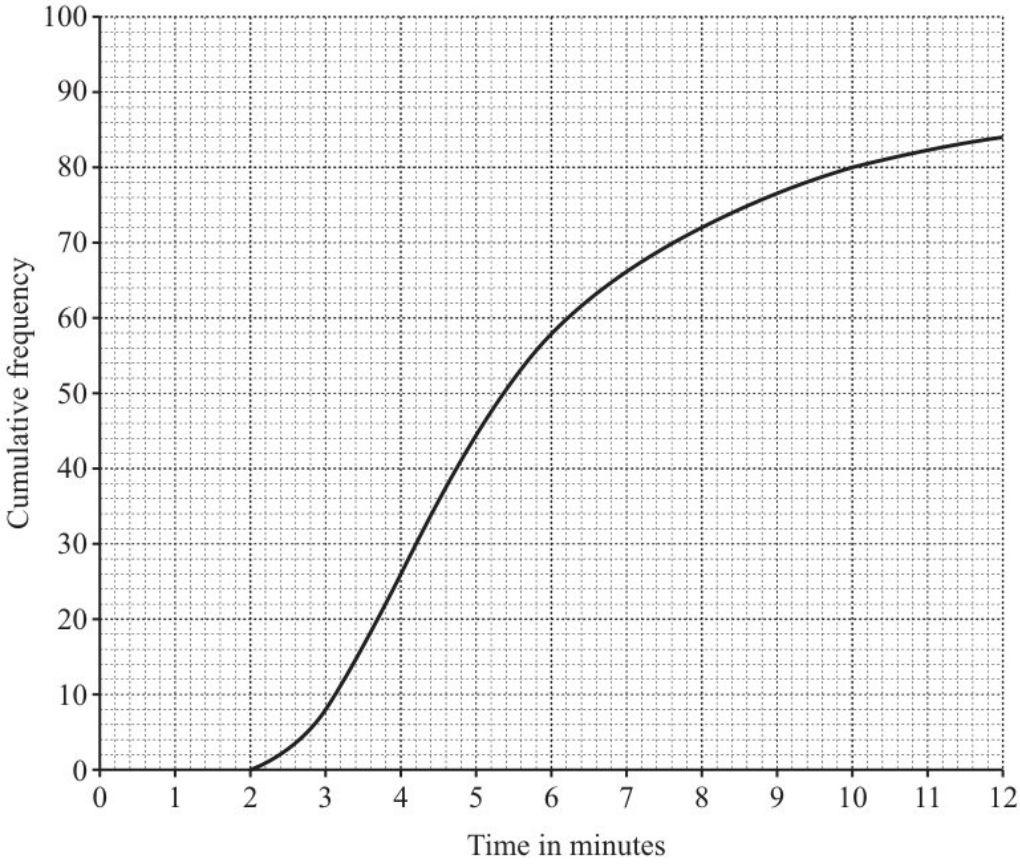
12 circle is divided into 6 sectors in such a way that the angles of the sectors are in arithmetic progression. The angle of the largest sector is 4 times the angle of the smallest sector. Given that the radius of the circle is 5 cm , find the perimeter of the smallest sector.

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

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

[6]

(i)



The orbit has a period of 25 hours.

[6]

(iv)

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

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

[6]

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

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

[8]

(vi) Show that the cartesian equation of C is

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

[6]

(i) the equation representing this decay.

is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

[4]

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

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

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.

Different isotopic nuclei have different proton numbers.

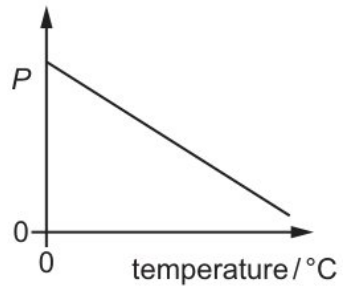
[12]

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

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

[3]

(b)



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

[6]

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

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

harmonic motion = ... *wb* **[6]**

(c) amplitude $\propto \sqrt{\text{intensity}}$

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

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.

[6]

(e) measuring instrument should be used?

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

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

[8]

(iii) (c) 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.

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

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

[4]

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

the value of α.

[5]

(b) 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.

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.

[6]

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

(b) (iv) marks of the pupils in a certain class in a History examination are as follows.

$$\overrightarrow{OA} = \mathbf{i} + 2\mathbf{j}, \quad \overrightarrow{OB} = \mathbf{i} + 3\mathbf{j} - 2\mathbf{k} \quad \text{and} \quad \overrightarrow{OC} = 2\mathbf{i} - \mathbf{j} + 3\mathbf{k}$$

[10]

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

down to up

[6]

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

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

[5]

(a) (v) temperature θ_R of the laboratory is measured using a thermometer.

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

[5]

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

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

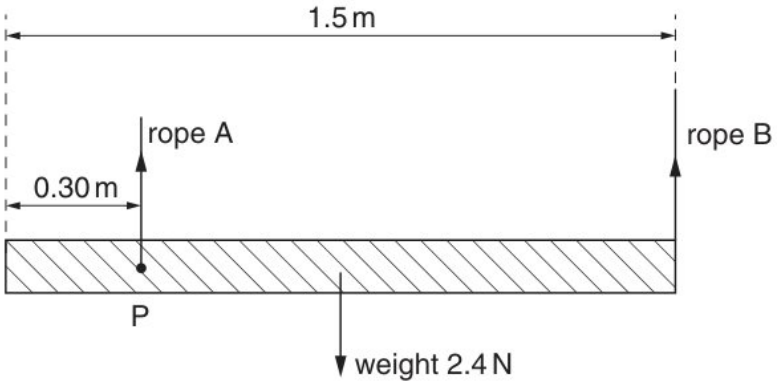
[6]

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

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.

[8]

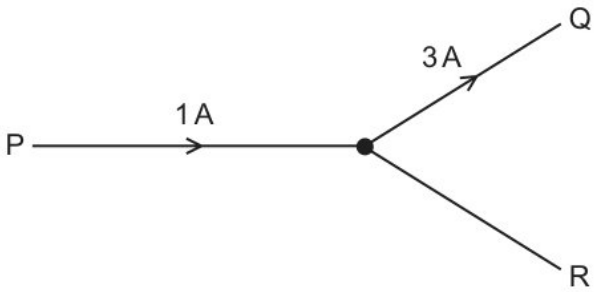
(g) (i)



Find the work done by the tension.

[4]

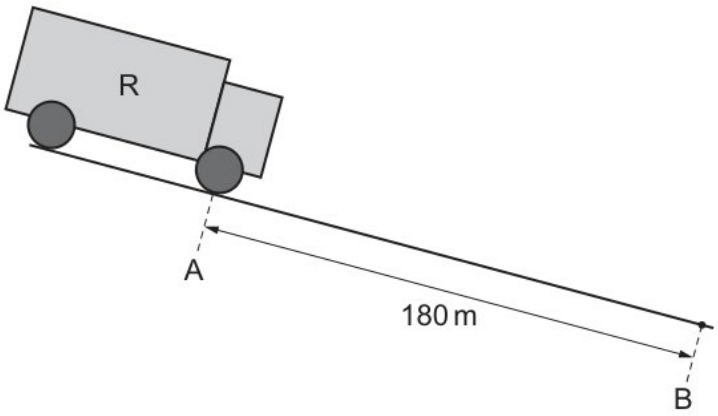
(ix)



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

[12]

(ii)



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

[1]

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

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

[2]

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

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

[6]

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

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

[6]

12 obtain the roots of the equation

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

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.

[3]

(iii) frequency of the signal is 50 kHz .

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.

[6]

(c) (iv) Use the trapezium rule, with two intervals, to estimate the value of

the exact value of I_2

[10]

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

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

[3]

(d) (ii) the value of μ and the value of X for which the block is on the point of moving up the plane.

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

[4]

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

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

[2]

20 Find the values of p and q such that

(b) (i) random variable Y is defined by $Y = X^3$. Find

a, b and c are integers to be determined.

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 $t = 4$.

[15]

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

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

[1]

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

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

[5]

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

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.

[5]

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

the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

[6]

(a) (iv) Show that x satisfies the equation

$$\mathbf{x} = \begin{pmatrix} p + 2\lambda + \mu \\ q + 2\lambda + 3\mu \\ -\lambda \\ \mu \end{pmatrix},$$

[4]

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

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 .

[8]

(g) (i) cable car of weight W hangs in equilibrium from its cable at point P.

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.

Show that x satisfies the equation

[6]

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

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

[10]

(iv) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

data give a pooled estimate of 10 for σ^2. Find N.

[8]

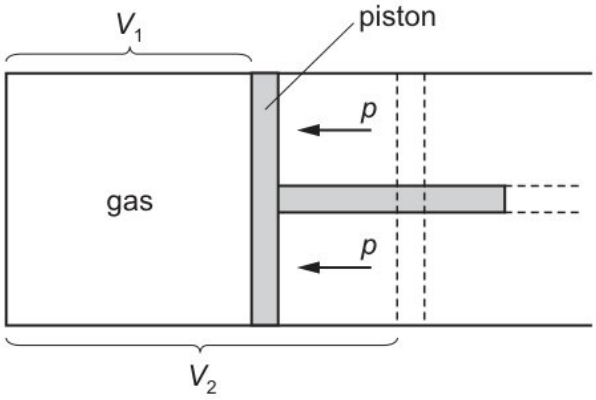
15 the arc length of C,

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

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

[5]

(iv)



Both light waves and sound waves show the Doppler effect.

[3]

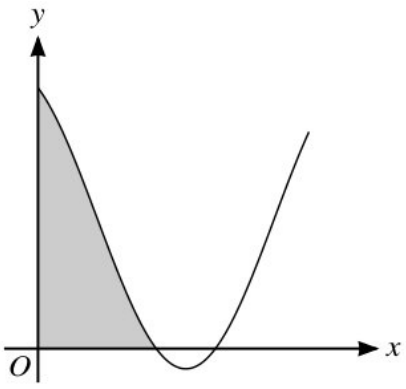
(iii) a cartesian equation of the plane Π containing l_1 and l_2.

object is fully submerged in a liquid.

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

[2]

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



[4]

(ii) Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

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.

large = ... ze **[6]**

(iv) analysis of the data,

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.

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

[6]

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

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

[5]

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

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.

have independent results = ... lj **[6]**

19 $\frac{1}{(2r+1)(2r+3)}$ in partial fractions and hence use the method of differences to find

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.

(a) (iv) mean, $\bar{x}$, is 28.325 .

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

[4]

(ii) the exact value of I_2.

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

[5]

(v) 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

is the grand-daughter product?

[12]

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

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

[8]

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

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

[1]

(iv) Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16\sin^5\theta \, \mathrm{d}\theta$.

the position vector of P.

[6]

(e) (iii) Prove by mathematical induction that, for all positive integers n,

Calculate the speed of the star relative to the Earth.

random variable Y is defined by $Y = X^3$. Find

[4]

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

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

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

[6]

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

the term ultimate tensile stress.

[4]

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

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

[3]

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

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

[10]

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

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

[6]

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

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

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

[5]

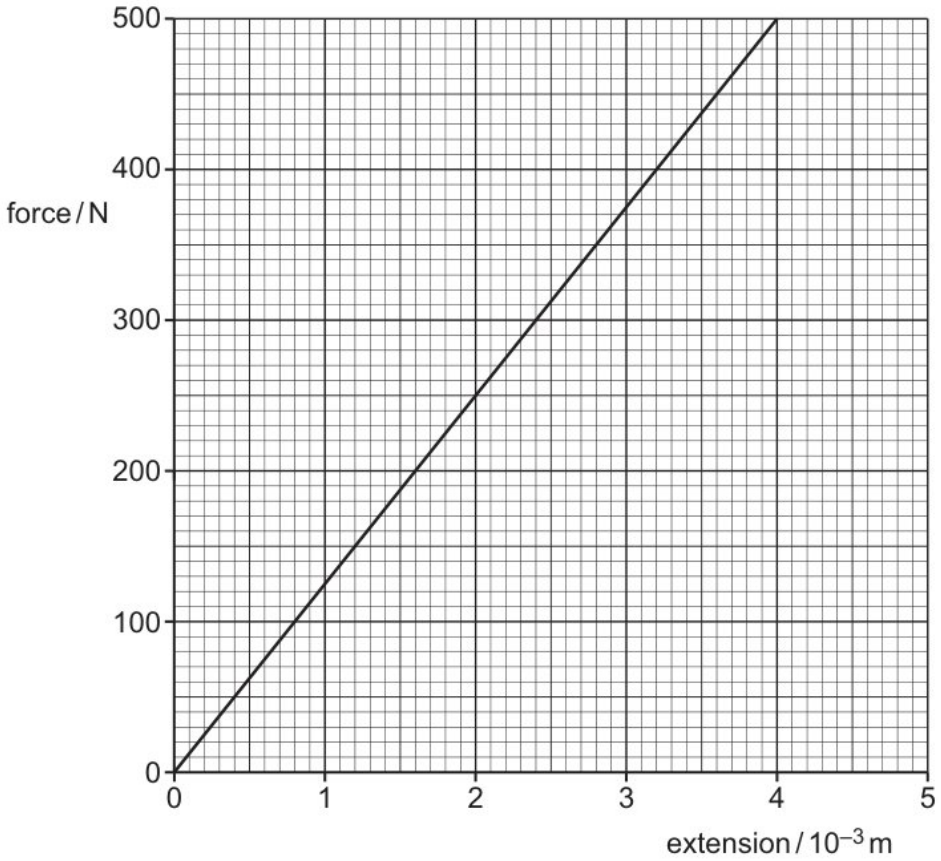
(iii) is the efficiency of the process?

The total momentum is conserved provided that no external forces act.

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

[6]

(ii)



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.

[8]

(c) (i) 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 $0 < \theta < 2\pi$

there are no restrictions,

[6]

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

Density is mass per cubic metre.

magnetic flux density.

[12]

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

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

[6]

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

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.

[4]

13 what is meant by the de Broglie wavelength.

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.

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

particle is not involved in the decay process?

(b) (ii) marks of the pupils in a Physics examination are summarised as follows.

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]

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

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

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

[8]

(a) (i) the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

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

the expected value and variance of Y.

[8]

(ii) 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

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

the expected value and variance of Y.

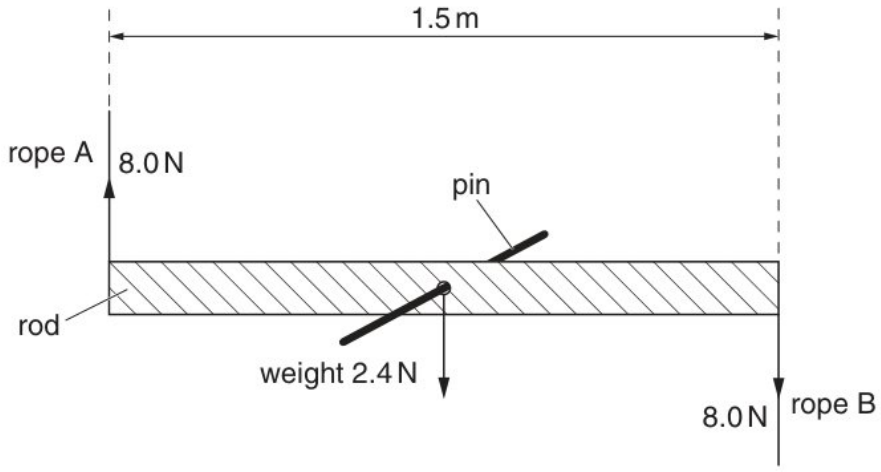
[6]

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

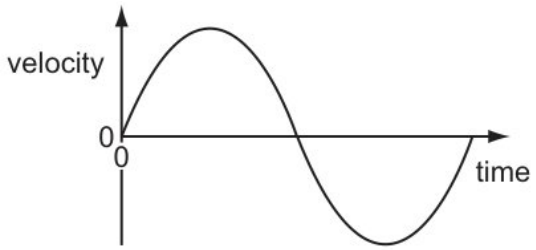
that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

[10]

(iv)



random variable X has the distribution Po(1.5).



[15]

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

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

[6]

(iv) arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.

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

the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

[5]

23 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

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

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

Find the period of the motion.

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

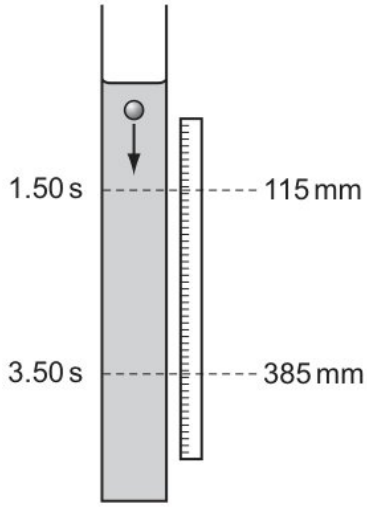
[2]

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

point D is the reflection of A in l.

[12]

(ii) (d)



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

[10]

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

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

[10]

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

continuous random variable X has probability density function f given by

that $\tan 2a = -4a$

[2]

15 (e) first, second and third terms of a geometric progression are $2k+3, k+6$ and k, respectively. Given that all the terms of the geometric progression are positive, calculate

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

the acute angle between the planes ABC and ABD.

moment of a force.

[5]

(v) weight of the parachutist is 850 N .

[15]

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

(ii) 400 nm to 700 nm

[6]

(iii) selects 4 books from her 10 different books from the series Squares and Circles.

[2]

(i) 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.

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

[8]

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

with = ... *un* **[5]**

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

(ii) procedure to be followed,

[5]

(vi) Find the area of the triangle ABC.

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.

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

[4]

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

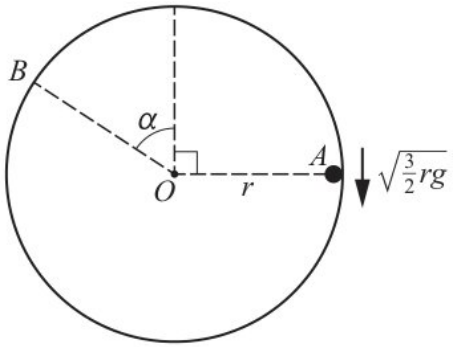
linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$
$$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}.$$

[6]

(iii) 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]

13 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.



(d) (iii) object is fully submerged in a liquid.

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

[6]

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

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

[12]

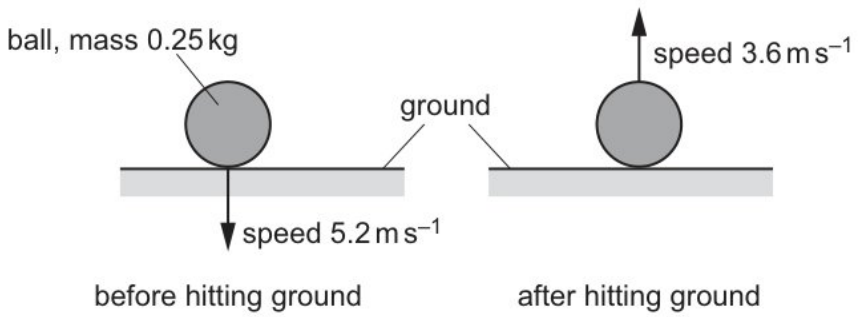
(iv) magnetic flux density.

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

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

[6]

(i) 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.



[3]

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

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

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).

[4]

(i) Find the equations of the asymptotes of C.

particle is not involved in the decay process?

[3]

24 Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

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).

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.

for $0° \leqslant \theta \leqslant 180°$ the equation $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) = 3$,

(b) (iii) the probability that fewer than 10 of these customers bought a computer made by company F.

A contains 6 red marbles, 5 blue marbles and 1 green marble.

[8]

(ii) $\mathrm{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

The total momentum is conserved provided that no external forces act.

[15]

(h) (iii) Find, in the form $ax^3 + bx^2 + c = 0$, an equation of which α is a root.

curve C has equation

a cartesian equation of the plane Π containing l_1 and l_2.

[12]

(ii) the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$.

[12]

(c) (iv) $5\sin\left(x + \frac{1}{6}\pi\right) - 4\cos x$ 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.

Carry out a goodness of fit test at the 10% significance level.

[5]

(vii) time-base setting on the oscilloscope should be used?

all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

[3]

(i) constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135$ mm s^{-1}.

is the total displacement of the ball from its original position after $1.5s$?

mass = ... fz **[12]**

10 Find the frictional and normal components of the contact force acting on B.

(a) (i) 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.

Hence, or otherwise, obtain an expression for $\mathrm{f}^{-1}(x)$.

up to down

[4]

(iv) Hence show that the differential equation

$$\int_0^a \left(1 + 2x + 3\mathrm{e}^{3x}\right) \mathrm{d}x = 250$$

[8]

(vii) k is a positive constant. The relevant expected frequencies are given in the following table.

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.

[12]

(b) (ii) state the corresponding eigenvalue.

the grid below, draw a box-and-whisker plot to summarise the information in the cumulative frequency graph.

student wishes to measure a distance of about 10 cm to a precision of 0.01 cm .

[8]

(iii) 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 $t = 2$.

$$\mathrm{f}(x) = \begin{cases} 0 & x < 0 \\ a\mathrm{e}^{-x\ln 2} & x \geqslant 0 \end{cases}$$

[8]

(i) object of mass 8 kg slides down a line of greatest slope of an inclined plane. Its initial speed at the top of the plane is 3 m s^{-1} and its speed at the bottom of the plane is 8 m s^{-1}. The work done against the resistance to motion of the object is 120 J . Find the height of the top of the plane above the level of the bottom.

obtain the roots of the equation

[5]

(e) (vi) a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.

Show that $m = 0.9$.

[6]

(ii) When the tensile force is removed, the wire does not return to its original length.

random variable, X, has the distribution Po(31). Use the normal approximation to the Poisson distribution to find $\mathrm{P}(X > 40)$.

[8]

18 $\sum_{r=1}^{n}(4r-3)(4r+1)$, giving your answer in its simplest form.

(b) (iii) the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

$\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5$.

[4]

(iv) The matrix $\mathbf{B}$, where

Find the values of a and b.

[3]

(c) (i) $\frac{\text{mass} \times (\text{ time })^2}{\text{length}}$

why the variation with time of the activity of a radioactive sample is exponential in nature.

time T, particle P is moving at an angle of 60° below the horizontal.

[12]

(v) the time that it takes from when P is initially projected until the instant at which P collides with the combined particle

the value of the constant k,

[3]

(iii) only one of the following two alternatives.

the period of small oscillations,

[6]

(d) (v) is suggested that the e.m.f. V is related to the number n of glass sheets by the equation

random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

	first higher note /Hz	second higher note /Hz
A	113	150
B	150	225
C	150	300
D	225	375

[2]

(i) 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?

curve with equation $y = \frac{2-\sin x}{\cos x}$ has one stationary point in the interval $-\frac{1}{2}\pi < x < \frac{1}{2}\pi$.

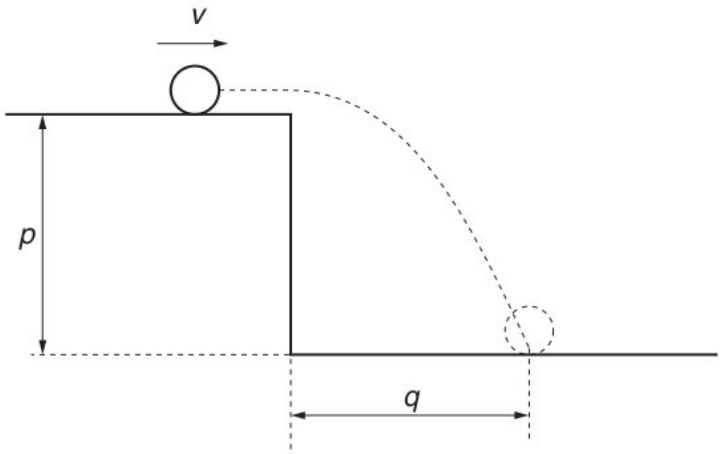
In a nuclear reaction, proton number and neutron number are conserved. Other than proton number and neutron number, state a quantity that is conserved in a nuclear reaction.

[12]

14 (b) was the by-product of this reaction?

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.

(i) Explain why the observed wavelength and the emitted wavelength have different values.



[5]

(iii) particle is not involved in the decay process?

point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

[8]

(ii) for a wire,

[6]

(e) isotopes of the element uranium are $^{235}_{92}\mathrm{U}$ and $^{238}_{92}\mathrm{U}$.

(ii) Express f(x) in partial fractions.

[6]

(v) Deduce that the cartesian equation of C is

data give a pooled estimate of 10 for σ^2. Find N.

[4]

(iii) 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.

[5]

27 your answer correct to 2 decimal places.

(a) (i) Find the distance OM.

the period of small oscillations,

[3]

(ii) the probability generating functions, $\mathrm{G}_X(t)$ of X and $\mathrm{G}_Y(t)$ of Y.

Find the value of I_2.

constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135$ mm s^{-1}.

[4]

(iii) a value, to three significant figures, for the specific latent heat of fusion of water.

airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.

[2]

(c) (iv) Draw box-and-whisker plots in a single diagram on graph paper to illustrate the marks for History and Physics.

wavelength of light is 550 nm .

[10]

(v) 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.

	direction of acceleration	separation of the plates
A	downwards	decrease
B	downwards	increase
C	upwards	decrease
D	upwards	increase

circle = ... mz **[5]**

(b) (ii) Find the equations of the asymptotes of C.

$$\operatorname{cosec}^5\theta = \frac{a}{\sin 5\theta + b\sin 3\theta + c\sin\theta}$$

[5]

(iv) 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.

is the magnitude of the net force acting on the ball?

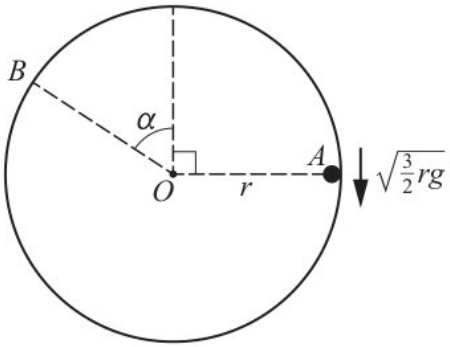
[6]

(i) Show that $a = \frac{1}{3}\ln\left(251 - a - a^2\right)$.

curve C has equation $y = \frac{1}{2}\left(\mathrm{e}^x + \mathrm{e}^{-x}\right)$ for $0 \leqslant x \leqslant 4$.

[10]

(g) (i)



that the distance travelled by the ball when it is moving upwards is $x = \frac{1}{2k}\ln\left(\frac{g+kU^2}{g+kv^2}\right)$.

[6]

(iii) coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

Find the position vector of D.

a set of 40 values of x, it is found that

[6]

9 - coming to rest instantaneously on hitting the ground.

curve C with equation

(i) (d) basic principle of note production in a horn is to set up a stationary wave in an air column.

a positron and an antineutrino

[6]

(b) would this object weigh on Pluto?

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

State what happens to the electron and to the positron.

[5]

(c) a tree diagram to represent this information, giving the probability on each branch.

weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.

[12]

(iii) (a) $I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

find corresponding eigenvectors.

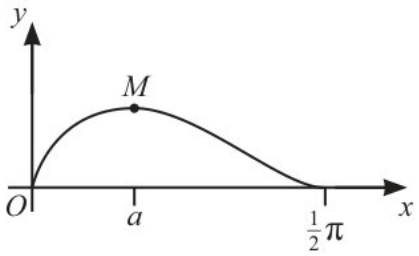
[3]

(b) 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

waves are emitted from two sources.

[6]

26 the exact value of I_2



(a) (ii) is given that $f(n) = 3^{3n} + 6^{n-1}$.

Find $\sum_{r=n+1}^{2n} u_r$.

random variable X is the number of heads obtained.

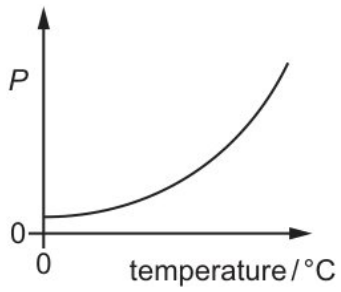
[12]

(iii) the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

shop sign weighing 75 N hangs from a frame attached to a vertical wall.

[3]

(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.



[12]

(d) (iv) Calculate the speed of projection of P.

diagram shows part of a current-carrying circuit. The ammeter has negligible internal resistance.

[10]

(iii) do each of the symbols represent for an electric current in a metal wire?

$\sum_{r=1}^{n}(4r-3)(4r+1)$, giving your answer in its simplest form.

[12]

(i) Find the coordinates of the point A on C at which $\frac{\mathrm{d}y}{\mathrm{d}x}=0$ and $x \neq 0$.

that, when $t=0, x=\frac{\mathrm{d}x}{\mathrm{d}t}=0$.

$I_n=\int_0^1 x^n(1-x)^{\frac{1}{2}}\,\mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

[8]

(b) (iii) It results in the measured value being different from the correct value.

(amplitude $)^2 \propto \sqrt{\text{intensity}}$

in terms of a, the distance that P moves down the plane before coming to rest.

[12]

(i) cube has volume V and is made of a material with resistivity ρ. The connections to the cube have negligible resistance.

the probability that fewer than 10 of these customers bought a computer made by company F.

[12]

(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.

$$I_n=\frac{1}{n-1}-I_{n-2}$$

[8]

(iii) it is given that $y=2$ when $x=1$. Solve the differential equation and obtain an expression for y in terms of x.

Find the coordinates of A and M.

[5]

(v)

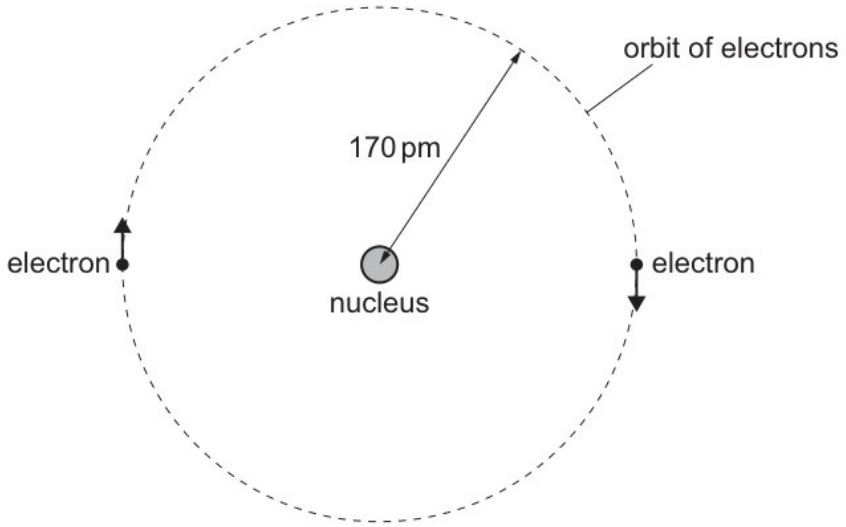


diagram shows the curve $y = \cos x\sqrt{\sin 2x}$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

[5]

(f) (iv) the probability density function of Y,

student wishes to investigate the effect of adding various thicknesses of glass in front of

[12]

(ii) Given that $\mathrm{E}(X) = 1.2$, find the value of a.

that $\mathrm{E}(X) = 3.05$, find the values of p and q.

circuit is set up as shown in Fig. 2.1.

[4]

(i) 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.

a similar method to find, in terms of n, a lower bound for $\sum_{r=1}^{n} \frac{1}{\sqrt{r}}\mathrm{e}^{\sqrt{r}}$.

Find the values of F and θ.

[4]

31 (d) 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.

(i) that, at the point of C furthest from the initial line,

[6]

(v) the equation of the tangent to the curve at the point e 3 Give your answer in the form $y = mx + c$ where m and c are exact

[2]

(b) cylindrical conductors, X and Y, are made from the same material. The conductors have equal lengths, but Y has a smaller diameter than X.

(i) Show that the length of the arc of C from the pole to the point furthest from the pole is given by

[4]

(iv) diagram shows the force-extension graph produced.

$$\overrightarrow{OA} = \begin{pmatrix} 2 \\ 3 \\ 5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} \quad \text{and} \quad \overrightarrow{OC} = \begin{pmatrix} 10 \\ 0 \\ 6 \end{pmatrix}.$$

[8]

(e) a positron and an antineutrino

It consists of two quarks that must both be the same flavour.

(i) Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

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.

is the work done by F on the skateboarder and skateboard?

[8]

(iii) all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is 10.3°C.

[5]

12 a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$.

masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

(c) (ii) an instant during the motion the velocity of the load is 1.5 m s^{-1}.

Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

across connected = ... ml **[2]**

(ix) 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.

Young modulus E can be determined from measurements made when a wire is stretched.

[6]

(vi) graph shows the variation with temperature of power, P, dissipated in the thermistor?

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.

[12]

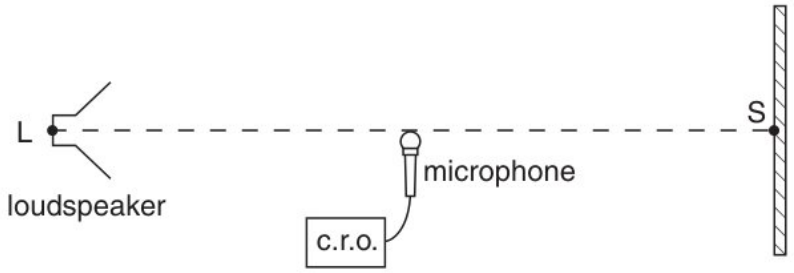
(e) (iii) the median and the interquartile range of the times of the runners from the Gulls.

polynomial $3x^3+pax^2+7a^2x+qa^3$ is denoted by f(x) where p, q and a are constants and $a \neq 0$

adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

[8]

(i)



is given that $\sum x = 175.0$ and that the mean of y is 8.4 .

linear transformation T: $\mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M}$, where

[5]

(ii) the average power of the aeroplane's engines.

Use your answer in (c)(i) to determine the half-life, in min, of the radioactive isotope.

[6]

(iv)

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

Find the cartesian equation of Π_1.

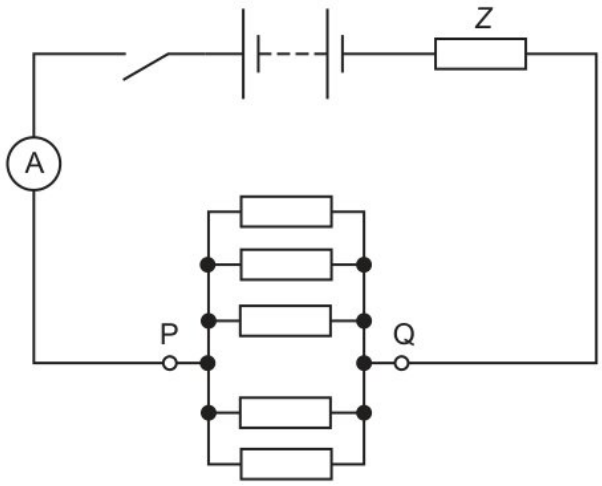
[6]

(b) (i) pendulum bob is held stationary by a horizontal force H. The three forces acting on the bob are shown in the diagram.

molecule of mass m travelling horizontally with velocity u hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.

[5]

(iii)



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?

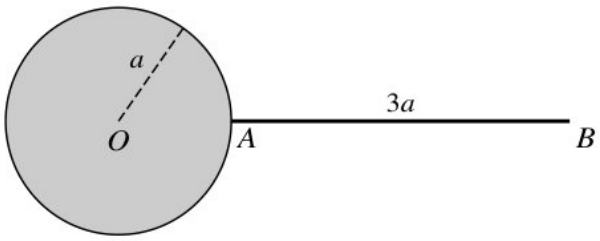
[4]

(a) (i) vertical forces that the ground exerts on a stationary van are shown.

$$\sin\frac{1}{5}\pi\sin\frac{2}{5}\pi\sin\frac{3}{5}\pi\sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right)+\sin^2\left(\frac{2}{5}\pi\right)$$

[10]

(vi) an instant during the motion the velocity of the load is 1.5 m s^{-1}.



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.

cabbages = ... *ou* **[12]**

20 (a) much charge passes a given point in wire R in a time of $5s$?

$$\sin 5\theta = 5\sin\theta - 20\sin^3\theta + 16\sin^5\theta$$

(ii) Given that the total number of cars sold during the 5 days is 5 , carry out the test.

For some nuclei, the nucleon number can be less than the proton number.

[5]

(i) Draw a sketch of C for the case $0 < \lambda < 1$.

[4]

(iii) State what is meant by the internal energy of a system.

[4]

(b) gas is then cooled at constant volume so that its temperature decreases to $2T$.

frequency of the signal is 50 kHz .

(iv) diagram shows a trace of a wave on a cathode-ray oscilloscope.

[6]

(ii) row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

[5]

(vi) Use the iterative formula

[15]

14 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.

(a) (iv) State the gradient of the curve at the point $(-1, 2)$ and sketch the curve.

that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.

random variable X has the distribution Po(1.5).

[5]

(i) cable has tensions T_1 and T_2 as shown.

that $\mathbf{e}$ is an eigenvector of $\mathbf{A}^3$ with corresponding eigenvalue λ^3.

[5]

(ii) only one of the following two alternatives.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} - \left(8x + \frac{1}{x}\right)\frac{\mathrm{d}y}{\mathrm{d}x} + 12x^2y = 4x^2\mathrm{e}^{-x^2}$$

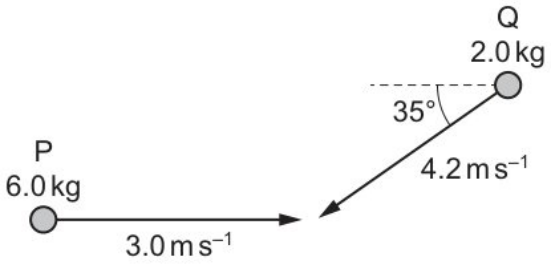
[4]

(c) (v) tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

Show that $\cos\theta = \frac{2}{3}$.

[6]

(iv)



curve C has equation $\tan y = x$, for $x > 0$.

[6]

(iii) random variable Y is defined by $Y = X^3$. Find

the differential equation to obtain an expression for y^2 in terms of x.

[5]

(d) (iii) the roots of the equation $z^3 = 27 - 27\mathrm{i}$, giving your answers in the form $re^{i\theta}$, where $r > 0$ and $-\pi \leqslant \theta < \pi$.

are selected from these 20 to perform at a concert.

[5]

(i) is given that $\sum x^2 = 1823.0$.

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}.

green = ... rw **[6]**

(ii) combination of changes must increase the amount of spreading due to diffraction?

Find the product moment correlation coefficient for the data.

[8]

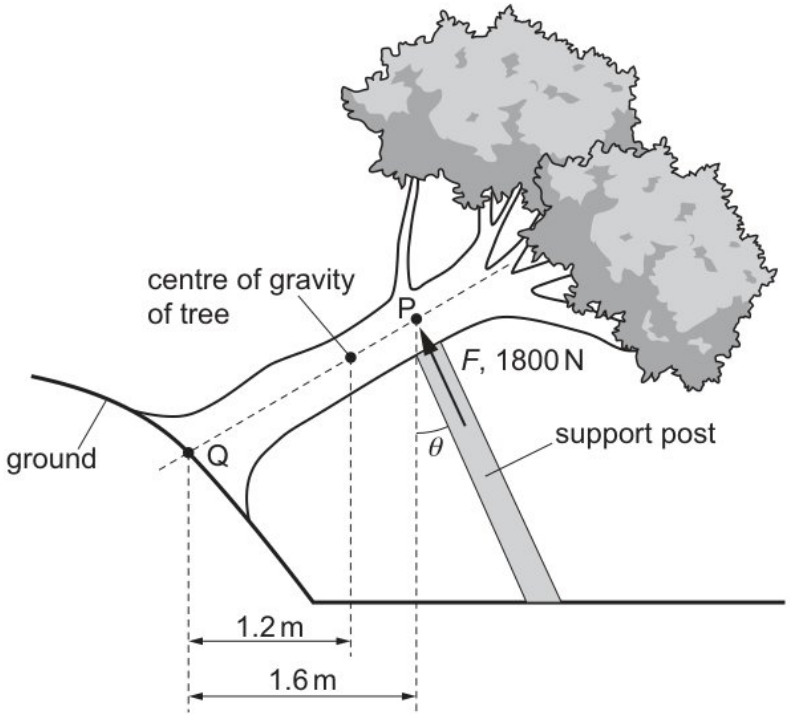
29 linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

(c) (i) circuit is set up as shown in Fig. 2.1.

is the average useful power at which he is working?

[1]

(iv)



the probability that more than 7 study Art or Music.

curve C has equation $y = \frac{2x^2-5x}{2x^2-7x-4}$.

[6]

(iii) 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.

$\mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - 2\mathbf{j} - \mathbf{k})$ and $\mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \mu(2\mathbf{i} + 3\mathbf{j} - \mathbf{k})$.

[4]

(b) (iii) variables x and y satisfy the differential equation

variable Y is related to X by $Y = 2^X$.

[3]

(iv) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

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.

[15]

(ii) the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is the fifth day of the week.

[12]

34 results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

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.

(c) (i) Calculate the length AG.

uniform disc with centre O, mass m and radius a is free to rotate without resistance in a vertical plane about a horizontal axis through O. One end of a light inextensible string is attached to the rim of the disc and wrapped around the rim. The other end of the string is attached to a block of mass $3m$ (see diagram). The system is released from rest with the block hanging vertically. While the block is in motion, it experiences a constant vertical resisting force of magnitude $0.9mg$. Find the tension in the string in terms of m and g.

the probability generating functions, $\mathrm{G}_X(t)$ of X and $\mathrm{G}_Y(t)$ of Y.

[4]

(iv) is given that λ is an eigenvalue of the non-singular square matrix $\mathbf{A}$, with corresponding eigenvector $\mathbf{e}$.

diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

two assumptions of the simple kinetic model of a gas.

[12]

(ii) lifetime, in hours, of a 'Trulite' light bulb is a random variable T. The probability density function f of T is given by

temperature θ_{R} of the laboratory is measured using a thermometer.

[15]

(iii) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

at the 2% significance level whether the population mean time for this year is less than 62.4 seconds.

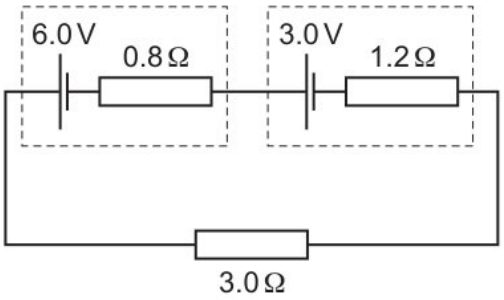
[10]

(a) (iv) 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.

solid cubes, A and B, are measured to determine the density of their materials.

[6]

(iii)



man has a mass of 80 kg . He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1}.

suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

also = ... ya **[5]**

(b) (i) how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

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.

the equation of the tangent to the curve at the point e 3 Give your answer in the form $y = mx + c$ where m and c are exact

[5]

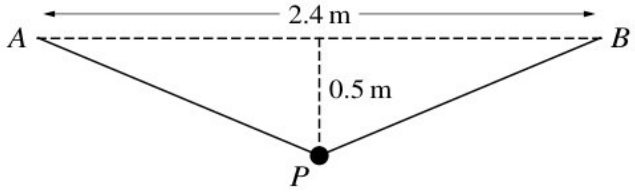
(iii) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

random sample of 140 customers who each bought a computer from this store is chosen.

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.

[6]

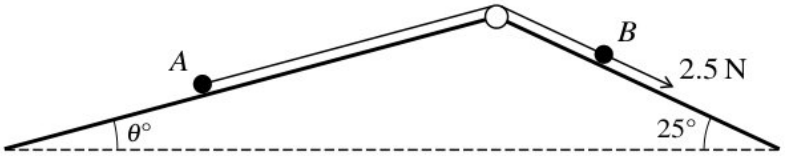
(ii) Use the information in (d)(iv) to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.



Given that the total number of cars sold during the 5 days is 5 , carry out the test.

[10]

(vii)



photocell. This may be carried out in the laboratory by varying the number of identical thin

[6]

(iv)

	amplitude /cm	period /ms
A	2	10
B	2	90
C	4	10
D	4	90

the curve with equation $y = \left|\frac{2x^2-5x}{2x^2-7x-4}\right|$.

[8]

(d) (ii) point D is such that $ABCD$ is a parallelogram.

progressive water waves X and Y travel along a straight line from point A to point B. The variation of displacement of the waves with distance from A at an instant in time is shown in Fig. 3.1.

the value of μ and the value of X for which the block is on the point of moving up the plane.

[8]

(iv) the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

a butternut squash seed is sown the probability that it will germinate is 0.86 , independently of any other seeds. A market gardener sows 250 of these seeds. Use a suitable approximation to find the probability that more than 210 germinate.

Calculate the exact value of I_1 and deduce the exact value of I_3.

[5]

15 with a reason, whether it was necessary to use the Central Limit Theorem in your answer to part (b).

(c) (iv) $I_n = \int_0^1 x^n(1-x)^{\frac{1}{2}}\,\mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

a cartesian equation of the plane Π containing l_1 and l_2.

polar equation of a curve C is $r = a(1+\cos\theta)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

[4]

(i) specific latent heat.

Calculate the distance the car travels from when the brakes are applied until the car comes to rest.

that the greatest height of B above the ground is 1.2 m , find the value of x.

[20]

(b) (ii) 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.

curve C with equation

[5]

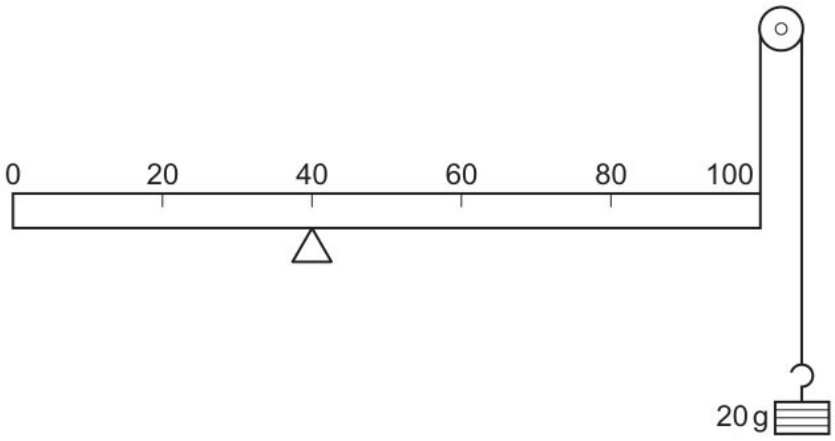
(iv) There will always be 9.0 V across the battery terminals.

skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

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

[6]

(v)



The matrix **B**, where

[8]

(ix) the term isotope.

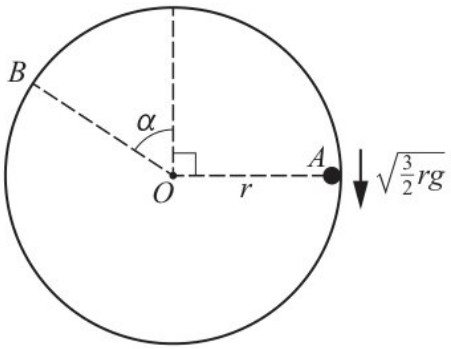
Find the value of I_2.

matrix **A** is given by

[12]

(e) (iii) a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1}.

Show that the cartesian equation of C is



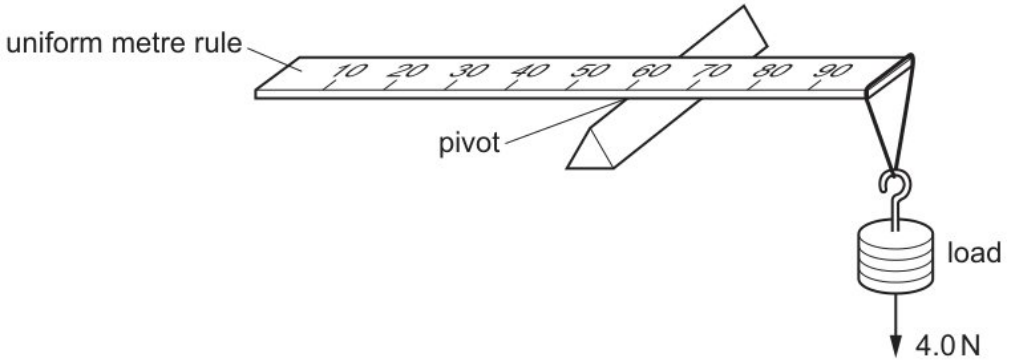
[3]

(i) process does not require energy to be supplied?

Find the set of values of k for which the line $y = k$ does not intersect C.

[4]

(vii)



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]

(iv) that $\mathrm{E}(X) = 3.05$, find the values of p and q.

changes to R_1 and to R_2 will increase the value of V_{out} ?

[4]

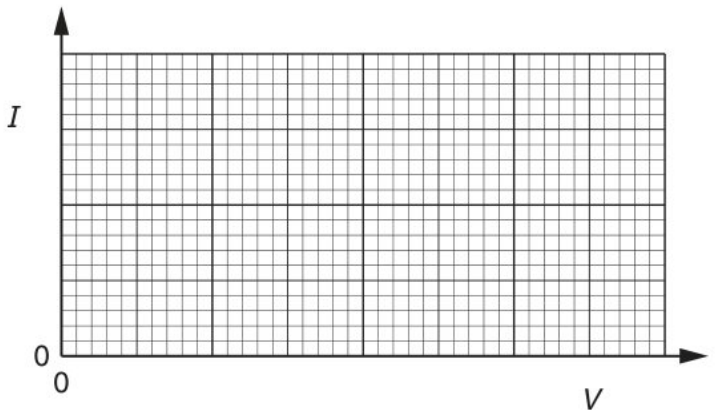
(d) (ii) planes have equations $x + 2y - 2z = 7$ and $2x + y + 3z = 5$.

a basis for the null space of T .

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.

[8]

(i)



obtain the expansion of $\mathrm{f}(x)$ in ascending powers of x, up to and including the term in x^2.

the curve with equation $y = \left|\frac{2x^2-5x}{2x^2-7x-4}\right|$.

[5]

(iv) for $0° \leqslant \theta \leqslant 180°$ the equation $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) = 3$,

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Observed frequency	1	3	15	31	59	107

[4]

(a) (ii) 6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

[20]

(vi) logarithms to solve the equation $3^x = 2^{x+2}$, giving your answer correct to 3 significant figures.

wire is extended by a tensile force so that its deformation is elastic.

[12]

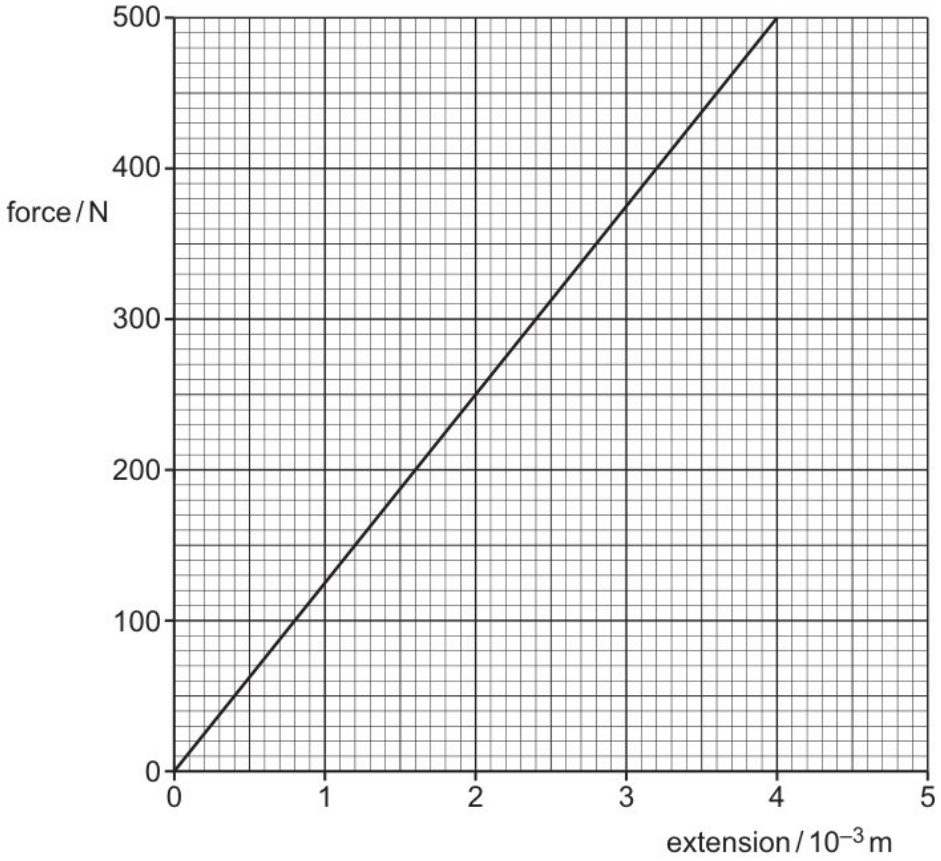
(iii) photocell. This may be carried out in the laboratory by varying the number of identical thin

the general solution of the differential equation

$$f(x) = \begin{cases} \frac{1}{4}(x+1) & 0 \leqslant x \leqslant 2 \\ 0 & \text{otherwise} \end{cases}$$

[3]

9 (a) Carry out a goodness of fit test at the 10% significance level.



(i) many electrons pass a point in the conductor in one minute?

[2]

(iii) why the variation with time of the activity of a radioactive sample is exponential in nature.

the expected value and variance of Y.

[2]

(b) 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).

(iii) solid cubes, A and B, are measured to determine the density of their materials.

$\mathbf{A} = \begin{pmatrix} 2 & 3 \\ 0 & 1 \end{pmatrix}$. Prove by mathematical induction that, for every positive integer n,

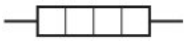
[12]

(i) Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.

[5]

(c) diagram best represents the electric field surrounding the charges?

the value of c such that $\mathrm{P}(-c < t < c) = \frac{1}{2}$.



(i) curve C has equation

[6]

(ii) a butternut squash seed is sown the probability that it will germinate is 0.86 , independently of any other seeds. A market gardener sows 250 of these seeds. Use a suitable approximation to find the probability that more than 210 germinate.

from = ... *ht* **[5]**

(iii) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .

[3]

(d) the graph of $y = |3x - 2a|$, where a is a positive constant.

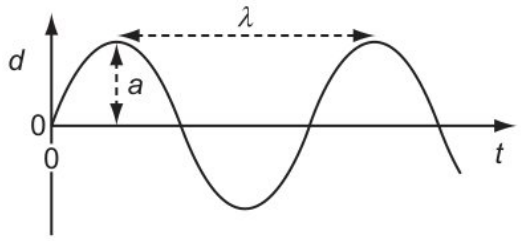
(vi) matrix **A** is given by

[4]

(iii) time taken by P to travel directly from L to M is 2 s .

[4]

(ii) Find the equation of the tangent to the curve at the point where $x = 0$.



[3]

13 Show that the tension in the string is 10 N .

(a) (v) 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 .

a transformation from $\mathbb{R}^4$ to $\mathbb{R}^4$.

Calculate the length AG.

[2]

(i) the equations of the asymptotes of C

the equations of the asymptotes of C

[4]

(c) (iii) is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

For this value of k, find the set of possible solutions, giving your answer in the form

[5]

(ii) curve with equation $y = \frac{2-\sin x}{\cos x}$ has one stationary point in the interval $-\frac{1}{2}\pi < x < \frac{1}{2}\pi$.

Find the values of a and b.

Calculate the speed of the star relative to the Earth.

[5]

(iv) uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.

person's eye colour may be categorised as "brown", "blue" or "other". A scientist claims that these eye colours are uniformly distributed and hence are equally likely to occur in the population. A survey of 120 people from this population found that 38 people had brown eyes, 52 people had blue eyes and 30 people had eyes which were neither brown nor blue.

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 ?

[4]

(e) (v) fair 8-sided dice has faces labelled K, A, N, G, A, R, O, O. The dice is rolled repeatedly.

the matrix $\mathbf{A}$,

[10]

(iii) by induction that $u_n = 6^n - 1$ for all positive integers n.

an assumption necessary for the test in part (a) to be valid.

[8]

(i) an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

Hence solve the equation $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4$, for $0^\circ \leqslant \theta \leqslant 360^\circ$.

coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.

[4]

(iv) uniform small smooth spheres A and B have equal radii and each has mass m. Sphere A is moving with speed u on a smooth horizontal surface when it collides directly with sphere B which is at rest. The coefficient of restitution between the spheres is $\frac{2}{3}$. Sphere B is initially at a distance d from a fixed smooth vertical wall which is perpendicular to the direction of motion of A. The coefficient of restitution between B and the wall is $\frac{1}{3}$.

$$x = 1 + 2\sin^2\theta, \quad y = 4\tan\theta$$

[3]

(b) (ii) the values of a, b, x and y.

continuous random variable X has probability density function f given by

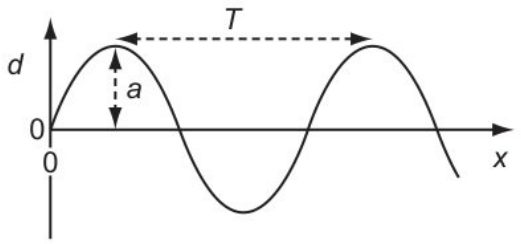
[10]

(i) nucleus of sodium- 21, $^{21}_{11}\text{Na}$, decays to form a new nucleus containing 10 protons and 11 neutrons.

6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

[5]

12 Show that $a = 19$ and find the values of b and c.



(d) (i) (amplitude)$^2 \propto \sqrt{\text{intensity}}$

Write down matrices $\mathbf{P}$ and $\mathbf{D}$ such that $\mathbf{P}^{-1}\mathbf{AP} = \mathbf{D}$, where $\mathbf{D}$ is a diagonal matrix, and hence find the matrix $\mathbf{A}^n$ in terms of n, where n is a positive integer.

[6]

(iv) For a different value of θ, the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ.

leptons are emitted from the sodium-21 nucleus during the decay?

all solutions in the interval $0° \leqslant \theta \leqslant 180°$.

[6]

(ii) V remains the same because the decrease of p.d. across r is balanced by the increase of p.d. across R.

In a nuclear reaction, proton number and neutron number are conserved. Other than proton number and neutron number, state a quantity that is conserved in a nuclear reaction.

Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

[4]

(b) (i) random sample of twelve pairs of values of x and y is taken from a bivariate distribution. The equations of the regression lines of y on x and of x on y are respectively

point P is the foot of the perpendicular from A to l.

[2]

(iv) The wavelength of maximum intensity of emission is used to determine a value for the surface temperature of the star.

Find the total distance travelled by the particle in the first 10 seconds of motion.

Show that $\cos\theta = \frac{2}{3}$.

[3]

(iii) overall efficiency of the turbine and generator system is 90%. The density of water is 1000 kg m^{-3}.

that $v = y^3$, show that

[6]

(vi)

Length (cm)	$5-9$	$10-14$	$15-19$	$20-24$	$25-29$	$30-39$
Frequency	18	28	60	72	48	24

$n \geqslant 0$. Show that, for all $n \geqslant 2$,

[4]

(c) (ii) Find the deceleration of the tractor at the instant it begins to climb the hill.

the arc length of C,

[5]

(i) Sound waves are transverse waves and light waves are longitudinal waves.

your answer correct to 2 decimal places.

[3]

13 (d) the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) \mathrm{d}x$.

$$\alpha + \beta + \gamma = -6, \quad \alpha^2 + \beta^2 + \gamma^2 = 38, \quad \alpha\beta\gamma = 30$$

(iii) Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

[10]

(iv) astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

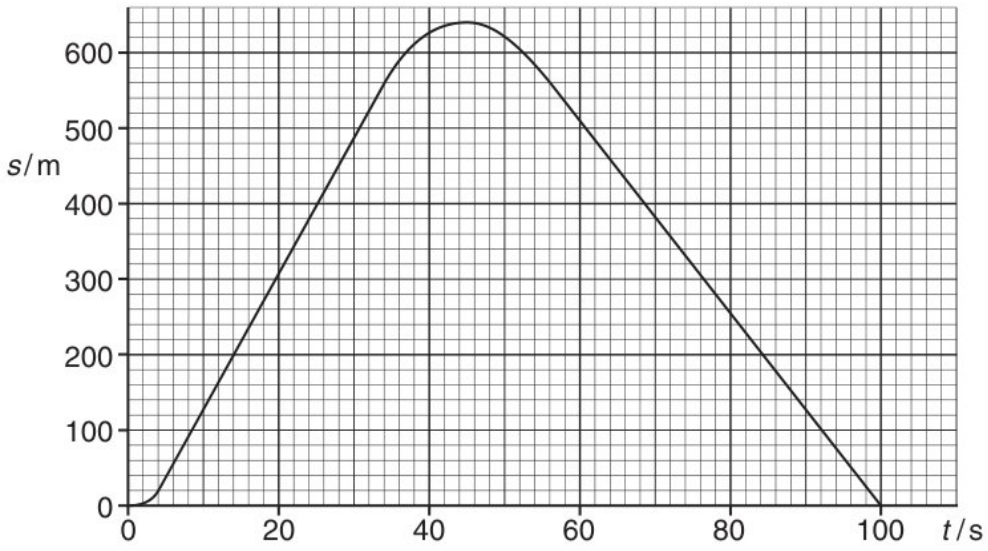
results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

[6]

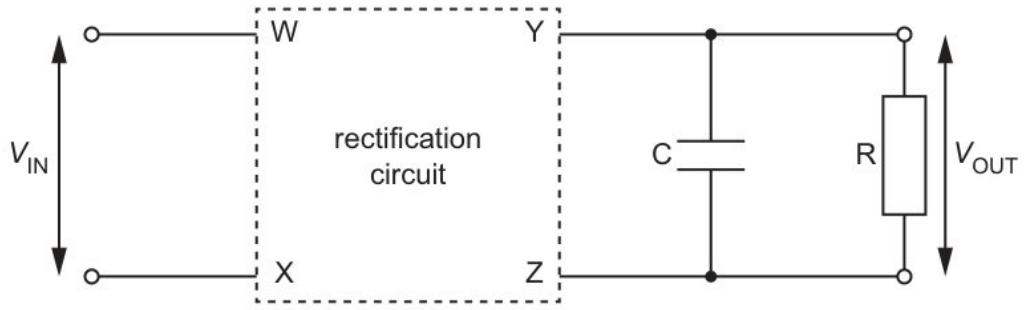
(i) particle oscillates in simple harmonic motion with centre O. When its distance from O is 3 m its speed is 16 m s^{-1}, and when its distance from O is 4 m its speed is 12 m s^{-1}. Find the period and amplitude of the motion.

[2]

(c)



a sketch of an Argand diagram, shade the region whose points represent complex numbers z which satisfy both the inequalities $|z| < 2$ and $|z| < |z - 2 - 2\mathrm{i}|$.



source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

(i) The matrix **B**, where

[5]

(vii) object weighs 6.0 N on Earth.

[6]

11 State the name of this type of reaction.

(b) (ii) random variables X and Y have the independent distributions $\mathrm{N}(44, 16)$ and $\mathrm{N}(30, 9)$ respectively.

doctor is investigating the concentration of blood glucose in patients at risk of developing type 2 diabetes where blood glucose is measured in appropriate units The doctor claims that a particular intervention reduces the concentration by more than k units on average A group of 8 at risk patients is selected at random and each patient follows the intervention for six months The blood glucose concentrations before and after the intervention are given in the following table

[4]

(i) 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.

a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A}^{-1} = \mathbf{PDP}^{-1}$.

[5]

(iii) Explain, with reference to the diagram, why the trapezium rule may be expected to give a good approximation to the true value of the integral in this case.

Potential difference is energy per unit current.

[5]

(c) (ii) 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.

is the change to the quark composition of a nucleus that takes place during β^+decay?

$$\tan 4\theta = \frac{4\tan\theta - 4\tan^3\theta}{1 - 6\tan^2\theta + \tan^4\theta}$$

[6]

(iv) 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 $\lambda\mu$.

Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

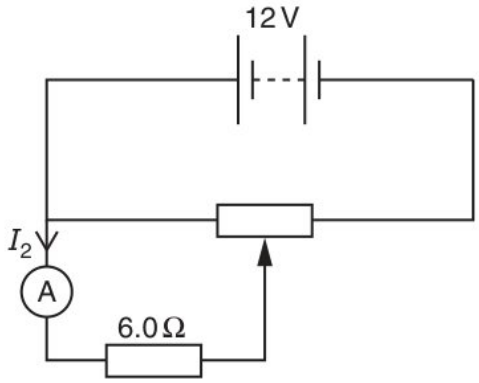
[5]

(i) eigenvalues $1, -1$ and -2 .

mean, $\bar{x}$, is 28.325 .

[8]

(a) (iii) copper wire is 6.4 m long and has a resistance of 0.92Ω.



[15]

(i) up the probability distribution table for X.

the probability that the mass of peaches sold on any given day is between 56 kg and 75 kg

[10]

(vi) eigenvalues $1, -1$ and -2 .

mass of peaches sold per day in a supermarket is normally distributed with mean 65.8 kg and standard deviation 9.6 kg

[3]

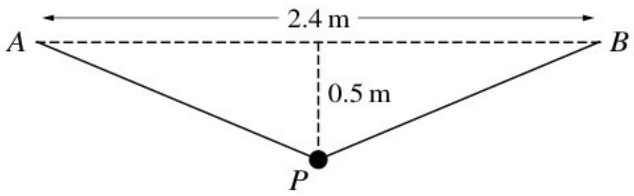
(iv) plane Π_2 contains the lines

results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

[10]

20 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).

(d) (ii) 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.



[4]

(i) only one of the following two alternatives.

$$\Sigma x = 210.9 \quad \Sigma(x - \bar{x})^2 = 151.2$$

variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

[8]

(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.

$$V = V_0 e^{-\alpha n t}$$

[6]

(a) (i) 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 .

Find the mean and variance of the daily income, in millions of dollars, generated by field A.

On Fig. 9.1, sketch the variation of the activity A of the sample with t for values of t between $t = 0$ and $t = 24$ min.

[6]

(ii) Find the x-coordinate of M.

the number of different ways in which the 12 letters of the word STRAWBERRIES can be arranged

Hence find the solutions of the equation

[10]

(iv) aircraft, initially stationary on a runway, takes off with a speed of 85kmh^{-1} in a distance of no more than 1.20 km .

diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

[4]

7 far apart are two adjacent interference fringes that are formed on the laboratory wall?

(b) (i) is given that $\sum x = 175.0$ and that the mean of y is 8.4 .

Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm \sin \frac{1}{5}\pi$ and $x = \pm \sin \frac{2}{5}\pi$.

[4]

(vi) is the magnitude of F when the child stands at X and when the child stands at Y ?

supermarket is open 7 days a week.

[6]

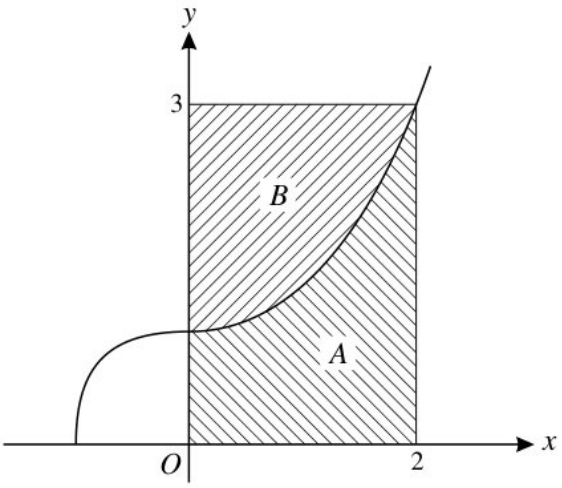
(iii) Hence obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

curve C has parametric equations $x = \mathrm{e}^t \cos t, y = \mathrm{e}^t \sin t$, for $0 \leqslant t \leqslant \pi$. Find the arc length of C.

one similarity and one difference between an electron and positron.

[2]

(a) (i) resistor of resistance 240Ω is now replaced by a new resistor X of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.



[4]

(ii) device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

only one of the following two alternatives.

[8]

(c) (iv) s friend says,"This survey is about sports facilities, so you should choose a sample of students from the school sports teams."

is the density of the mixture with volume 2.0 m^3 ?

[6]

(v) time taken by P to travel directly from L to M is 2 s .

Find the equations of the asymptotes of C.

[10]

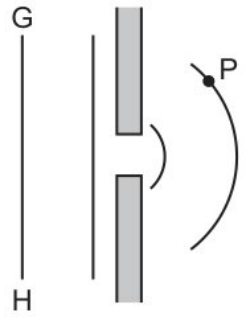
(iii) quartile: 28, Median: 39, Upper quartile: 67.

Find the area of the sector of C between $\theta = 0$ and $\theta = \frac{1}{3}\pi$.

[10]

(f) (ii) the exact solutions of the equation f(x) = 1.

points A, B, C have position vectors



about rotated = ... kz **[4]**

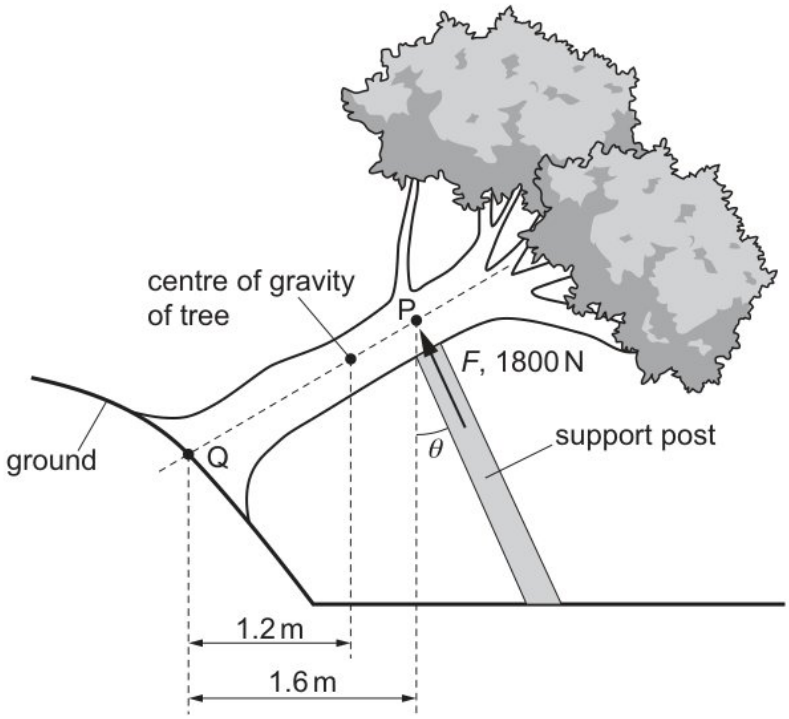
(v) random variable Y is defined by $Y = X^3$. Find

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

[12]

7 probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

(c) (ii)

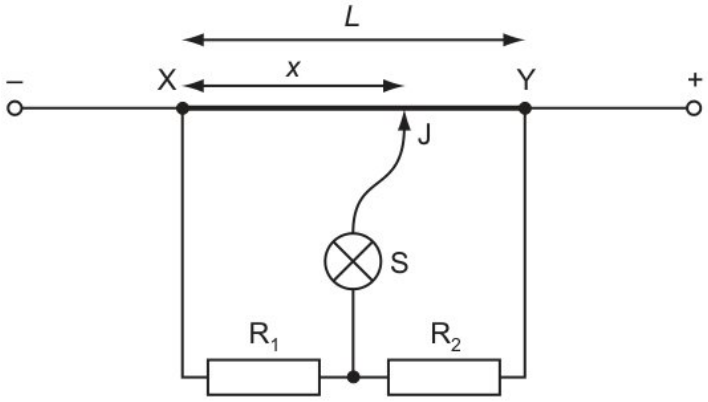


Verify that $\frac{2r+1}{r(r+1)(r+2)} = \frac{1}{2}\left\{\frac{(2r+1)(2r+3)}{(r+1)(r+2)} - \frac{(2r-1)(2r+1)}{r(r+1)}\right\}$.

flows out of a pipe and hits a wall.

[8]

(vi) smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.



[5]

(b) (i) adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

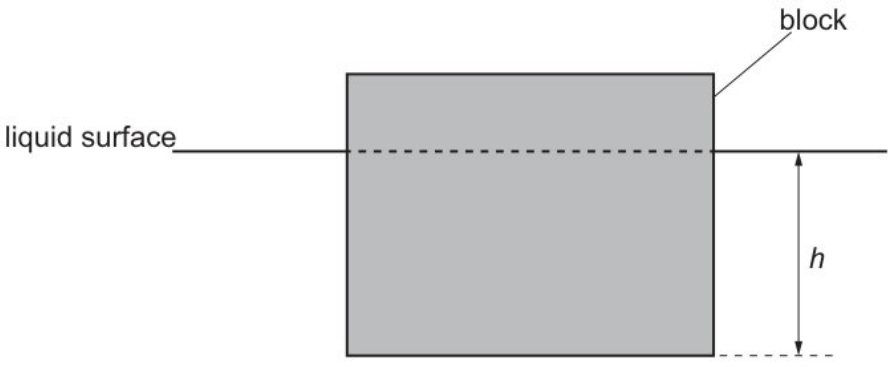
[5]

(ii) system is released from rest with OP making a small angle α with the downward vertical. Find

524 526 520 523 530

[5]

(a) (i)



point P is the foot of the perpendicular from A to l.

[8]

(ii) 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 $t = 4$.

constant a is such that $\int_1^a 6x \ln x \, \mathrm{d}x = 4$

small threaded system mass = ... ng **[12]**

(vi) Find the value of $(\alpha + 1)(\beta + 1)(\gamma + 1)$.

Use the iterative formula $x_{n+1} = \frac{1}{\sin x_n}$ to determine this root correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

[15]

17 that $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$ is an eigenvector of the matrix $\mathbf{D}$, where

Show that if

Find the coordinates of the turning points of C.

(a) (i) copper wire is 6.4 m long and has a resistance of 0.92Ω.

is the speed of the block at the bottom of the slope?

[5]

(vi) a result of the collision, A moves in a direction which is perpendicular to the line of centres.

$$\Sigma x = 210.9 \quad \Sigma(x - \bar{x})^2 = 151.2$$

Derive an expression for v in terms of B and the electric field strength E.

[6]

(b) (ii) values, x, in a particular set of data are summarised by

the form $\sec(q\pi)$ where q is rational

Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16 \sin^5\theta \, \mathrm{d}\theta$.

[6]

(v) student wishes to measure a distance of about 10 cm to a precision of 0.01 cm .

Find the area of the triangle ABC.

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

[5]

(d) (i) object is held in equilibrium by the forces F_1 and F_2. The object weighs 10 N . There is negligible friction between the rods and cords. Angle θ is 90°.

how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

[4]

(iii) t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

the eigenvalues and corresponding eigenvectors of the matrix $\mathbf{A} = \begin{pmatrix} 4 & -1 & 1 \\ -1 & 0 & -3 \\ 1 & -3 & 0 \end{pmatrix}$.

$$\sum_{r=1}^{n} \frac{1}{(2r+1)(2r+3)}$$

[4]

(ii) the eigenvalues of the matrix $\mathbf{C}$, where

Find the period of the motion.

parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV .

[3]

17 Find the proportions of large, small and medium pineapples.

(d) (i) Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

variables x and y are related by the differential equation

[3]

(ii) source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

amplitude $\propto$ intensity

[4]

(iii) Velocity is proportional to wavelength.

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]

(b) (i) the number of different ways in which these three bands can be selected.

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.

[5]

(ii) Show that $\frac{\mathrm{d}^{n+1}}{\mathrm{d}x^{n+1}}\left(x^{n+1}\ln x\right) = \frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n + (n+1)x^n \ln x\right)$.

wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

[4]

(iii) the inequality $3x - 1 < |2x - 3|$.

Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

[10]

17 the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

ball is thrown against a vertical wall. The path of the ball is shown in Fig. 3.1.

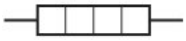
(a) (iii) Carry out a goodness of fit test at the 10% significance level.

$$a^2\left(\frac{1}{6}\pi - \frac{1}{8}\sqrt{3}\right)$$

[6]

(vi) students are selected at random from the students who study Science.

is given that a is a positive constant such that



[8]

(c) (i) 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.

525 520 522 524 518 520 519 525 527 516

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.

[3]

(iv) that, for $n \geqslant 2$, $\quad I_n = -1 + n(n-1)I_{n-2}$.

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.

[10]

(ii) random variable, X, has the distribution Po(31). Use the normal approximation to the Poisson distribution to find $\mathrm{P}(X > 40)$.

curve C has parametric equations

Write down matrices $\mathbf{P}$ and $\mathbf{D}$ such that $\mathbf{P}^{-1}\mathbf{A}\mathbf{P} = \mathbf{D}$, where $\mathbf{D}$ is a diagonal matrix, and hence find the matrix $\mathbf{A}^n$ in terms of n, where n is a positive integer.

[5]

23 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.

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.

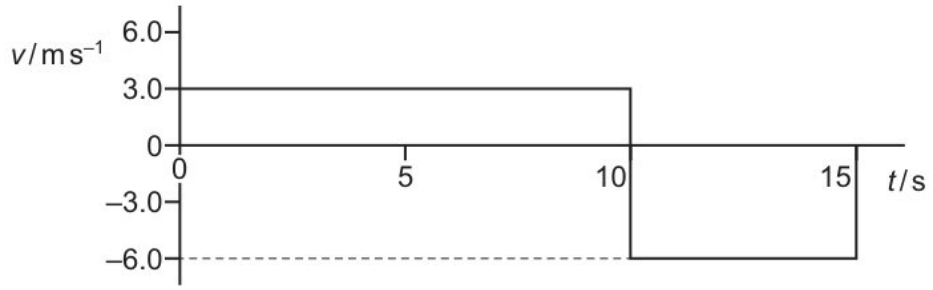
number, x, of beech trees was counted in each of 50 randomly chosen regions of equal size in beech forests in country A. The number, y, of beech trees was counted in each of 40 randomly chosen regions of the same equal size in beech forests in country B. The results are summarised as follows.

(a) (ii) Express u in the form $x + \mathrm{i}y$, where x and y are real.

$\frac{\text{mass} \times (\text{ time })^2}{\text{length}}$

[3]

(iii) decides to choose 35 students at random. If 3 or fewer of these students are left-handed, Amir will reject his belief.



[3]

(d) (i) smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.

cable car of weight W hangs in equilibrium from its cable at point P.

[5]

(iii) X and Y are connected in series to a cell.

number of cars sold per day at another showroom has the independent distribution Po(0.6). Assume that the distribution for the first showroom is still Po(0.7).

[5]

13 is the force on an electron when it is in the uniform electric field between the plates?

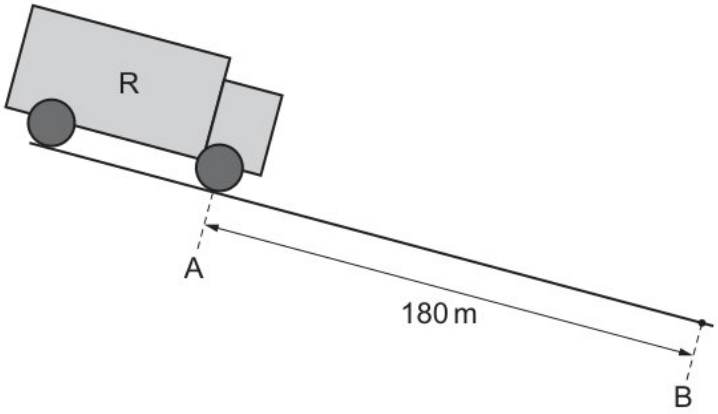
(iii) (f) roller-coaster car (including passengers) has a mass of 840 kg . The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

Derive an expression for v in terms of B and the electric field strength E.

specific latent heat.

[8]

(e) magnetic flux density.



[4]

(a) battery is marked 9.0 V .

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.

[10]

(i) (b) There will always be 9.0 V across the battery terminals.

three coplanar forces shown in the diagram act at a point P and are in equilibrium.

matrix $\mathbf{M}$ represents a sequence of two geometrical transformations in the $x - y$ plane

[8]

(d) is a statement of the principle of conservation of momentum for a system?

Deduce that the cartesian equation of C is

[8]

(c) matrix **A** is given by

Find, showing all necessary working, the equation of the regression line of y on x.

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

[15]

(a) quartile: 28, Median: 39, Upper quartile: 67.

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.

[10]

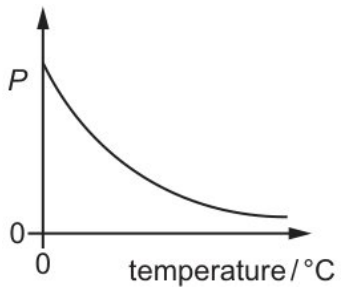
18 random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.

(a) (iii) the time that it takes for the block to move 2 m down the plane from rest.

flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in Fig. 4.1.

[5]

(iv) a 90% confidence interval for the difference in mean crop mass associated with each type of fertiliser.



[6]

(ix)

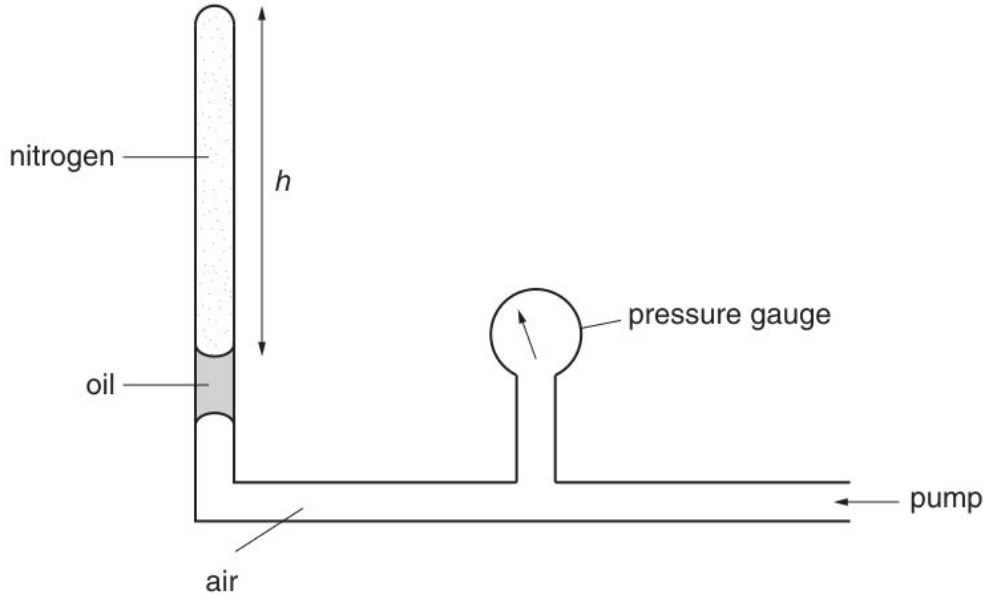


diagram shows part of the curve

parametric equations of a curve are

[8]

(c) (iii) this compression, work W is done on the gas.

Find $\frac{dy}{dx}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.

[6]

(iv)

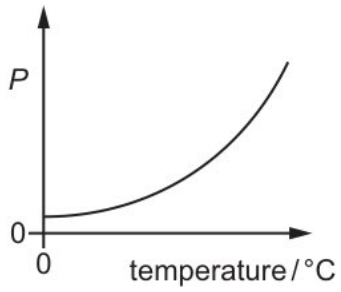
Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

the vertical and horizontal components of velocity at time t.

[10]

30 Find the area of the triangle ABC.

(b) (i)



On Fig. 9.1, sketch the variation of the activity A of the sample with t for values of t between $t = 0$ and $t = 24$ min.

[8]

(iii) by calculation that a lies between 2 and 2.1.

the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

[4]

(c) (i) 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 $\lambda\mu$.

Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

de Moivre's theorem to prove that

[8]

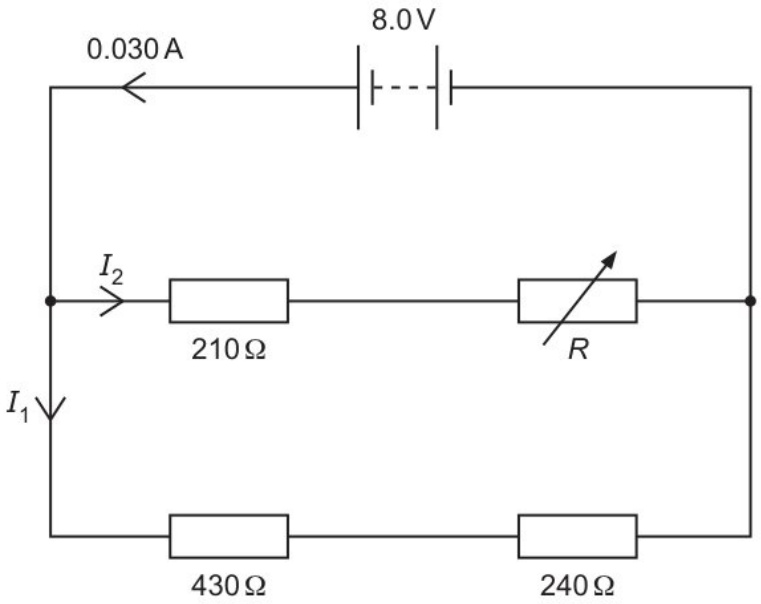
(iii) fixed hollow sphere with centre O has a smooth inner surface of radius a. A particle P of mass m is projected horizontally with speed $2\sqrt{(ag)}$ from the lowest point of the inner surface of the sphere. The particle loses contact with the inner surface of the sphere when OP makes an angle θ with the upward vertical.

the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

activity of a radioactive sample.

[4]

(ii)



Find a vector equation for the line of intersection of the planes.

[5]

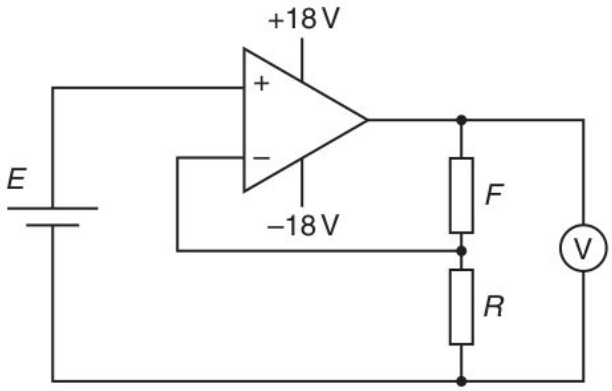
(d) (iv) the number of different arrangements of the 7 men and 4 women in a line in which all the men stand together and all the women stand together.

Show that $\mathrm{ff}(x) = x$.

[8]

(ii) is the average useful power at which he is working?

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.



[10]

(iii) Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

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.

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 .

speeds centres = ... *cd* **[20]**

(f) (i) transmitted light has intensity I.

believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p, is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $\mathrm{H}_0 : p = 0.2$, against the alternative hypothesis, $\mathrm{H}_1 : p < 0.2$.

[10]

(v) airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.

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.

[2]

14 is the current in the load resistor?

(c) (i) diagram shows the curve $y = \sqrt{\left(1 + x^3\right)}$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.

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.

[3]

(vii)

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

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.

[4]

(vi) tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

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.

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.

[15]

(b) (i) is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

diagram shows the curve $y = \sqrt{(1 + x^3)}$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.

[5]

(iii) Show that there is no point on C for which $\frac{1}{3} < y < 3$.

uniform small smooth spheres A and B have equal radii and each has mass m. Sphere A is moving with speed u on a smooth horizontal surface when it collides directly with sphere B which is at rest. The coefficient of restitution between the spheres is $\frac{2}{3}$. Sphere B is initially at a distance d from a fixed smooth vertical wall which is perpendicular to the direction of motion of A. The coefficient of restitution between B and the wall is $\frac{1}{3}$.

the value of c such that $\mathrm{P}(-c < t < c) = \frac{1}{2}$.

[8]

(v) diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

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

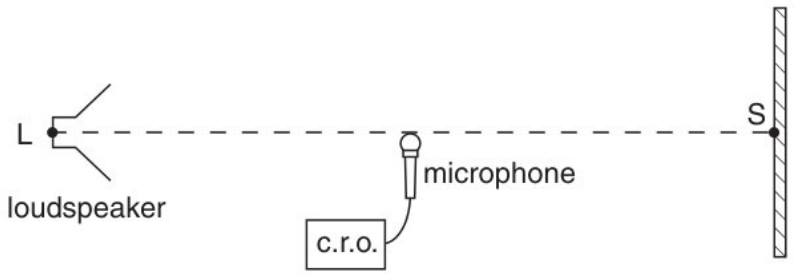
[1]

(a) (iii) throws three coins at the same time.

Find the probability that the total number of cars sold in the two showrooms during 3 days is exactly 2 .

[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.

[8]

(ii) are the weight and the mass of the body when it is on the Moon?

the value of θ for which the transformation represented by $\mathbf{M}$ has a line of invariant points. [7]

radio-controlled toy car travels along a straight line for a time of 15 s .

[6]

15 has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.

the matrix **A**,

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)(vii) the curve with equation $y = \left|\frac{2x^2-5x}{2x^2-7x-4}\right|$.

isolated stationary nucleus Q decays into nucleus R and an α-particle. The α-particle has speed 1.5×10^7 ms^{-1}.

Determine the decay constant, in min^{-1}, of the radioactive isotope.

[8]

(iii) diagram shows a semicircle ACB with centre O and radius r. The tangent at C meets AB produced at T. The angle BOC is x radians. The area of the shaded region is equal to the area of the semicircle.

Find the magnitude and direction of the force exerted by the surface on the lamina at A.

[3]

(i) When a and b have these values, factorise p(x) completely.

the gas has a volume V_1 and is in equilibrium with the external pressure p. The gas is then heated slowly so that it expands at constant pressure, pushing the piston back until the volume of the gas has increased to V_2.

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

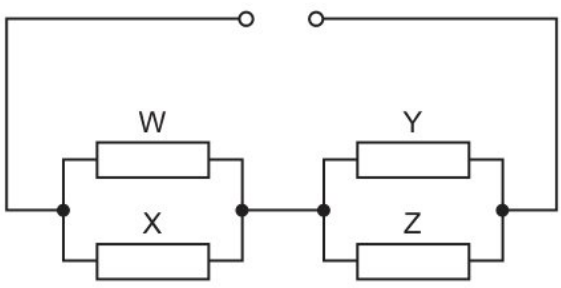
[10]

(v) random variable X is the number of heads obtained.

waves are emitted from two sources.

[1]

(a) (iii) graph shows the variation with time of the velocity of the object?



For some nuclei, the nucleon number can be less than the proton number.

[10]

(ii) uniform disc with centre O, mass m and radius a is free to rotate without resistance in a vertical plane about a horizontal axis through O. One end of a light inextensible string is attached to the rim of the disc and wrapped around the rim. The other end of the string is attached to a block of mass $3m$ (see diagram). The system is released from rest with the block hanging vertically. While the block is in motion, it experiences a constant vertical resisting force of magnitude $0.9mg$. Find the tension in the string in terms of m and g.

Find the value of t when the particle is instantaneously at rest.

[10]

14 polynomial $\mathrm{p}(x)$ is defined by

(c) (i) forces, of magnitudes F N, $3F$ N, G N and 50 N , act at a point P, as shown in the diagram.

diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm .

[3]

(iii) random variable Y is defined by $Y = \sqrt[3]{X}$

Find the modulus of elasticity of the string in terms of W.

is the average useful power at which he is working?

[6]

(a) (ii) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$

$$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}.$$

the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

[2]

(iv) overall efficiency of the turbine and generator system is 90%. The density of water is 1000 kg m^{-3}.

or otherwise solve the inequality $|3x - 2a| < x + 5a$.

variables x and y satisfy the differential equation

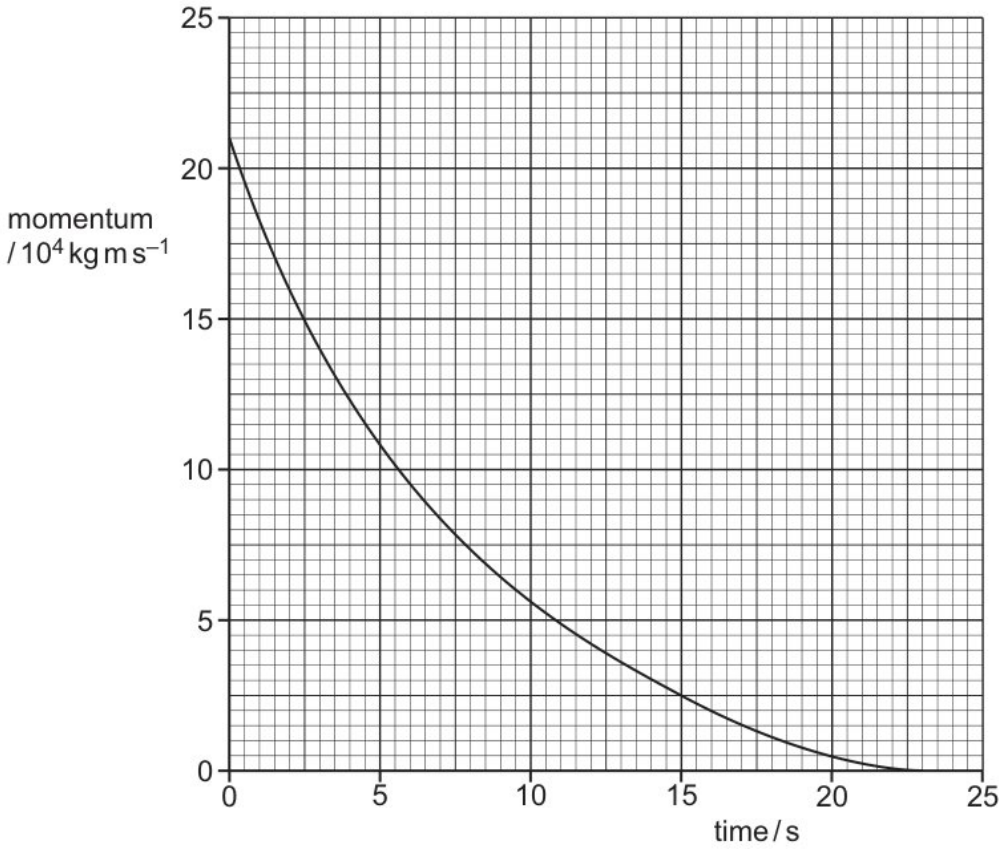
[5]

(i) At a certain instant, P and Q are above the ground and $3h_P = 8h_Q$. Find the velocities of P and Q at this instant.

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.

[10]

(iii)



why Kieran is incorrect.

[1]

15 (d) that the forces are in equilibrium, find the values of θ and X.

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.

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.

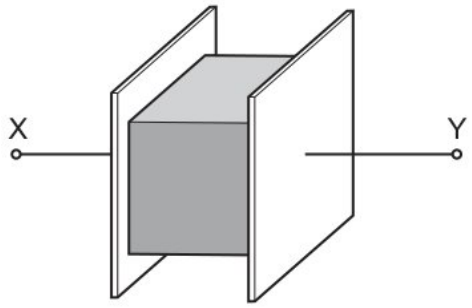
(iii) star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

[3]

(iv) the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

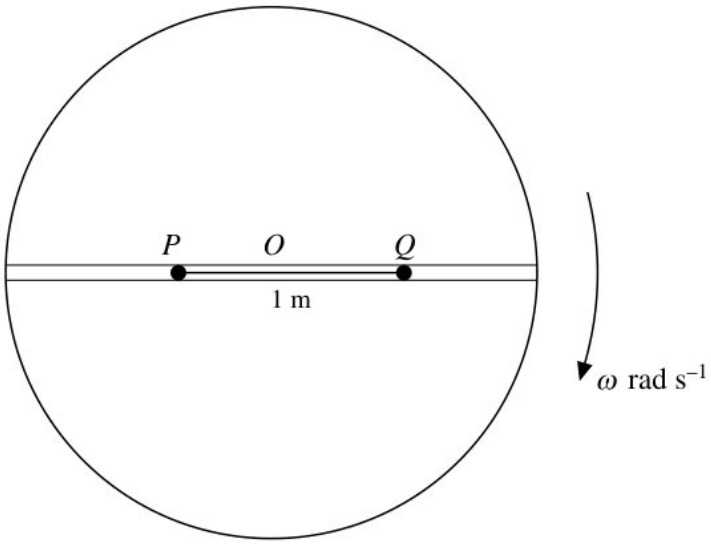
[5]

(ii) a, b and c are integers to be determined.



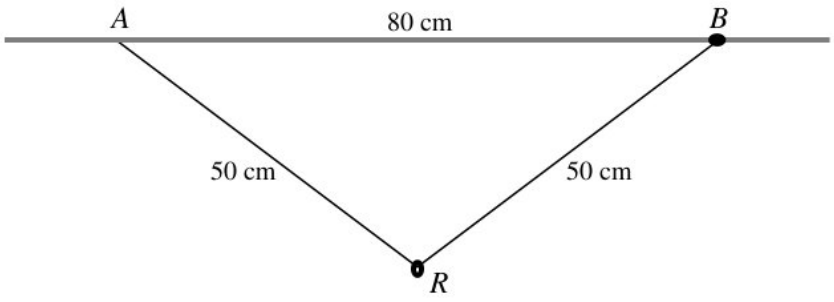
[10]

(i) Show how the expected value of 22.18 , for $x = 3$, is obtained and find the expected values for $x = 6$ and for $x \geqslant 7$.



[12]

(c) specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.



(i) that u_{2n} is divisible by u_n for $n \geqslant 1$.

the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

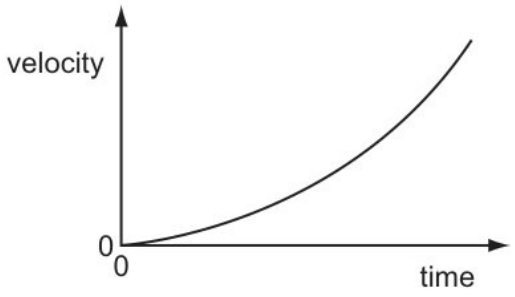
[6]

(iii) Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

[12]

10 the probability that the sum of three independent values of X is between 3 and 5 inclusive. [3]

(c) (vi)



selects 4 books from her 10 different books from the series Squares and Circles.

[4]

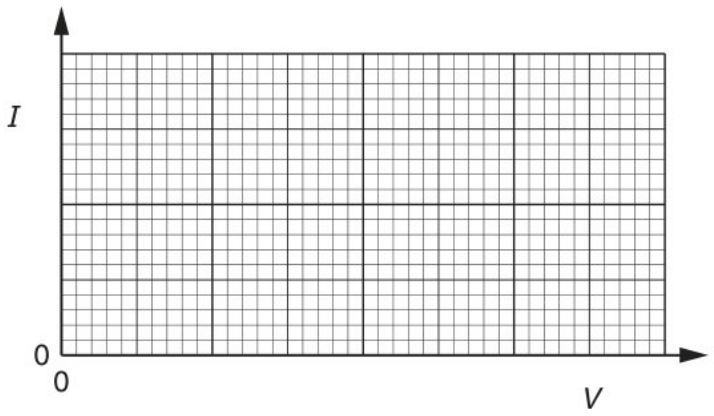
(i) is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

$$\operatorname{cosec}^5 \theta = \frac{a}{\sin 5\theta + b \sin 3\theta + c \sin \theta}$$

[12]

(ii) resultant force of 3800 N causes a car of mass of 1500 kg to accelerate from an initial speed of 15 ms^{-1} to a final speed of 30 ms^{-1}.

Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.



[5]

(d) (ii) curve C has equation

the value of c such that $\mathrm{P}(-c < t < c) = \frac{1}{2}$.

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.

[1]

(iv) the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

control of variables,

[6]

(i) A contains 6 red marbles, 5 blue marbles and 1 green marble.

525 520 522 524 518 520 519 525 527 516

that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[8]

(a) (ii) R has an amplitude of 8 cm and a period of 30 ms .

that l_1 and l_2 do not intersect.

For this value of k, find the set of possible solutions, giving your answer in the form

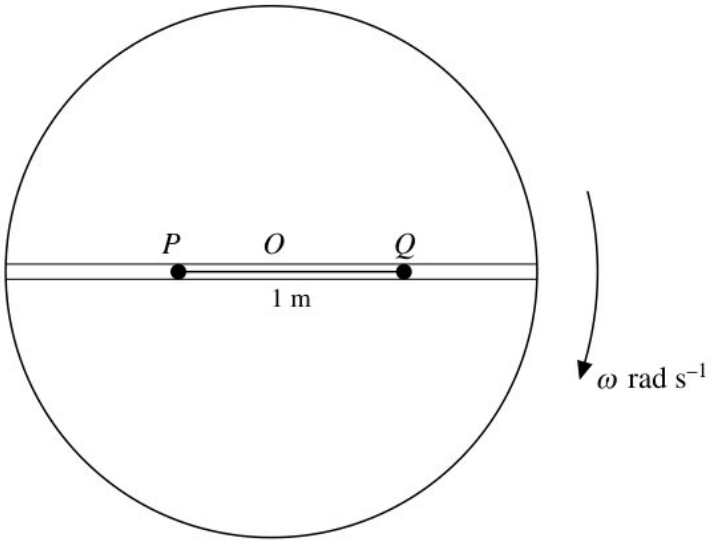
[4]

(iii) ripple tank is used to demonstrate interference between water waves.

the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

[2]

(iv)



one similarity and one difference between an electron and positron.

[3]

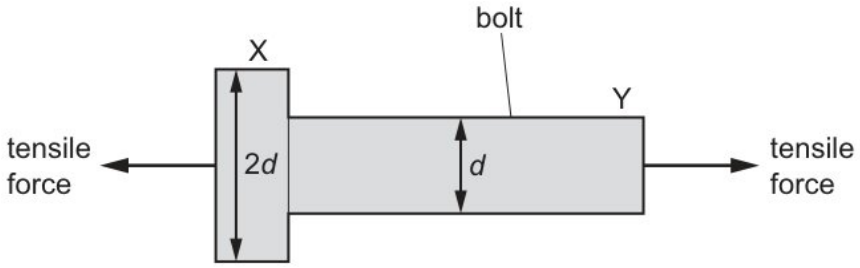
(v) Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

Find the values of p and q.

the exact value of $\lim_{n\to\infty} \sum_{r=1}^{n} \frac{n}{n^2+r^2}$.

[4]

(b) (ii)



that when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$

[4]

(iii) is given that $\mathrm{f}(n) = 3^{3n} + 6^{n-1}$.

Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

down to antiup

[15]

8 considering the sum of the areas of these rectangles, show that

(c) (ii) curve has equation $y = \frac{4}{3x-4}$ and $P(2, 2)$ is a point on the curve.

plank has a mass of 7.0 kg and has a pivot at its midpoint. The plank is horizontal and in equilibrium.

the position vector of P.

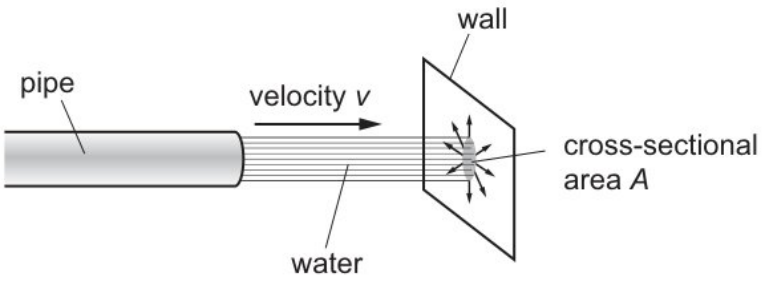
[8]

(v) Express $\mathrm{f}(x)$ in partial fractions.

$$\alpha + \beta + \gamma = -6, \quad \alpha^2 + \beta^2 + \gamma^2 = 38, \quad \alpha\beta\gamma = 30$$

[8]

(a) (iii)



Find the value of x.

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

[3]

(ii) small ball is rolled with velocity v along a horizontal surface. When the ball reaches the end of the horizontal surface, it falls and lands on a lower horizontal surface. The vertical displacement of the ball is p and the horizontal displacement of the ball is q, as shown in Fig 1.1.

The total momentum is conserved provided that no external forces act.

the form $\sec(q\pi)$ where q is rational

[5]

(iv) down to antiup

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]

(v) curve C has equation $y = x^{\frac{3}{2}}$. Find the coordinates of the centroid of the region bounded by C, the lines $x = 1, x = 4$ and the x-axis.

is the efficiency of the process?

random sample of 12 customers who each bought a computer from this store is chosen.

[8]

(b) (i) Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16\sin^5\theta \, \mathrm{d}\theta$.

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

[6]

(iii) Find angle ABC.

activity of a radioactive sample.

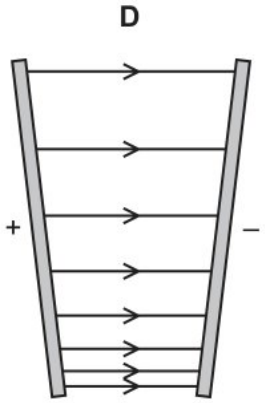
[20]

(d) (i) three coplanar forces shown in the diagram act at a point P and are in equilibrium.

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.

[10]

(ii) this compression, work W is done on the gas.



him. = ... yl **[10]**

(iii) 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 .

aircraft, initially stationary on a runway, takes off with a speed of 85 km h^{-1} in a distance of no more than 1.20 km .

[6]

8 that $\tan 2a = -4a$

(d) (iv) the values of a, b, x and y.

the acute angle between the directions of l_1 and l_2.

exact = ... mt **[12]**

(iii)

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

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.

[3]

(ii) Find, showing all necessary working, the equation of the regression line of y on x.

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

plank rests on fixed supports at its ends X and Y.

[10]

(a) (iv) the probability that the mass of pasta in a randomly chosen large bag is less than 2.65 kg .

uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.

[1]

(ii) It limits the range of values obtained in repeated measurements.

$$\Sigma b = 92.0 \quad \Sigma b^2 = 216.5 \quad \Sigma g = 129.8 \quad \Sigma g^2 = 288.8$$

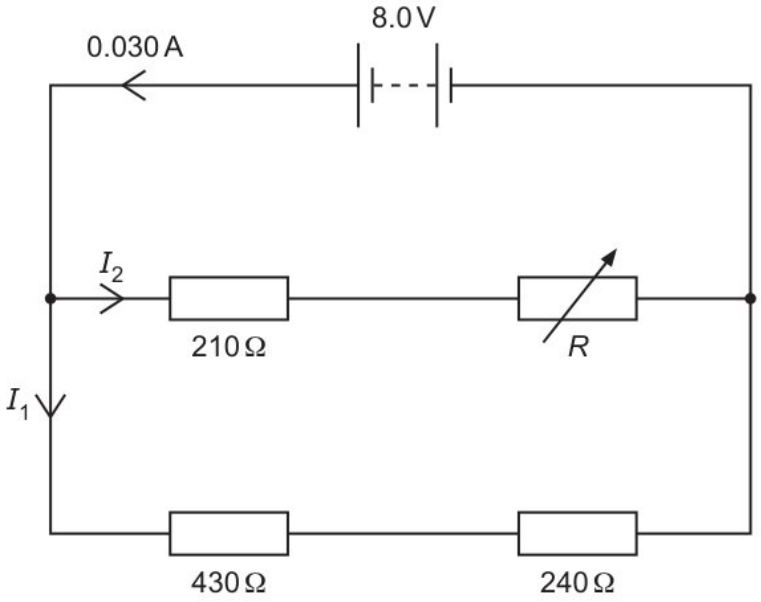
[8]

(c) (ii) Use the iterative formula $x_{n+1} = \frac{1}{\sin x_n}$ to determine this root correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

object hangs by means of two cords around two rods, as shown.

[4]

(v)



considering momentum, calculate the speed of nucleus R after the decay.

[5]

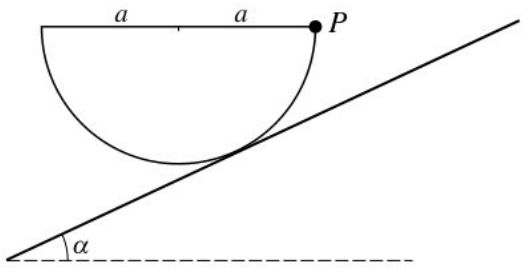
6 ice cube of mass 37.0 g at temperature 0.0°C is placed in a beaker containing water of mass 208 g at temperature 26.4°C.

(d) (iv) 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.

the area of the region bounded by C and the initial line, giving your answer in the form $\left(p\pi^2 + q\pi + r\right)\mathrm{e}^{\frac{1}{2}\pi} + s$, where p, q, r and s are integers to be determined.

[6]

(iii)



is an approximate value for the speed of sound in air?

It consists of three quarks that do not need to be the same flavour.

[4]

(ii) curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.

why the variation with time of the activity of a radioactive sample is exponential in nature.

[6]

(i) the value of σ.

a value, to three significant figures, for the specific latent heat of fusion of water.

[4]

(c) (i) Find the value of t when the particle is instantaneously at rest.

doctor is investigating the concentration of blood glucose in patients at risk of developing type 2 diabetes where blood glucose is measured in appropriate units The doctor claims that a particular intervention reduces the concentration by more than k units on average A group of 8 at risk patients is selected at random and each patient follows the intervention for six months The blood glucose concentrations before and after the intervention are given in the following table

gas is then cooled at constant volume so that its temperature decreases to $2T$.

[5]

(iv) curve C has equation $y = \frac{2x^2 - 5x}{2x^2 - 7x - 4}$.

for a wire,

Calculate the greatest deceleration of P.

[6]

(b) (ii) star in a distant galaxy emits radiation that has a maximum intensity of emission at a wavelength of 4.62×10^{-7} m.

ball is released from rest at time zero. After 1.0 s it bounces inelastically from a horizontal surface and rebounds, reaching the top of its first bounce after 1.5 s .

random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

[10]

(iv) graph shows the variation with temperature of power, P, dissipated in the thermistor?

the value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ at P,

[4]

(iii) 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

is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

[10]

20 selects 4 books from her 10 different books from the series Squares and Circles.

your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

Find the frictional and normal components of the contact force acting on B.

(c) (ii) 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.

Hence obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

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.

[3]

(iv) The individual ages in years of people in the first Art class are denoted by x and those in the second Art class by y. By first finding $\sum x^2$ and $\sum y^2$, find the standard deviation of the ages of all 19 people.

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 .

$$s = (\sqrt{2})a \int_{-\frac{1}{2}\pi}^{\frac{1}{2}\pi} \sqrt{(1 + \sin\theta)} \mathrm{d}\theta$$

[10]

(d) (i) smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.

is given that $z_1 = r_1 e^{i\theta_1}$ and $z_2 = r_2 e^{i\theta_2}$.

[8]

(iii) the distribution function of X.

marks of the pupils in a Physics examination are summarised as follows.

State the name of this type of reaction.

[4]

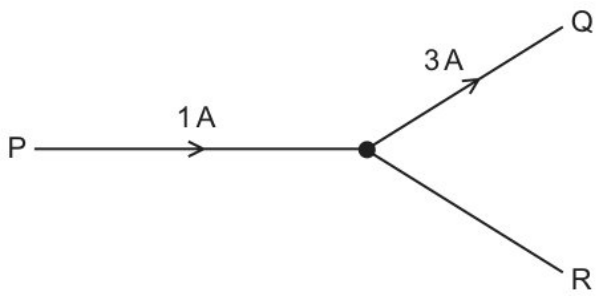
(v) row of the table gives an angle θ of $90°$?

the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

[3]

11 - coming to rest instantaneously on hitting the ground.

(f) (i) coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.



[3]

(ii) $n \geqslant 0$. Show that, for all $n \geqslant 2$,

the roots of the equation $z^3 = 27 - 27\mathrm{i}$, giving your answers in the form $r\mathrm{e}^{\mathrm{i}\theta}$, where $r > 0$ and $-\pi \leqslant \theta < \pi$.

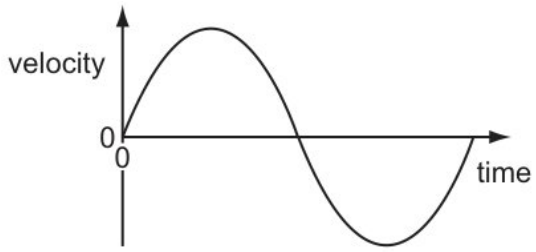
[5]

(iv) expression has the same SI base units as pressure?

Use your answer in (c)(i) to determine the half-life, in min, of the radioactive isotope.

[5]

(c) (ii)



hollow cylinder of radius r is fixed with its axis horizontal. Points A, B and O are in the same vertical plane perpendicular to the axis of the cylinder, with A and B on the smooth inner surface and O on the axis. OA and OB make angles 90° and α respectively with the upward vertical through O, with A and B on opposite sides of the vertical. A particle of mass m is projected vertically downwards from point A with speed $\sqrt{\frac{3}{2}rg}$ and moves in a vertical circle inside the cylinder (see diagram). The particle loses contact with the cylinder at point B.

[15]

(i) Show that $v\frac{\mathrm{d}v}{\mathrm{d}x} = 5 - 0.5v^2$.

matrix **A** is given by

[8]

(g) (i) an instant during the motion the velocity of the load is 1.5 m s^{-1}.

the equation of the tangent to the curve at the point e 3 Give your answer in the form $y = mx + c$ where m and c are exact

[8]

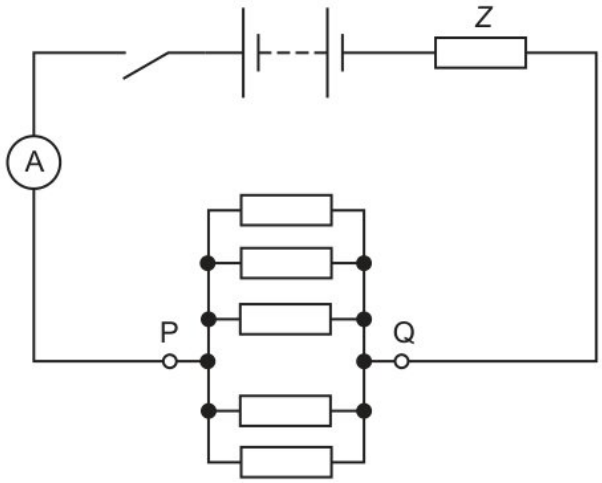
(iii) there are no restrictions,

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

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.

[5]

(b) (i) specific latent heat.



[5]

(iii) Given also that -1 is an eigenvalue of **A**, find a corresponding eigenvector.

Find the arc length of C between the point where $\theta = 0$ and the point where $\theta = \frac{1}{3}\pi$.

[4]

(e) (ii) $z = 3e^{\frac{1}{4}\pi i}$ is a root of the equation $z^2 + bz + c = 0$, where b and c are real.

linear transformation $T : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix **A**, where

[5]

(i) λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.

The battery supplies 9.0 J to an external circuit for each coulomb of charge.

[4]

(iii) 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.

Find the greatest height that P reaches above the level of O.

[8]

16 It limits the range of values obtained in repeated measurements.

down to antiup

(a) (iv) identical uniform smooth spheres A and B, each with mass m, are moving on a horizontal surface with speeds $2u$ and u respectively when they collide. Immediately before the collision, the spheres are moving parallel to each other in opposite directions such that their directions of motion each make an angle θ with the line of centres (see diagram). As a result of the collision, B moves in a direction which is perpendicular to its initial direction of motion. The coefficient of restitution between the spheres is e.

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 acceleration of the particle during the first 5 seconds of motion.

[6]

(ii) beaker has negligible specific heat capacity and is perfectly insulated from the surroundings.

continuous random variable X has probability density function f given by

[10]

(c) (iii) equation of a curve is $x^3y - 3xy^3 = 2a^4$, where a is a non-zero constant.

region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

[6]

(ii) Show that the tension in the string is 10 N .

$$\mathbf{A} = \begin{pmatrix} -1 & 3 & 4 \\ 0 & 1 & 0 \\ 0 & -2 & 5 \end{pmatrix}$$

P hears a sound of increasing frequency.

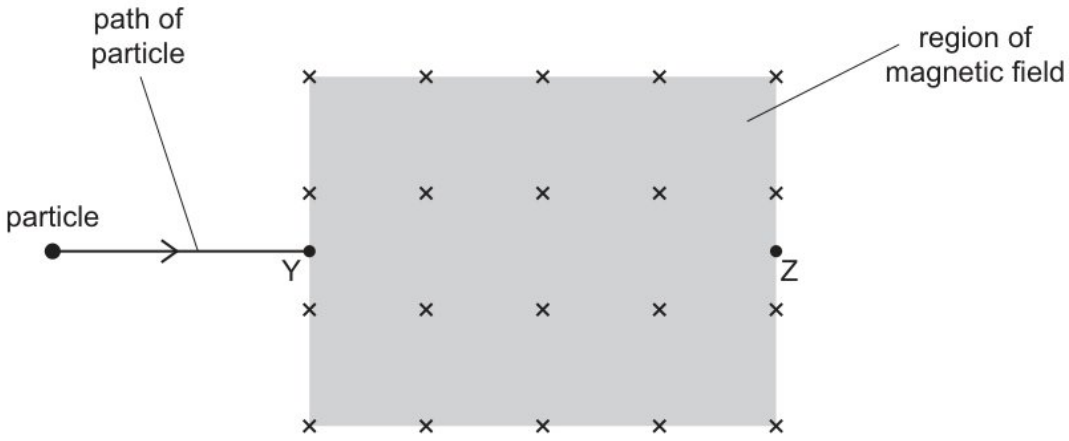
[10]

(iv) 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.

Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

[5]

(b) (v) only one of the following two alternatives.



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.

[8]

(iii) the value of θ for which the transformation represented by $\mathbf{M}$ has a line of invariant points 7

matrix $\mathbf{A}$ is given by

[10]

(ii) if there are no restrictions,

gas is enclosed inside a cylinder which is fitted with a frictionless piston.

[4]

(d) (v) When the tensile force is removed, the wire does not return to its original length.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n \ln x\right) = n!\left(\ln x + 1 + \frac{1}{2} + \ldots + \frac{1}{n}\right).$$

[10]

(iii)

that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

[5]

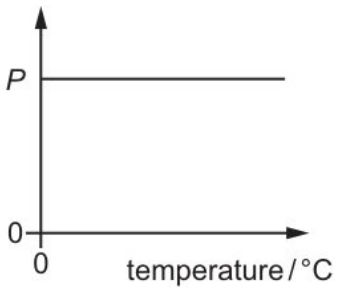
11 car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

(a) (iii) 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).

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 $t\mathrm{e}^{-v}$ 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 $t = 2$.

[5]

(iv)



cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ

[4]

(g) (iii) that $a = \exp\left(\frac{1}{6}\left(\frac{5}{a^2} + 3\right)\right)$ where $\exp(x)$ denotes e^x

State the work W done by F.

is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

[5]

(v) Show that the substitution $u = 1 + \sin\theta$ reduces this integral for s to $(\sqrt{}2)a\int_0^2 \frac{1}{\sqrt{(2-u)}}\mathrm{d}u$. Hence evaluate s.

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.

[10]

(i) the equations of the asymptotes of C.

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.

sample of an ideal gas at thermodynamic temperature T has internal energy U.

[6]

(c) (iv)

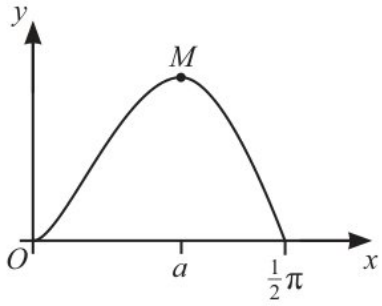
	amplitude /cm	period /ms
A	2	10
B	2	90
C	4	10
D	4	90

aircraft, initially stationary on a runway, takes off with a speed of 85kmh^{-1} in a distance of no more than 1.20 km .

[6]

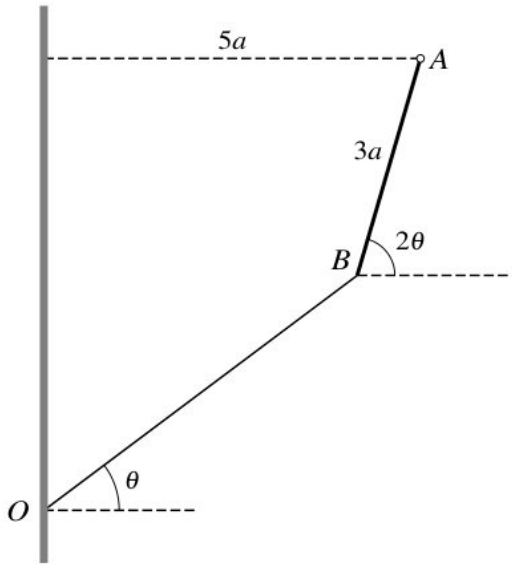
(i) Find the modulus of elasticity of the string in terms of W.

statement about light waves and sound waves is correct?



[4]

23 (b)



polarised beam of light with intensity I is incident normally on a polarising filter.

(ii) The extension of the wire is proportional to the tensile force.

k is a positive constant. The relevant expected frequencies are given in the following table.

[4]

(iii) measurements to be taken,

inclined = ... dy **[6]**

(i) State one difference, which can be seen from the diagram, between the marks for History and Physics.

[4]

(a) the inequality $3x - 1 < |2x - 3|$.

(iv) the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

plank rests on fixed supports at its ends X and Y.

[8]

(iii) the period of small oscillations,

[4]

(c) in exact form the set of values of x for which $\left|\frac{2x^2-5x}{2x^2-7x-4}\right| < \frac{1}{9}$.

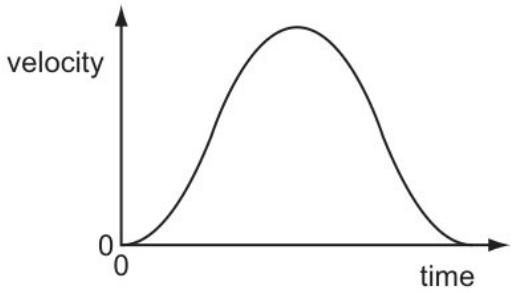
(iv) $\frac{\text{mass}}{\text{length} \times (\text{ time })^2}$

a large college, all students who study Science also study exactly one of Art or Drama or Music. 20% of these students study Art, 45% study Drama and 35% study Music.

[8]

(i) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

a large college, all students who study Science also study exactly one of Art or Drama or Music. 20% of these students study Art, 45% study Drama and 35% study Music.



[8]

(e) 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.

(i) gas is then cooled at constant volume so that its temperature decreases to $2T$.

Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

[2]

(v) could M and N be?

[6]

(iv) the principle of superposition.

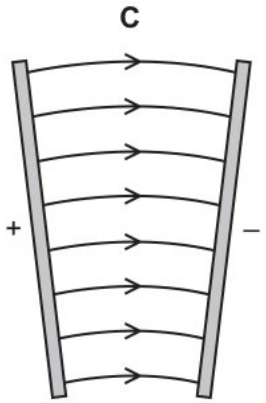
constant resultant force F acts on a car of mass m. The car moves from rest with constant acceleration a along horizontal ground. When the car has displacement s, the speed of the car is v.

28 33 55 38 42 39 27 48 51 37 57 49 33

[4]

7 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?

(b) (iii)



Find the equations of the asymptotes of C.

[6]

(vi) Show that the total distance fallen is 1048 m .

the principle of moments.

[6]

(iv) particle P is moving in simple harmonic motion with centre O. When P is 5 m from O its speed is V m s^{-1}, and when it is 9 m from O its speed is $\frac{3}{5}V$ m s^{-1}. Show that the amplitude of the motion is $\frac{15}{2}\sqrt{2}$ m.

doctor is investigating the concentration of blood glucose in patients at risk of developing type 2 diabetes where blood glucose is measured in appropriate units The doctor claims that a particular intervention reduces the concentration by more than k units on average A group of 8 at risk patients is selected at random and each patient follows the intervention for six months The blood glucose concentrations before and after the intervention are given in the following table

that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - y\mathrm{e}^x}{x\mathrm{e}^x + 2y}$.

[3]

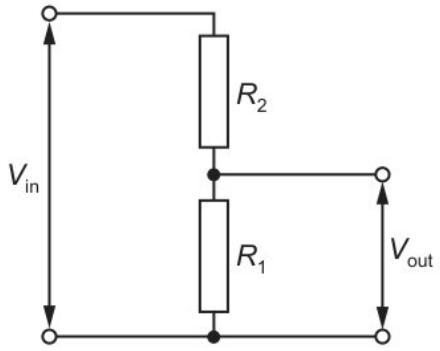
(e) (i) identical uniform smooth spheres A and B, each with mass m, are moving on a horizontal surface with speeds $2u$ and u respectively when they collide. Immediately before the collision, the spheres are moving parallel to each other in opposite directions such that their directions of motion each 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.

measuring instrument should be used?

people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

[5]

(ii) 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.



[5]

(a) (ii) find the probability that in 15 throws the number of 4 s obtained is 2 or more.

current-carrying coil produces a magnetic field.

[3]

(i) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

[10]

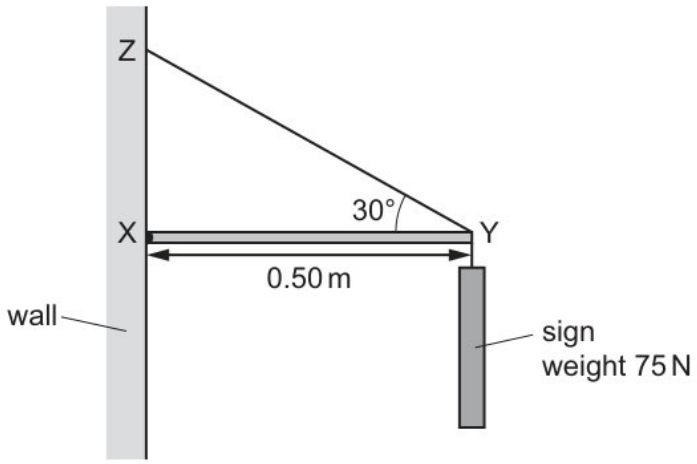
(c) (iv) uniform small smooth spheres A and B have equal radii and each has mass m. Sphere A is moving with speed u on a smooth horizontal surface when it collides directly with sphere B which is at rest. The coefficient of restitution between the spheres is $\frac{2}{3}$. Sphere B is initially at a distance d from a fixed smooth vertical wall which is perpendicular to the direction of motion of A. The coefficient of restitution between B and the wall is $\frac{1}{3}$.

row describes the horizontal and vertical components of its motion as it travels between the plates?

the kinetic model of gases and Newton's laws of motion to explain how a gas exerts a pressure on the sides of its container.

[4]

(iii)



people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

[4]

(vi) following table shows most of the corresponding expected frequencies, correct to 2 decimal places, using a Poisson distribution with mean 3.25.

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.

[5]

17 the number of different ways in which the 12 letters of the word STRAWBERRIES can be arranged

(a) (i) first coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{3}$.

λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.

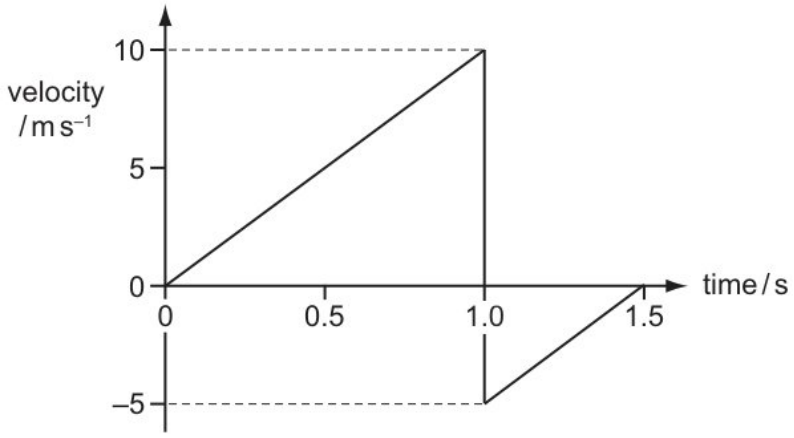
[3]

(ii) polynomial $\mathrm{p}(x)$ is defined by

λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.

[2]

(d) (ii)



support at end X exerts a force F vertically upwards on the plank.

Calculate the distance of the centre of mass of the lamina from A.

[8]

(vii) the exact volume of the solid generated

respect to the origin O, the points A and B have position vectors $2\mathbf{i} + 4\mathbf{k}$ and $5\mathbf{i} + \mathbf{j} + 6\mathbf{k}$ respectively. The line l_1 passes through the points A and B.

[3]

(vi) that $rp^3 = q^3$.

child of weight 600 N stands in different positions on the plank.

marks of the pupils in a certain class in a History examination are as follows.

[6]

(iii) Use the iterative formula $x_{n+1} = \frac{1}{\sin x_n}$ to determine this root correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[12]

20 Find the least tension in the string during the motion.

(d)(vii) 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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted

[12]

(i) Show that there is no point on C for which $\frac{1}{3} < y < 3$.

expression has the same SI base units as pressure?

the value of μ and the value of X for which the block is on the point of moving up the plane.

[5]

(b) (iv) diagram illustrates successive wavefronts.

diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

particle P moves on a straight line in simple harmonic motion. The centre of the motion is O, and the amplitude of the motion is 2.5 m . The points L and M are on the line, on opposite sides of O, with $OL = 1.5$ m. The magnitudes of the accelerations of P at L and at M are in the ratio $3 : 4$.

[6]

(ii) 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.

How many possible arrangements are there of seating Mary, Ahmad, Wayne, Elsie and John assuming there are no restrictions?

[8]

(a) (i) a is a positive constant. Sketch C_1 and C_2 on the same diagram.

$$p\begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q\begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}.$$

[10]

(vi) On Fig. 9.1, sketch the variation of the activity A of the sample with t for values of t between $t = 0$ and $t = 24$ min.

the grid below, draw a box-and-whisker plot to summarise the information in the cumulative frequency graph.

[6]

12 the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

(c) (iii) car is accelerated by a constant resultant force of 300 N for 5.0 s .

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,

cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ.

[3]

(vi) solid cubes, A and B, are measured to determine the density of their materials.

stationary nucleus has nucleon number A.

Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

[3]

(f) (iv) Explain why two gamma-ray photons are produced, rather than just one.

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

[6]

(ix) Find the area of the triangle ABC.

The extension of the wire is not proportional to the tensile force.

$$x_1 = 1, \quad x_{n+1} = \frac{1}{2}\sqrt[3]{\left(x_n^2 + 6\right)}$$

[8]

(i) is the force on an electron when it is in the uniform electric field between the plates?

lifetime, in hours, of a 'Trulite' light bulb is a random variable T. The probability density function f of T is given by

measuring instrument should be used?

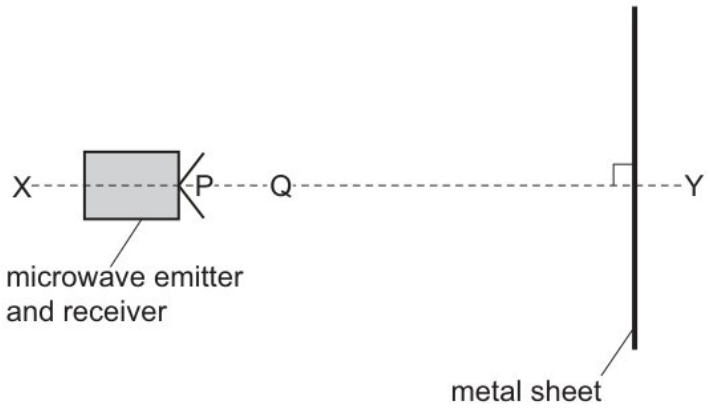
[8]

(b) (iii) Form two simultaneous equations and hence find x and v.

$$\frac{\mathrm{d}^2v}{\mathrm{d}x^2} + 2\frac{\mathrm{d}v}{\mathrm{d}x} - 15v = 24\mathrm{e}^{-x}$$

[5]

(ii) The battery supplies 9.0 J to an external circuit for each coulomb of charge.



researcher records the time, T seconds, taken by adults to complete a questionnaire.

[4]

18 find the moment of inertia of the body about an axis l, through A, in the plane of the body and tangential to the circle.

4 astronauts are chosen from a certain number of candidates. If order of choosing is not taken into account, the number of ways the astronauts can be chosen is 3876 . How many ways are there if order of choosing is taken into account?

$$I = \frac{P}{4\pi r^2}$$

(ii) (b)

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Observed frequency	1	3	15	31	59	107

Find the proportions of large, small and medium pineapples.

[6]

(c) the ductile material,

There will always be 9.0 V across the battery terminals.

[3]

(a) is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

Find the weight of the lamina.

[4]

(i) (b) 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.

pendulum bob is held stationary by a horizontal force H. The three forces acting on the bob are shown in the diagram.

rest = ... mi **[6]**

(a) that $v = y^3$, show that

polynomial p(x) is defined by

When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

[8]

(c) particle P is projected from a point O with speed U at an angle 45° above the horizontal and moves freely under gravity.

Calculate the exact value of I_1 and deduce the exact value of I_3.

[2]

14 three quantities that are conserved during the decay.

procedure to be followed,

body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

(g) (iv) fair 8-sided dice has faces labelled K, A, N, G, A, R, O, O. The dice is rolled repeatedly.

gravitational potential at a point.

skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

[4]

(ii)

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

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.

[12]

(i) mass of the liquid is 0.36 kg $\pm$ 10%.

$$\mathrm{p}(x) = 6x^3 + ax^2 + bx + 10$$

[10]

(c) (ii) that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\mathrm{sech}^{-1}\, t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

cells are connected to a load resistor of resistance 3.0Ω. The electromotive force (e.m.f). and the internal resistance of each of the cells is shown.

[20]

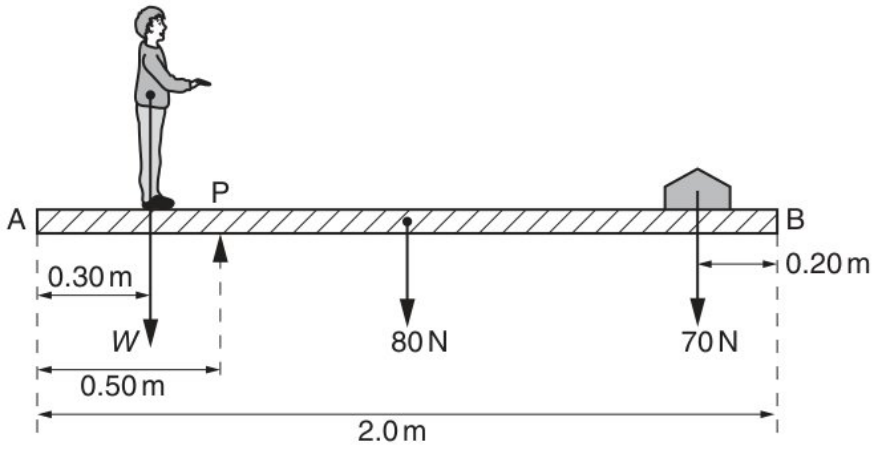
(iv) the average output power of the car during this time

the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

[6]

(e) (ii) $\sum_{r=1}^{n}(4r-3)(4r+1)$, giving your answer in its simplest form.



[4]

(i) 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.

Draw up the probability distribution table for X.

[1]

(b) (ii) the acute angle between the directions of l_1 and l_2.

is given that P remains at rest in this new position.

lowest mark was 17 and the highest mark was 74 .

[8]

(i) cubic equation $2x^3 - 3x^2 + 4x - 10 = 0$ has roots α, β and γ.

curve C has parametric equations

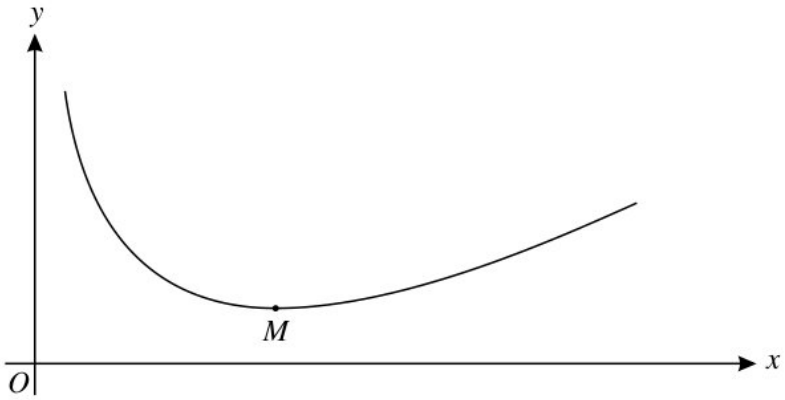
[12]

(vi) gravitational potential at a point.

B bounces when it strikes the plane, and leaves the plane with speed 20 m s^{-1} but with its horizontal component of velocity unchanged.

[2]

(a) (ii) person's eye colour may be categorised as "brown", "blue" or "other". A scientist claims that these eye colours are uniformly distributed and hence are equally likely to occur in the population. A survey of 120 people from this population found that 38 people had brown eyes, 52 people had blue eyes and 30 people had eyes which were neither brown nor blue.



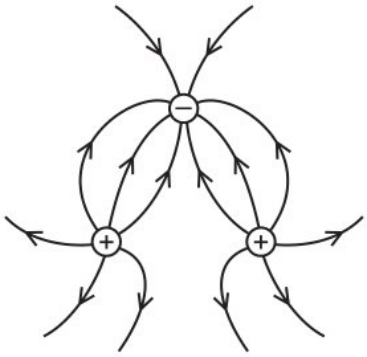
[4]

(iv) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$

force = mass × acceleration

[3]

(i)



Find the perpendicular distance of the point A from the line BC.

[3]

20 is the total resistance between the two ends of the coil?

Nucleus X undergoes β^-decay to form nucleus Z.

(i) (a) diagram shows the electric field between the plates?

is given that $2\ln p + \ln(p-1) - \frac{1}{2}\ln(q+1) = 3$.

the values of the constants k_1 and k_2 are to be determined.

[4]

(d) is the work done by F on the skateboarder and skateboard?

the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

[10]

(b) p and q are given real numbers, then

cubic polynomial p(x) is defined by

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 $\frac{84}{5}Ma^2$.

[4]

(iii) (b) in terms of m and g, the magnitude of the frictional force in this position.

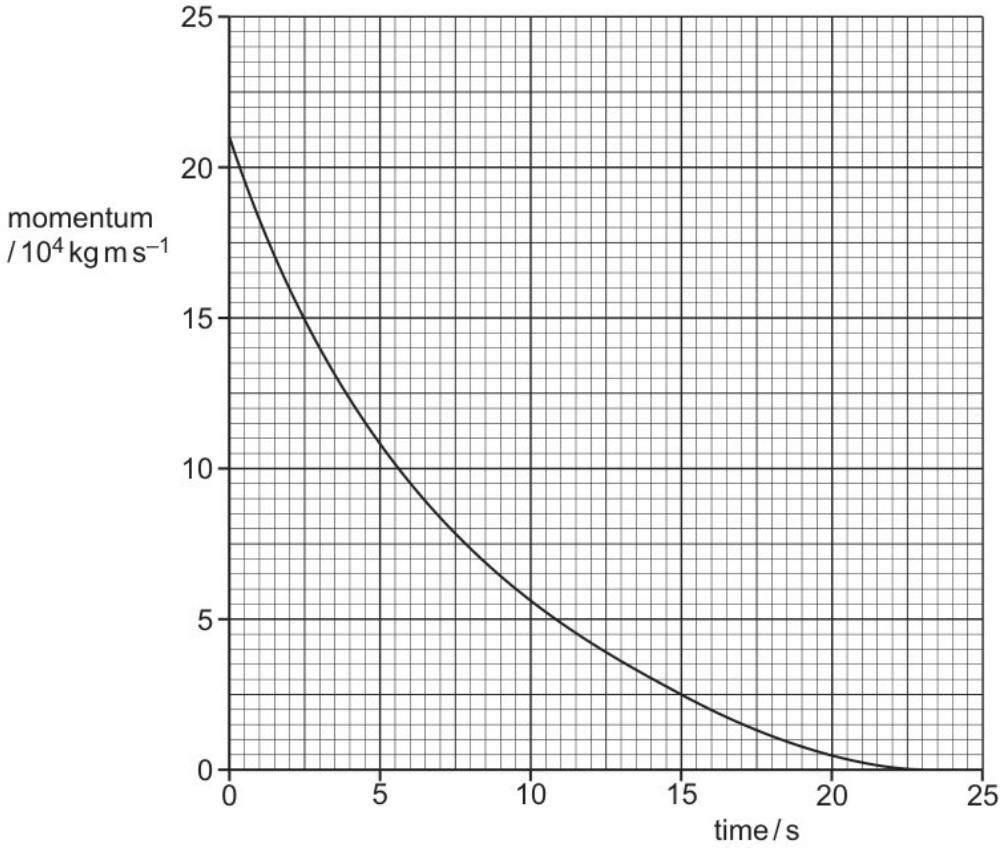
procedure to be followed,

$$\sum(x-k) = 836.0, \quad \sum(x-k)^2 = 25410.8$$

[4]

(a) Find $\frac{\mathrm{d}}{\mathrm{d}x}\left(x\left(4+x^2\right)^{-n}\right)$ and hence show that

Find the coordinates of any intersections with the coordinate axes.



[5]

(vii) (a) up the probability distribution table for X.

all necessary working, solve the equation $2\log_2 x = 3 + \log_2(x+1)$, giving your answer correct to 3 significant figures.

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.

[8]

(c) is the magnitude of F when the child stands at X and when the child stands at Y ?

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 3\left(2^n - 1\right) \\ 0 & 1 \end{pmatrix}$$

[15]

(b) specific heat capacity of water is 4.18 J $g^{-1}{}^{\circ}C^{-1}$.

only one of the following two alternatives.

[5]

9 Find the perpendicular distance of the point A from the line BC.

(c) (iii) could M and N be?

Find the coordinates of the turning points of C.

[3]

(v) Find the angle between the vertical and the side AO of the lamina.

is the horizontal distance of the van's centre of gravity from the front of the van?

[5]

(ii) Sound waves are transverse waves and light waves are longitudinal waves.

source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

[8]

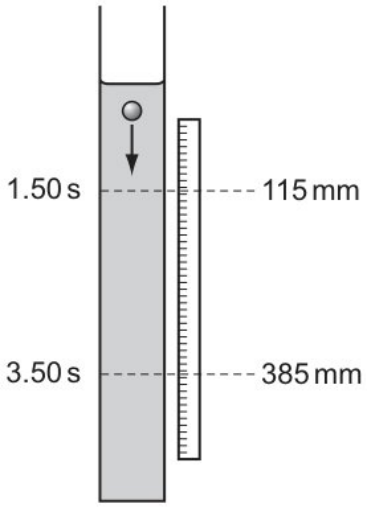
(b) (v) student wishes to investigate projectile motion.

the equation of the plane ABC, giving your answer in the form $ax + by + cz = d$.

down to up

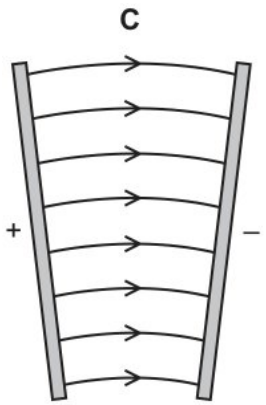
[3]

(i) Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.



[3]

(ii) $\mathbf{a} \times \mathbf{b}$ and deduce the area of the triangle OAB.



[12]

(a) (ii) what is meant by a fundamental particle.

sample contains a single radioactive isotope that decays to form a stable isotope.

[2]

(iv) Find the weight exceeded by the heaviest 5% of pineapples.

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).

[5]

(i) the value of θ for which the transformation represented by $\mathbf{M}$ has a line of invariant points 7

only one of the following two alternatives.

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 .

[6]

20 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.

the kinetic energy of the car at time $t = 5.8$ s.

(c) (iii) is a statement of the principle of conservation of momentum for a system?

$$x = \ln(\cosh t), \quad y = \tan^{-1}(\sinh t), \quad \text{for } 0 \leqslant t \leqslant 1.$$

[3]

(i) or otherwise solve the inequality $|3x - 2a| < x + 5a$.

$I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

[8]

(iv) diagram shows a sketch of the curve $y = \frac{3}{\sqrt{(9-x^3)}}$ for values of x from -1.2 to 1.2 .

Find the probability that a randomly chosen letter weighs more than 13 g .

value for the Hubble constant is 2.3×10^{-18} s^{-1}.

[8]

(a) (i) gas is compressed so that its temperature increases to $3T$.

Write down the least value of $15\cos\theta - 9\sin\theta$ as θ varies.

lines values = ... *ew* **[5]**

(iv)

show that $PQ = 13$,

the type of each transformation, and make clear the order in which they are applied.

[15]

(iii) curves C_1 and C_2 have polar equations

Calculate the greatest deceleration of P.

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 $t = 4$.

[4]

(v) The weight of the plank is causing an anticlockwise moment.

a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$.

[12]

(d) (iii) source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

$$^{14}_{.....}X \rightarrow ^{.....}_{.....}Z + \ldots..\cdots .$$

Show that, for $n > 2$,

[4]

(v) Find the equation of the tangent to the curve at the point where $x = 0$.

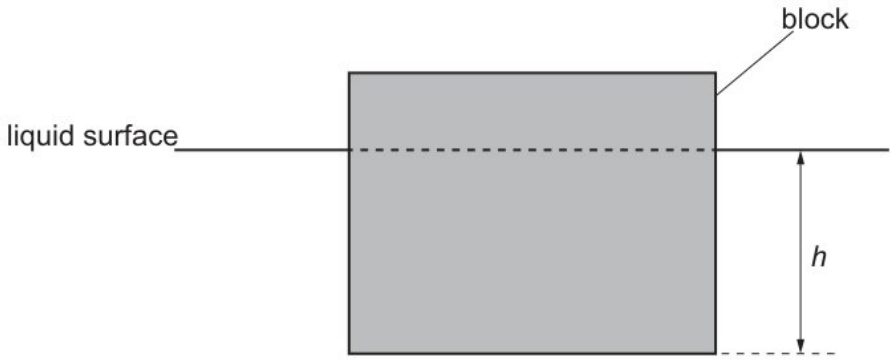
the significance level of the test.

the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

[5]

16 marble is now chosen at random from bag B.

(d) (iii)



the value of $\sum_{r=1}^{\infty} \frac{1}{(2-3r)(5-3r)}$.

[2]

(v) 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.

Explain why two gamma-ray photons are produced, rather than just one.

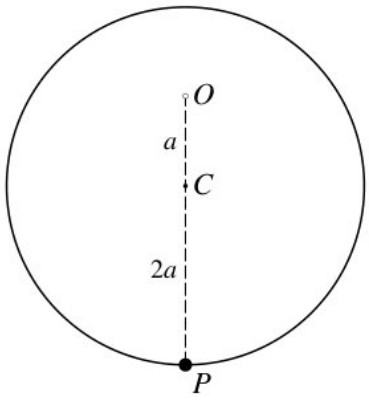
[15]

(g) (i) State the gradient of the curve at the point $(-1, 2)$ and sketch the curve.

continuous random variable X has probability density function f given by

[8]

(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

[5]

(iv) the number of different ways in which these three bands can be selected.

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 $AC = a$.

[12]

(a) (iii) the ductile material,

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.

Hence solve the equation $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} = 4$, for $0° \leqslant \theta \leqslant 360°$.

[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

The power to X will increase and the powers to Y and Z will decrease.

rotate = ... jf **[6]**

(i) Find the cartesian equation of the plane through A, B and C.

no digit can be repeated,

[2]

21 that the object is on the point of toppling in its vertical plane about the vertex D, find the value of k.

force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

(d) (i) suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\operatorname{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

[6]

(iii) 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.

what time will some portion of the wavefront GH reach point P ?

[5]

(b) (ii) The extension of the wire is not proportional to the tensile force.

parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV .

a, b and c are integers to be determined.

[3]

(iii) Find the area of the sector of C between $\theta = 0$ and $\theta = \frac{1}{3}\pi$.

$$\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 2\frac{\mathrm{d}x}{\mathrm{d}t} + 5x = 4 - 5t^2$$

Calculate the distance moved by the car during this acceleration.

[6]

(a) (i) object hangs by means of two cords around two rods, as shown.

projectile is thrown at an angle to the ground.

suitable = ... ex **[6]**

(iv) support at end X exerts a force F vertically upwards on the plank.

particle oscillates in simple harmonic motion with centre O. When its distance from O is 3 m its speed is 16 m s^{-1}, and when its distance from O is 4 m its speed is 12 m s^{-1}. Find the period and amplitude of the motion.

[3]

16 ripple tank is used to demonstrate interference between water waves.

(a) (i) speeds of the particles.

the probability generating function of Z, expressing your answer as a polynomial in t.

the value of μ and the value of X for which the block is on the point of moving up the plane.

[5]

(iii) specific heat capacity of water is 4.18 J $\mathrm{g}^{-1}{}^{\circ}\mathrm{C}^{-1}$.

diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.

[4]

(c) (ii) Find the equations of the asymptotes of C.

graph shows the variation with temperature of power, P, dissipated in the thermistor?

[2]

(iii) body of mass m, moving at velocity v, collides with a stationary body of the same mass and sticks to it.

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.

[5]

(b) (i) Find the perpendicular distance of the point A from the line BC.

a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$.

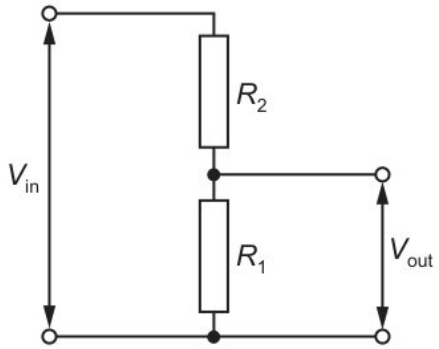
[12]

(iv) Show that the mass of Mars is 6.4×10^{23} kg.

Young modulus E can be determined from measurements made when a wire is stretched.

[5]

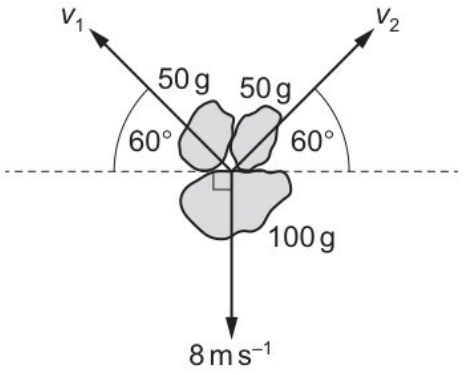
(v) definition is correct and uses only quantities rather than units?



[5]

26 Find the angle between the vertical and the side AO of the lamina.

Nucleus X undergoes β^-decay to form nucleus Z.



(b) (i) the values of p and q

Find the value of I_2.

$$I_3 = \frac{3}{1024}\pi + \frac{1}{128}$$

[12]

(vi) the probability that both marbles chosen are the same colour.

number of cars sold per day at another showroom has the independent distribution Po(0.6). Assume that the distribution for the first showroom is still Po(0.7).

[10]

(a) (ii) Find the equations of the asymptotes of C.

The total momentum is conserved only in elastic collisions.

[3]

(iii) variables x and y satisfy the differential equation

is the ratio $\frac{\text{stress at } Y}{\text{stress at } X}$?

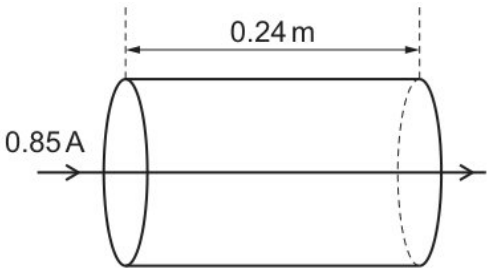
[4]

(e) (ii) Hence show that $\sum_{r=1}^{n} \frac{2r+1}{r(r+1)(r+2)} = \frac{1}{2}\left\{\frac{(2n+1)(2n+3)}{(n+1)(n+2)} - \frac{3}{2}\right\}$.

electric potential difference across a component.

[6]

(iii)



how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

[3]

(i) 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 moment of inertia of the body about an axis l, through A, in the plane of the body and tangential to the circle.

[6]

(c) (i) a similar method to find, in terms of n, a lower bound for $\sum_{r=1}^{n} \frac{1}{\sqrt{r}} \mathrm{e}^{\sqrt{r}}$.

van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

Find the perpendicular distance of the point A from the line BC.

[6]

(ii) the complex numbers z for which $\frac{z+4}{z+4\mathrm{i}}$ is real and $|z| = \sqrt{10}$. Give your answers in the form $z = x + \mathrm{i}y$, where x and y are real.

restaurant manager buys 160 of these large bags of pasta.

[5]

(iii) Given that $\cos\alpha = \frac{1}{6}$, find the greatest speed achieved by the centre of the sphere in the subsequent motion.

would this object weigh on Pluto?

k is a positive constant. The relevant expected frequencies are given in the following table.

[4]