24 the experimental observations that show radioactive decay is

single change would double the value of this ratio?

(a) (i) Draw up the probability distribution table for X.

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

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[10]

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

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

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[3]

(iii) object is fully submerged in a liquid.

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

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

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.....

[6]

(d) (ii) is the magnitude of F when the child stands at X and when the child stands at Y ?

the significance level of the test.

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.

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[6]

(i) the time taken for the ball to reach its maximum height

statement about light waves and sound waves is correct?

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

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[4]

14 Calculate the initial speed and the angle of projection of P.

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

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

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three Elsie = ... zf **[4]**

(i) the apparatus used to produce two sources of coherent waves that have circular wavefronts,

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

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[6]

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

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

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[8]

(ii) 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.

Calculate the acute angle between the planes.

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[2]

(i) the range of f,

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.

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[5]

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

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

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

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

the values of a, b, x and y.

(b) (iii) 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.

The waves must be coherent.

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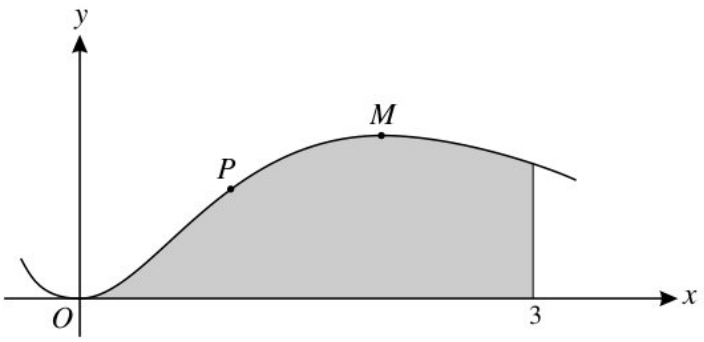
[10]

(iv)



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

Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

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[6]

(a) (iii) variables x and y satisfy the differential equation

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

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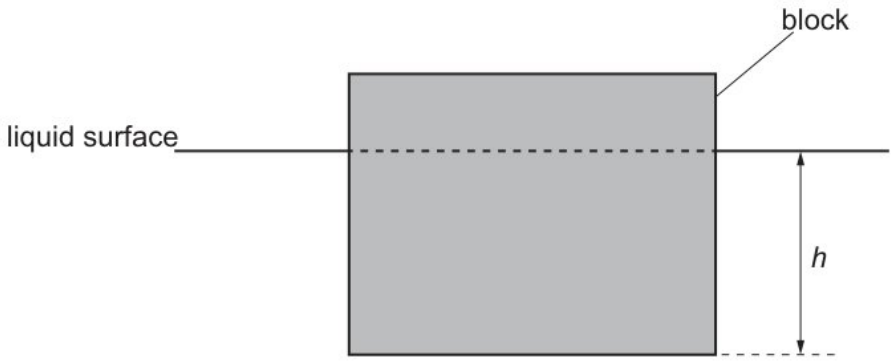
[10]

(ii)



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

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[8]

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

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.

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

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[3]

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

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.

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[5]

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

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.

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

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[8]

(vi) only one of the following two alternatives.

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

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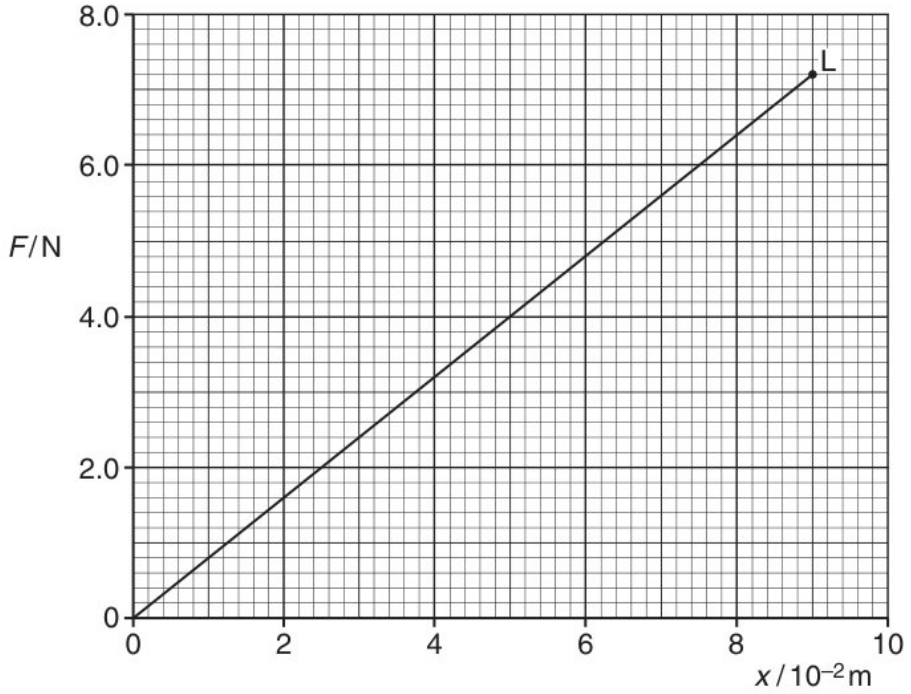
[20]

(ii)

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



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[3]

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

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

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

(iv) object is fully submerged in a liquid.

[4]

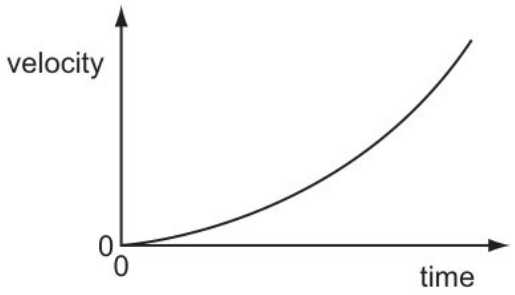
(ii) sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.

[8]

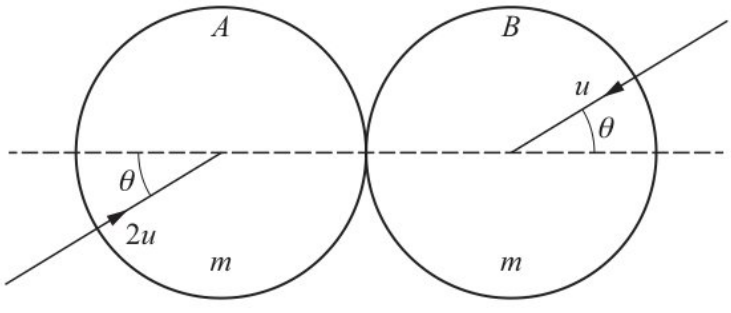
(i) Using the concept of work done on the car, show that the kinetic energy E_K of the car is given by the equation

[4]

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



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



[8]

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

[5]

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

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

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

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[10]

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

is a general description of a baryon?

curve C with equation

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resistances consists = ... *yo* **[3]**

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

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

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attached = ... *uc* **[4]**

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

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

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

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[6]

(iv) the exact value of the positive constant k for which

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

Find the area of the region enclosed by C.

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[8]

(c) (i) Sunday, teams of runners took part in a charity event. The time taken, in seconds, to run 50 m was recorded, correct to 1 decimal place, for each runner. The times recorded for 11 runners from each of the Gulls and the Herons are shown in the table.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = -2x\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2$$

specific heat capacity of water is 4.18 J $\mathrm{g}^{-1\circ}\mathrm{C}^{-1}$.

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[4]

(v) 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.

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

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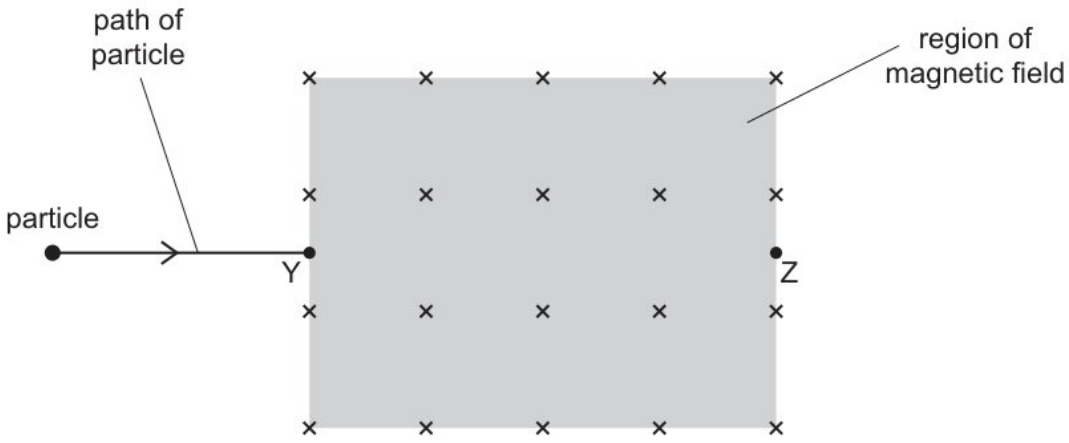
[3]

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



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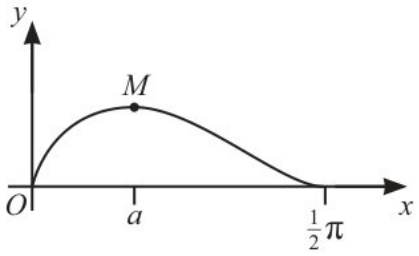
[8]

(h) (iv)



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

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

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[6]

(ii) 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.

$$\sum_{r=1}^{n} \frac{n}{n^2 + r^2} < \frac{1}{4}\pi$$

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[10]

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

matrix **A** is given by

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

. . . . . .
. . . . . .
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[4]

12 projectile is launched at 45° to the horizontal with initial kinetic energy E.

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

is the output power of the car's engine when travelling up the slope?

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. . . . . .
. . . . . .
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[8]

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

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

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[6]

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

Over 50 198 212 217 229 235 242

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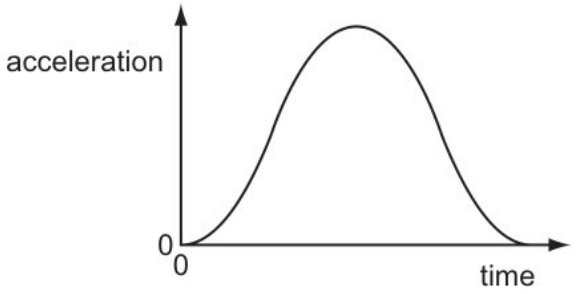
[3]

(d) (i)



Q hears a sound of decreasing frequency.

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

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[4]

(iii) control of variables,

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

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[4]

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

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

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

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

. . . . . .
. . . . . .
. . . . . .
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[6]

(ii) is the angle θ ?

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

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

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[2]

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

the period of small oscillations,

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[8]

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

that $v = y^3$, show that

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[15]

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

only one of the following two alternatives.

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[5]

(iv) an electron and a neutrino

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.

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.

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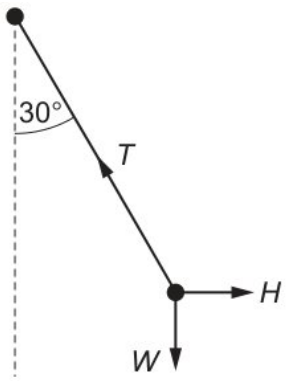
[10]

13 curve C has equation

(b) (iii)



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

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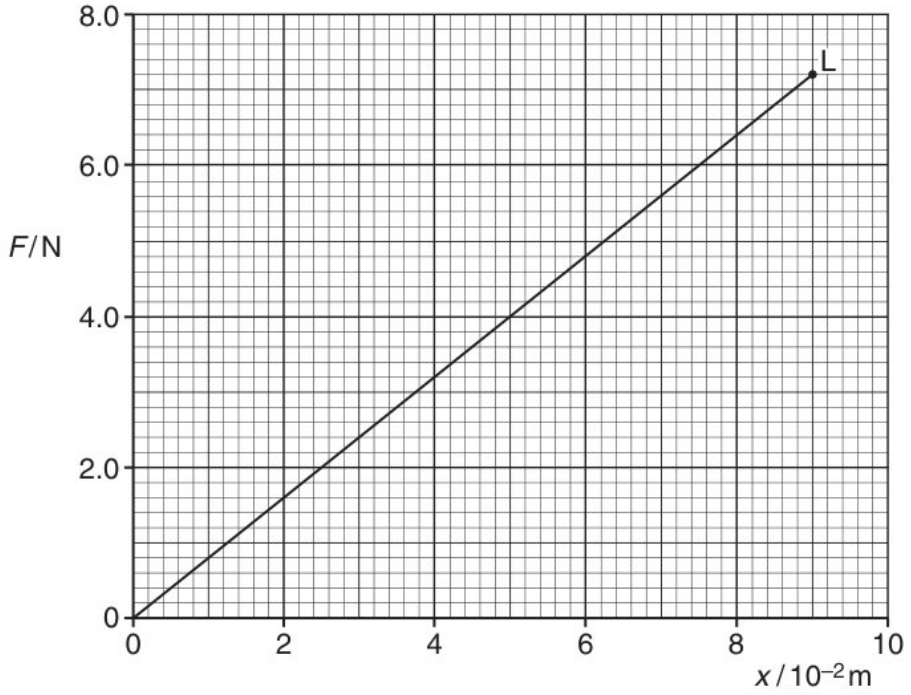
[12]

(iv) force = mass × acceleration



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[8]

(a) (ii)

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

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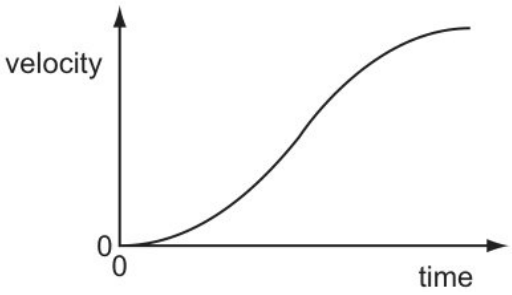
[8]

(i)



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

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[5]

10 the moment of a force about a point.

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

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

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[15]

(a) is the current in the load resistor?

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.

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

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[3]

(b) 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.

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

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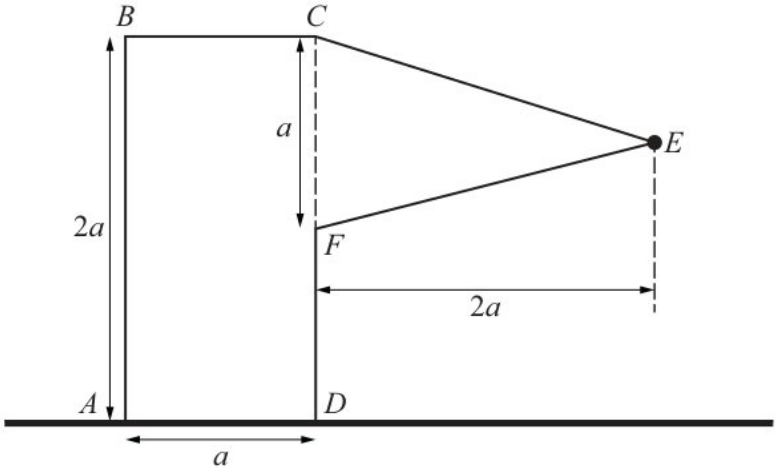
[12]

(i) (f)



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.

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[6]

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

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.

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[10]

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

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

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[8]

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

is the reading on the ammeter?

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[8]

(ix) (d) a tree diagram to represent this information, giving the probability on each branch.

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

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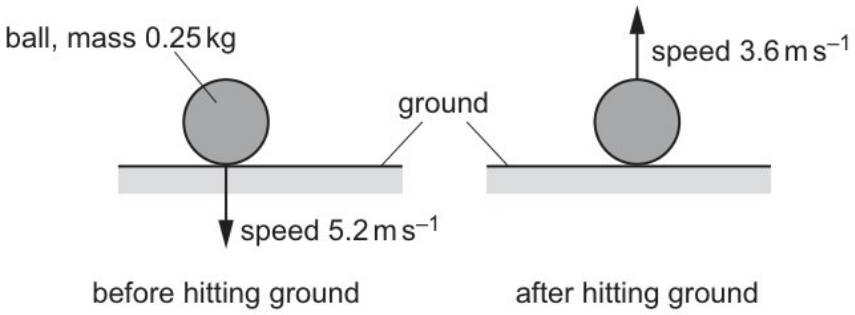
[5]

(b) random variable X is the number of heads obtained.



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[6]

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

no digit can be repeated,

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

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[6]

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

(d) (iv) Show that x satisfies the equation

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.

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[8]

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

quantities would be measured in order to determine E ?

de Moivre's theorem to show that

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[10]

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

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

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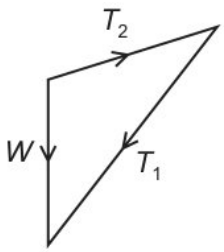
[4]

(ii)



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

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[15]

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

is given that

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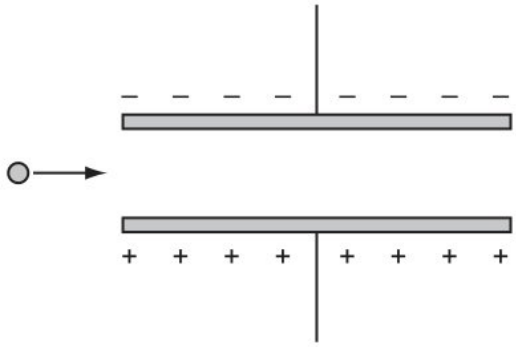
[6]

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

(c) (i)



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

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Trulite = ... *uo* **[10]**

(ii) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

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

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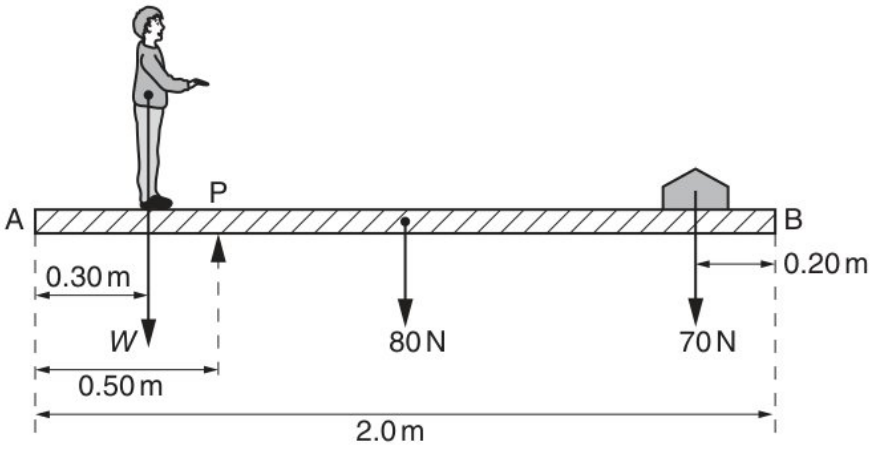
that = ... *wj* **[4]**

(g) (i)



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

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[6]

(ii) up to antidown

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

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[12]

(iv) X and Y are connected in series to a cell.

Density is mass per cubic metre.

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[6]

15 diagram shows four forces applied to a circular object.

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).

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

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

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[5]

(i) the value of α.

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

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[3]

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

curve C has equation

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[6]

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

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.

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[4]

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

the values of a for which the system of equations

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

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[2]

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

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

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[6]

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

the ratio $H : D$.

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

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[10]

(iv) experiment consists of throwing a biased die 30 times and noting the number of 4 s obtained. This experiment was repeated many times and the average number of 4 s obtained in 30 throws was found to be 6.21.

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

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[10]

9 find the position vectors of P and Q.

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

Use implicit differentiation to show that

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mean = ... gr **[12]**

(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

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

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[12]

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

$$\Sigma(x - 25) = 133, \quad \Sigma(x - 25)^2 = 3762.$$

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$y^2 + 5equation$ = ...vx **[5]**

(a) (i) the value of μ.

the probability density function of Y,

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[8]

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

arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.

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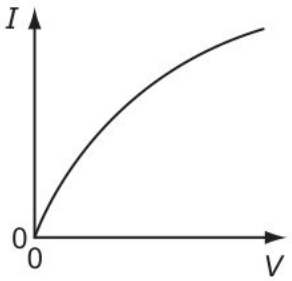
[6]

(ii)



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

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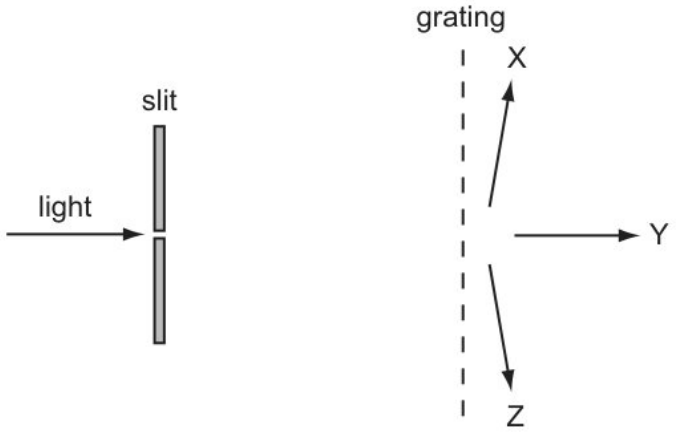
[6]

(d) (iv)



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

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

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[5]

(i) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.

The matrix **B**, where

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

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[6]

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

$$x = \mathrm{e}^{\tan t}, \quad y = 3\tan^2 t$$

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

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

State one other feature of this orbit.

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load four = ... zw **[5]**

(ii) 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.

continuous random variable X has probability density function f given by

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[10]

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

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

the values of p and q

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[6]

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

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.

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[10]

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

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

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[2]

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

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

data give a pooled estimate of 10 for σ^2. Find N.

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[4]

14 with a reason, whether you agree with Nikki's friend.

the moment of a force about a point.

what is meant by work done.

Prove that, for $n \geqslant 2$,

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

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

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matrix matrix = ... *pe* **[2]**

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

no digit can be repeated,

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. . . . . .
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[8]

(b) (iii) anywhere between point R and point S

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

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[4]

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

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

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[8]

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

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

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[3]

(a) (iv) the value of σ.

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

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[3]

(v) only one of the following two alternatives.

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

internal diameter of the beaker is 0.05 m $\pm$ 3%.

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[6]

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

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

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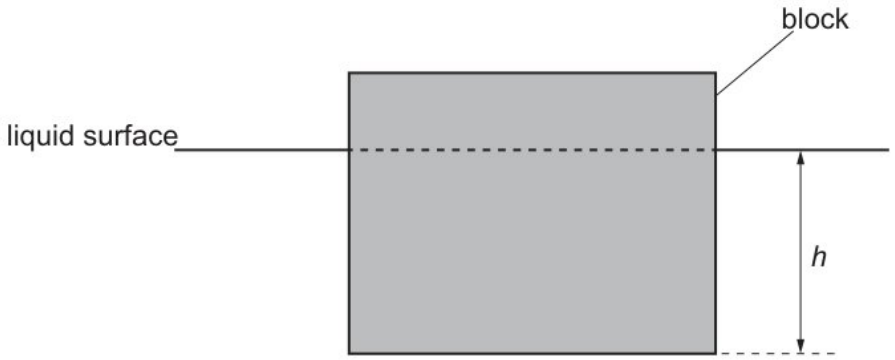
[15]

13 Find the power output of the tractor's engine.

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

(b) (iii)



the solution of the differential equation

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currents resistor resistor = ... dm **[4]**

(ii) Given that $\mathrm{E}(X) = 1.2$, find the value of a.
gas is enclosed inside a cylinder which is fitted with a frictionless piston.

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[5]

(a) (v) Find the perpendicular distance of the point A from the line BC.
many different colour arrangements are there of the 10 books?
the mean of the times taken by all 50 runners.

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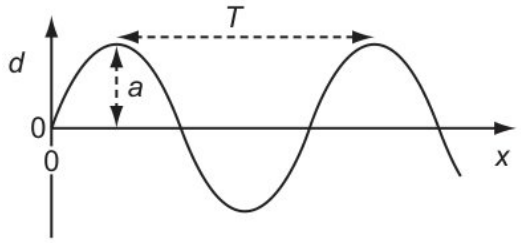
[15]

(iv) 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?



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[6]

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

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

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

variables x and y satisfy the differential equation

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[6]

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

variables x and y are related by the differential equation

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[2]

(b) (i) an iterative formula based on the equation in part (a) to determine a correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

Find the probability that a box is rejected.

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that = ... wl **[6]**

(ii)

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

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[12]

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

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

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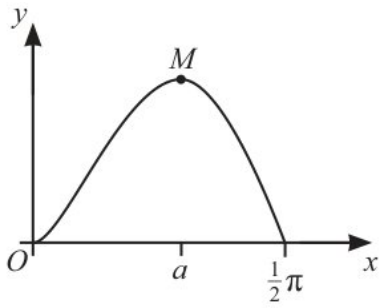
proton = ... bq **[5]**

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

marble is now chosen at random from bag B.

(b) (i) 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 .



bolt is subjected to a tensile force, as shown.

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[4]

(v) 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

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

ripple tank is used to demonstrate interference between water waves.

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[20]

(a) (v) is now given that the true value of p is 0.05 .

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

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[4]

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

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

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

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[3]

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

force = mass × acceleration

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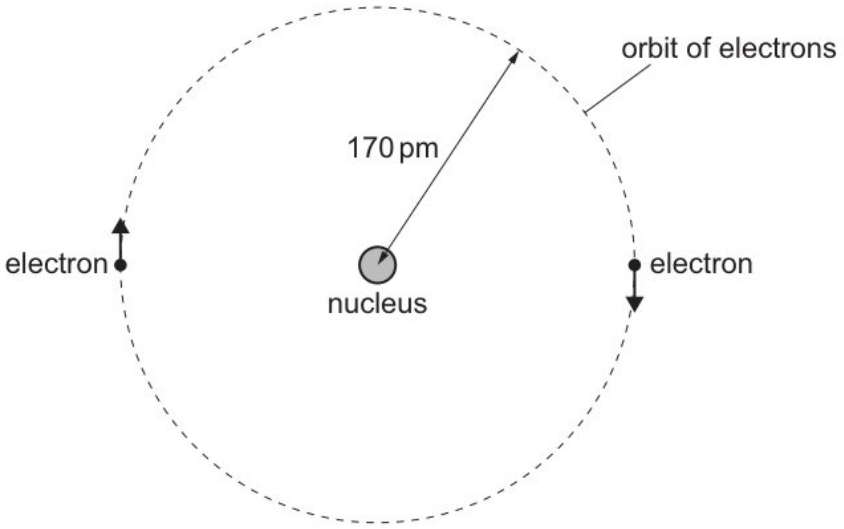
[3]

8 only one of the following two alternatives.

(a) (ii) 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.



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[3]

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

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

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[20]

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

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.

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[10]

(i) 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.

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

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[2]

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

1,2 and 3

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[6]

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

was the by-product of this reaction?

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[2]

(c) (ii)

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

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

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weight maintained = ... mk **[4]**

(i) the experimental observations that show radioactive decay is

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

the experimental observations that show radioactive decay is

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[4]

(iii) an iterative formula based on the equation in part (a) to determine a correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

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

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[6]

(b) (iii) V increases because there is a p.d. across R.

$$\mathrm{f}(x) = \begin{cases} 0 & x < 0 \\ a\mathrm{e}^{-x\ln 2} & x \geqslant 0 \end{cases}$$

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[6]

(ii) 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

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.

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.

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[6]

(i) are selected from these 20 to perform at a concert.

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

$$\mathbf{A} = \begin{pmatrix} -1 & 3 & 4 \\ 0 & 1 & 0 \\ 0 & -2 & 5 \end{pmatrix}$$

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[8]

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

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

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.

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[5]

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

the distribution function of X.

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[10]

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

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

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

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[2]

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

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.

1.1 shows the measurements for cube A.

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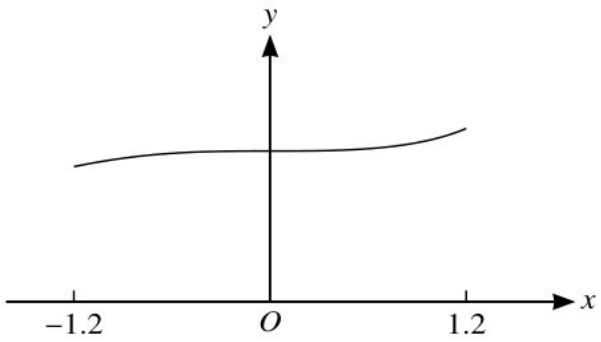
[6]

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



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[6]

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

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

Find the exact area of the shaded region.

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[4]

(ii)

	filament lamp	semiconductor diode
A	P	R
B	P	S
C	Q	R
D	Q	S

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.

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[8]

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

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

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[12]

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

the solution of the differential equation

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inclined ramp throughout above = ... le **[4]**

(i) Find the value of I_2.

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

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

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[3]

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

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

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[15]

(b) (vi) 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.

The waves must be coherent.

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[10]

(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.

$$y^2\frac{\mathrm{d}^2y}{\mathrm{d}x^2}+2y^2\frac{\mathrm{d}y}{\mathrm{d}x}+2y\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2-5y^3=8\mathrm{e}^{-x}$$

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another = ... jt **[4]**

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

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

waves are emitted from two sources.

(iv) the probability of a Type I error.

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 .

parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV .

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[4]

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

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

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[8]

(c) Find the exact value of the arc length of C.

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

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

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

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triangular = ... zq **[10]**

(i) the length of C.

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[4]

12 When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

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

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

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[4]

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

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

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[6]

(d) (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.

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

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[10]

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

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

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[4]

(vii) 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 .

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.

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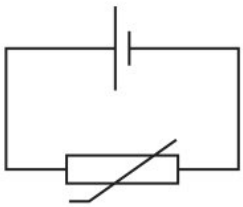
[6]

(e) (i)



Q has mass 2.0 kg and is moving at a speed of 4.2 m s^{-1} at an angle of 35° to the path of P.

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

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[5]

(iv) 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.

by calculation that $0.9 < a < 0.95$.

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[12]

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

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

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Given = ... *hl* **[10]**

(iv) 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.

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

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.

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with angle = ... fy **[5]**

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?

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

points A, B, C have position vectors

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

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[3]

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

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

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[2]

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

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

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[4]

(iii)

matrix $\mathbf{M}$ is given by $\mathbf{M} = \begin{pmatrix} 1 & 2 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$, where $0 < \theta < 2\pi$.

none of them

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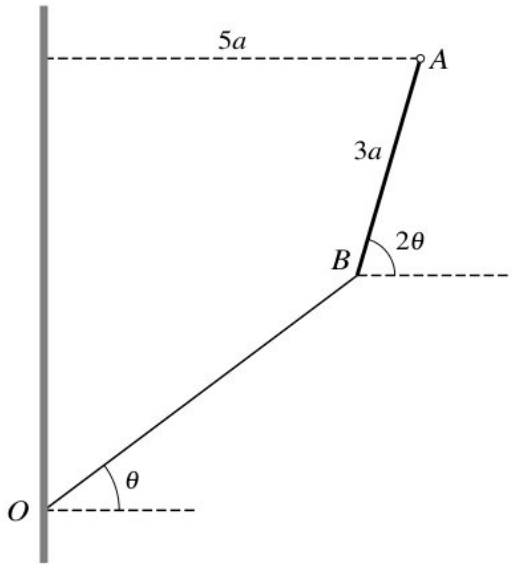
eigenvalue that = ... *ql* **[3]**

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

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



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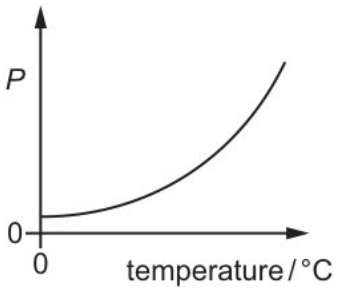
[5]

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



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.

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

(b) (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.

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

graphs show possible current-voltage ($I - V$) relationships for a filament lamp and for a semiconductor diode.

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[6]

(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.

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

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

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[8]

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

Draw up a probability distribution table for X.

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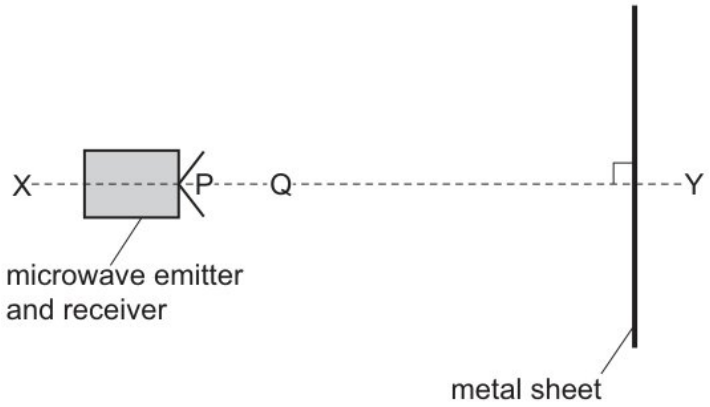
[2]

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



the value of θ for which the transformation represented by **M** has a line of invariant points. [7]

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[15]

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

line l passes through B and C.

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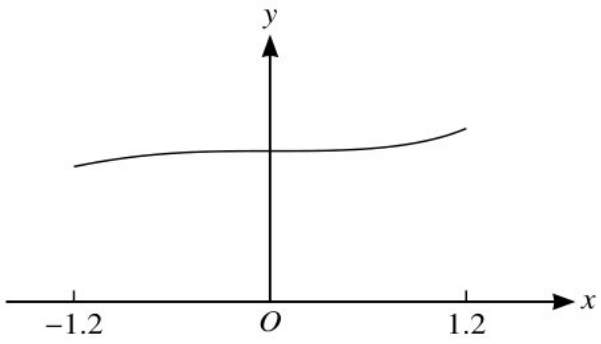
[4]

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



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[4]

(iv) is the total elastic potential energy stored in the four springs?

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

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

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[4]

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

is given that

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

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

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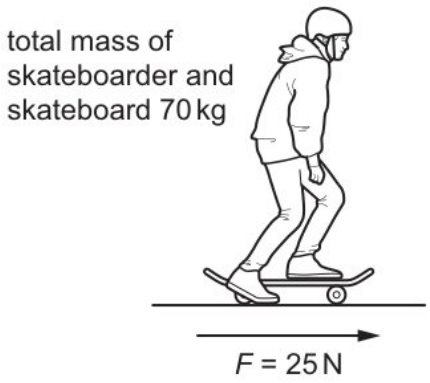
[12]

(iv)



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

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[5]

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

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

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[2]

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

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

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

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[8]

(iv) this question the use of a calculator is not permitted.

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.

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

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[3]

(iii) arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.

$$\overrightarrow{OA} = \begin{pmatrix} 2 \\ 3 \\ 5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} \quad \text{and} \quad \overrightarrow{OC} = \begin{pmatrix} 10 \\ 0 \\ 6 \end{pmatrix}.$$

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[20]

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

Use de Moivre's theorem to prove that

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[4]

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

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

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[8]

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

(a) (ii) random variable T has probability density function given by

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

fair tetrahedral die has faces numbered $1, 2, 3, 4$. A coin is biased so that the probability of showing a head when thrown is $\frac{1}{3}$. The die is thrown once and the number n that it lands on is noted. The biased coin is then thrown n times. So, for example, if the die lands on 3 , the coin is thrown 3 times.

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[6]

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

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

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[2]

(vi) 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.

Find the acute angle between Π_1 and Π_2.

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[4]

(d) (i) Find the total distance travelled by the particle in the first 10 seconds of motion.

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

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

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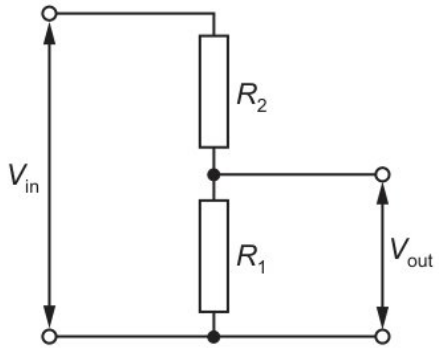
[8]

(v) The orbit has a period of 25 hours.



a laboratory experiment that uses a Hall probe to test the relationship between B and r. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

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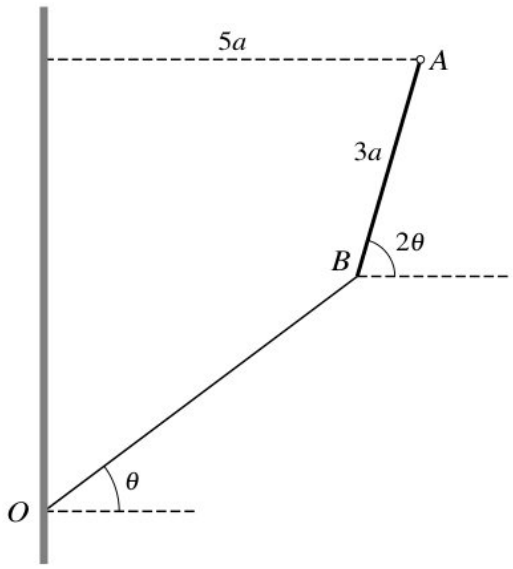
number, = ... *jo* **[6]**

(b) (ii) the value of x.



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[3]

(i)

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

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

$$x^2 \sin y + \cos 3y = 4$$

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[2]

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

$\left[\Sigma x = 191, \quad \Sigma x^2 = 4564.46, \quad \Sigma y = 188.8, \quad \Sigma y^2 = 4458.4, \quad \Sigma xy = 4510.99.\right]$

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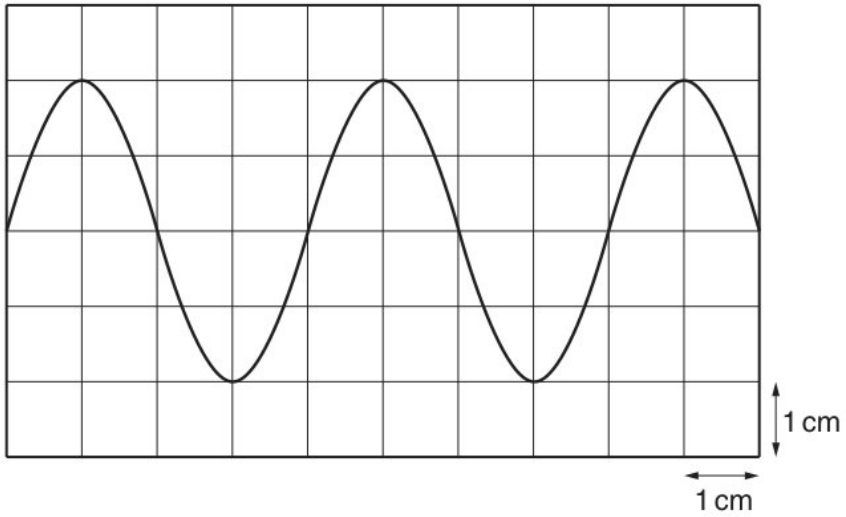
[8]

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



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[6]

11 the apparatus used to produce two sources of coherent waves that have circular wavefronts,

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

X and Y are connected in series to a cell.

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

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

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[8]

(i) the significance level of the test.

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.

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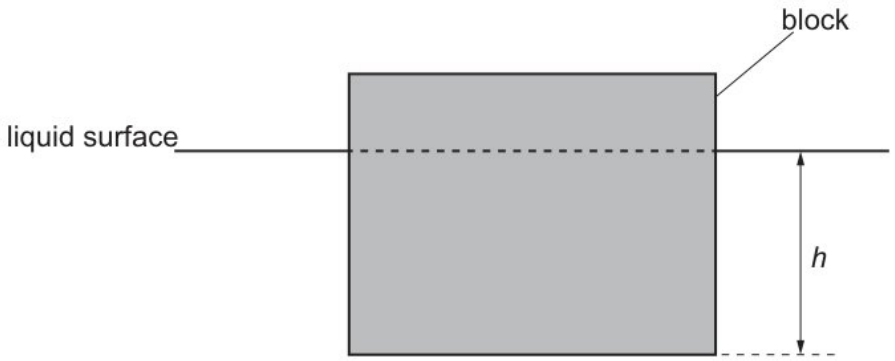
[4]

(e) (ii)



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

the standard deviation of these 40 values of x.

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[5]

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

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

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[8]

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

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

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[3]

(f) (i) 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 .

Find the equations of the asymptotes of C.

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[4]

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

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

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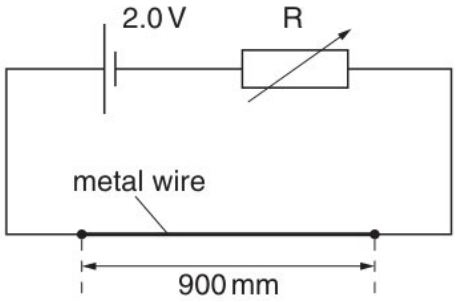
[5]

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



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together? = ... *dm* **[10]**

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

the distribution function of X.

(iii) the equations of the asymptotes of C.

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[6]

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

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[2]

(b) 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.

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

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

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[5]

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

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.

what is meant by the accuracy of a measured value.

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[5]

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

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

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.

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[6]

(ii) the exact value of I_2.

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[6]

(iii) marks of the pupils in a certain class in a History examination are as follows.

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[5]

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

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

$$\left(x^2 + y^2\right)^{\frac{3}{2}} = -4axy.$$

point P is the foot of the perpendicular from A to l.

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[5]

(ii) 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 rank of the matrix

the apparatus used to produce two sources of coherent waves that have circular wavefronts,

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[5]

(i) selects 4 books from her 10 different books from the series Squares and Circles.

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

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[10]

(c) (i) magnetic flux density.

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

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[5]

(ii) the exact value of the positive constant k for which

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

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[10]

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

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

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

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[8]

(iii) 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.

matrix **A** is given by

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

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[4]

(b) (i) statement is correct?

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

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[3]

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

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

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[6]

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

Find the values of a and b.

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[12]

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

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

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[6]

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

ripple tank is used to demonstrate interference between water waves.

Wavelength is proportional to amplitude.

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[4]

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

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

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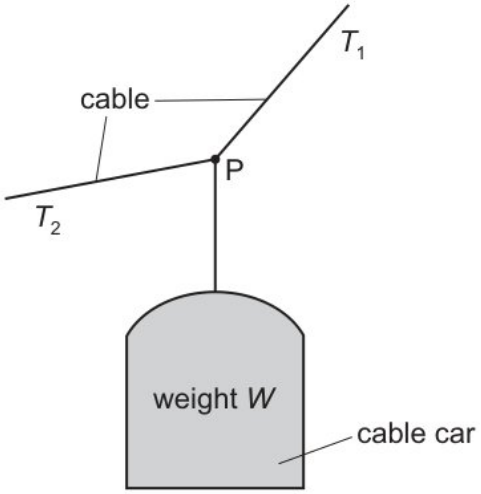
[8]

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



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[12]

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

(d) (iii) 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.

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

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[6]

(i) Find the modulus of elasticity of the string in terms of W.

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

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[8]

(b) (v) 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.

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.

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

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[6]

(ii) 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.

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

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[6]

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

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

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[8]

(iii) displacement = velocity × time

Show that if

the value of the constant k,

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[5]

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

Calculate the acute angle between the planes.

current-carrying coil produces a magnetic field.

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[6]

(c) (vi) ages of a group of 12 people at an Art class have mean 48.7 years and standard deviation 7.65 years. The ages of a group of 7 people at another Art class have mean 38.1 years and standard deviation 4.2 years.

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

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

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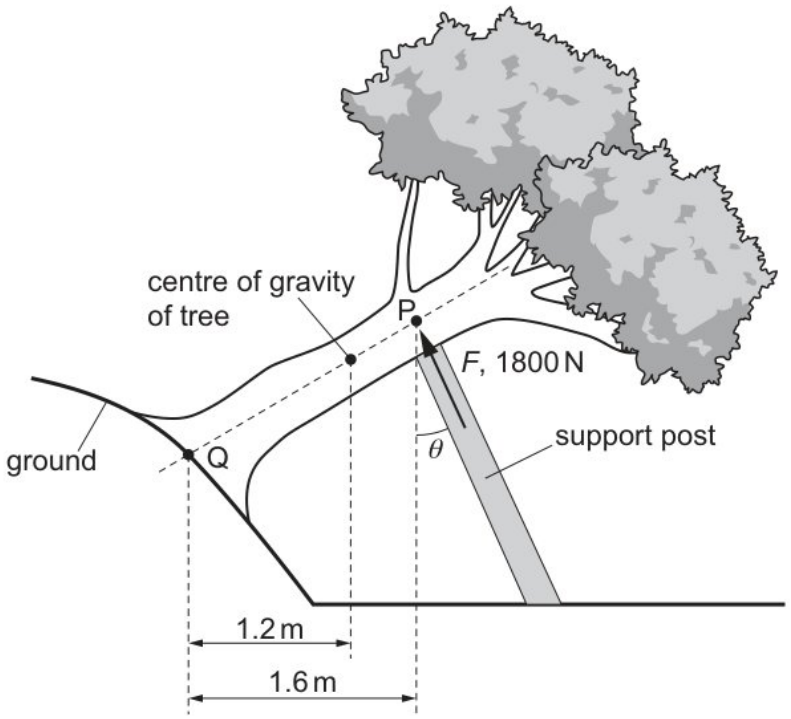
[6]

(i)



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

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[10]

(iii) 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.

Find a set of corresponding eigenvectors.

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[15]

23 (b) m.f. for $n = 0$.

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

(i) 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.

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[6]

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

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

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[8]

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

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[4]

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

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

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

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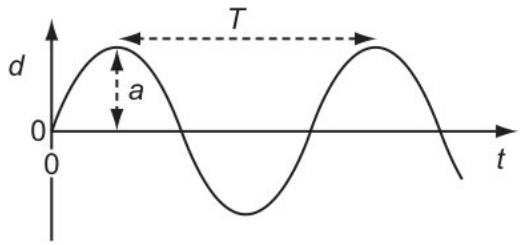
attached = ... kh **[4]**

(i) 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.



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[3]

(vii) restaurant manager buys 160 of these large bags of pasta.

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circle divided smallest = ... *hc* **[5]**

(c) 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.

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

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member beginning = ... *op* **[8]**

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

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

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[10]

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

one similarity and one difference between an electron and positron.

Hence solve the equation

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

is the useful power output of the power station?

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[8]

(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.

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

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[1]

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

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

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

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[6]

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

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[5]

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

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counts = ... xg **[6]**

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

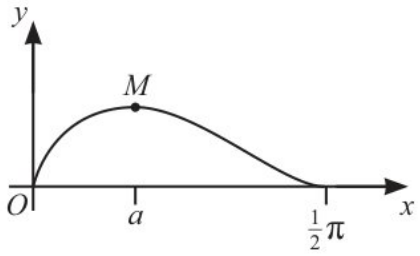
small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

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

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

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

(b) (ii) Find the x-coordinate of the maximum point M on the curve.



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

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[3]

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

weight of the parachutist is 850 N .

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wire Fig. = ... *nr* **[15]**

(a) (v) 1.1 shows the measurements for cube A.

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°.

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[2]

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

measurements to be taken,

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[5]

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

the speed of the aeroplane.

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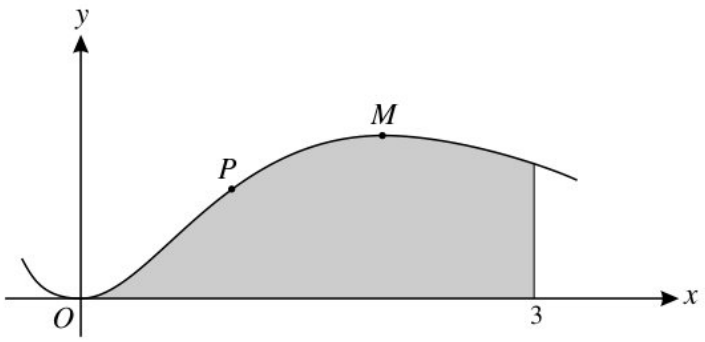
[8]

(v)



Find Σx^2.

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[6]

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

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

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.

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numbered = ... ms **[3]**

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

(d) (i)

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

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

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

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collides second = ... qd **[3]**

(iv) is the grand-daughter product?

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

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

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[6]

(ii) curve C has equation

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

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second = ... *db* **[4]**

(c) (iv) amplitude $\propto$ intensity

Find the equations of the asymptotes of C.

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letters mean. business = ... *js* **[5]**

(i) what is meant by centre of gravity.

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

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[5]

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

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

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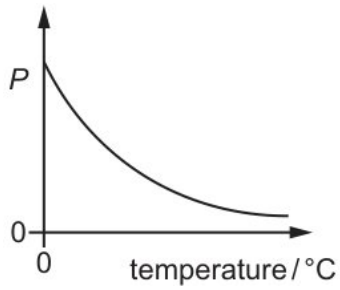
[6]

(a) (i) this compression, work W is done on the gas.

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



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[8]

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

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

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

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[6]

(b) (i) a normal distribution, calculate a 95% confidence interval for the population mean.

is the average useful power at which he is working?

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.

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[12]

(iv) 191.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3}.

a vector equation for l.

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[6]

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

(b) (iv) Find the frictional and normal components of the contact force acting on B.

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

[4]

(iii) this compression, work W is done on the gas.

speeds of the particles.

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

[6]

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

between gravitational potential energy and electric potential energy.

[5]

(a) (iii) $n \geqslant 0$. Show that, for all $n \geqslant 2$,

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.

[5]

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

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

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]

(c) (i) P and Q form an isolated system.

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.

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

[6]

(iii) sheets between a light source and the front of the photocell.

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

[1]

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

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

[3]

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

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

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

[3]

(i) 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 .

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

[2]

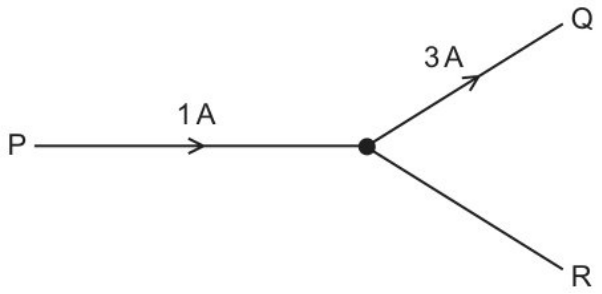
(iv) Without using a calculator, find the exact values of

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

study = ... mi **[12]**

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

(c) (ii)



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

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[4]

(vi) Calculate the speed of projection of P.

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

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[6]

(iii) ripple tank is used to demonstrate interference between water waves.

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

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

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[8]

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

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

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[12]

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

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

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[3]

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

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

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[3]

(iii) this compression, work W is done on the gas.

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

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[8]

25 not have a unique solution.

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

(c) (iv) p and q are given real numbers, then

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

State the equation of the other asymptote.

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away = ... *om* **[6]**

(ii) by mathematical induction that, for all positive integers n,

object is fully submerged in a liquid.

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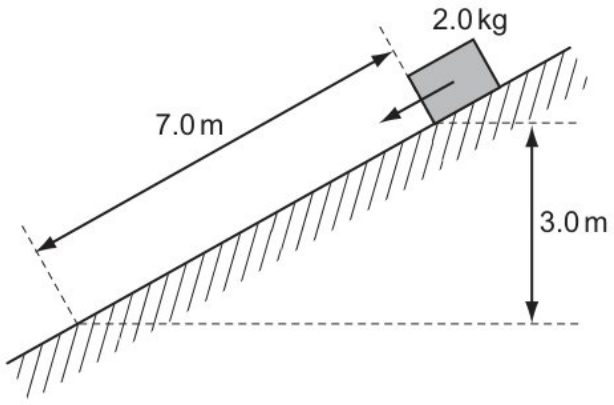
[8]

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



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[4]

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

the probability of a Type I error.

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[6]

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

de Moivre's theorem to show that

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[6]

(v) up to antidown

There will always be 9.0 V across the battery terminals.

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

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[6]

(d) (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.

points A, B, C have position vectors

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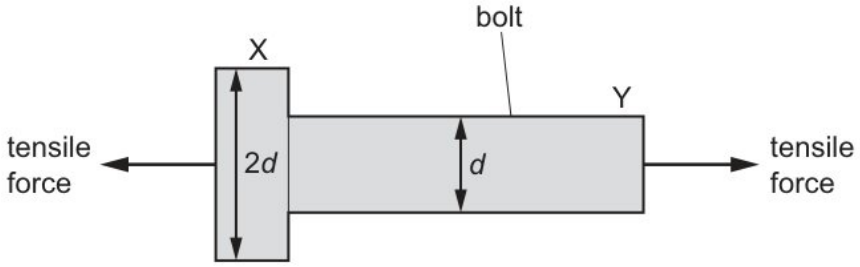
[2]

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



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

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[10]

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

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

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[3]

(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.

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

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

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[5]

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

(e) (i) up to down

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

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

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[12]

(ii) When a and b have these values, factorise p(x) completely.

Show that the cartesian equation of C is

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

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[8]

(c) (v) no digit can be repeated,

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

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[5]

(iv) curve has equation $y = \frac{4}{3x-4}$ and $P(2, 2)$ is a point on the curve.

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

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from = ... *om* **[3]**

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

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

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

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[10]

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

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[5]

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

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[5]

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

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

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

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[6]

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

flows out of a pipe and hits a wall.

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[20]

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

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

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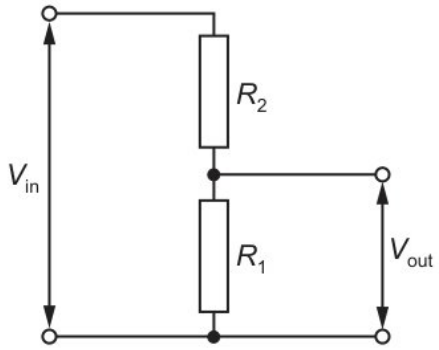
[12]

14 Find the coordinates of the turning points of C.

(b) (i)



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

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[6]

(iii) neutron decays to form a proton.

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

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[8]

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

Find the values of F and θ.

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[4]

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

the average output power of the car during this time

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[4]

(ii) Under 25 178 181 183 192 203 209 223 231

the acute angle between the planes ABC and ABD.

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[4]

(v) sheets between a light source and the front of the photocell.

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

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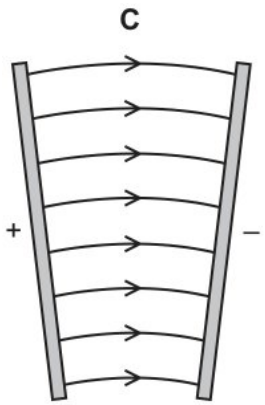
[5]

(a) (iii) 1 and 2 only



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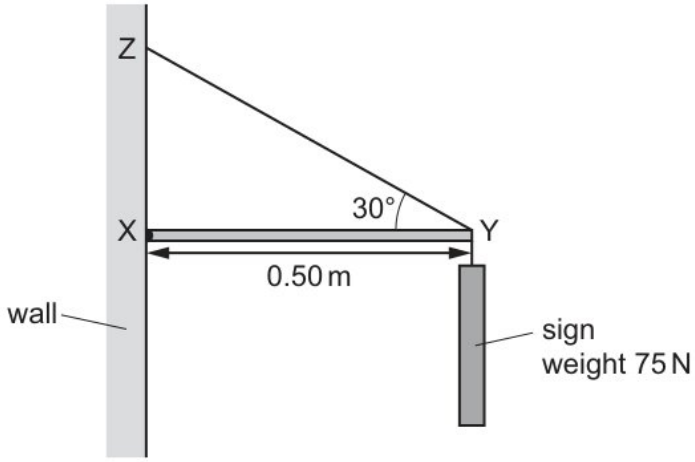
passes = ... *ox* **[5]**

(i)



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

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[5]

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

is a general description of a baryon?

for a wire,

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distance = ... iz **[6]**

(ii) 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.

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

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[20]

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

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

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[6]

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

cube has volume V and is made of a material with resistivity ρ. The connections to the cube have negligible resistance.

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

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[6]

16 (iv) 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.

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

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[8]

(b) 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.

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[2]

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

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[4]

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

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

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[15]

(a) 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.

Hence solve the equation

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

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[4]

(b) Hence find the solutions of the equation

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

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

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[5]

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

(b) Hence find the solutions of the equation

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 $t = 4$.

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[4]

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

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[6]

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

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[5]

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

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

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

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

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[20]

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

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

Hence solve the equation

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[6]

(e) 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.

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

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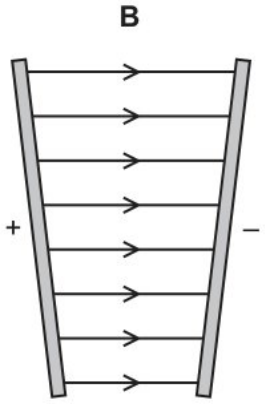
[10]

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

The weight of the plank is causing a clockwise moment.



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[4]

(d) Find the work done by the tension.

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

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[10]

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

524 526 520 523 530

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[10]

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

point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

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

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wire = ... bh **[5]**

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

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

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probability = ... *ig* **[15]**

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

that $rp^3 = q^3$.

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[5]

(a) - falling freely with the parachute closed,

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

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

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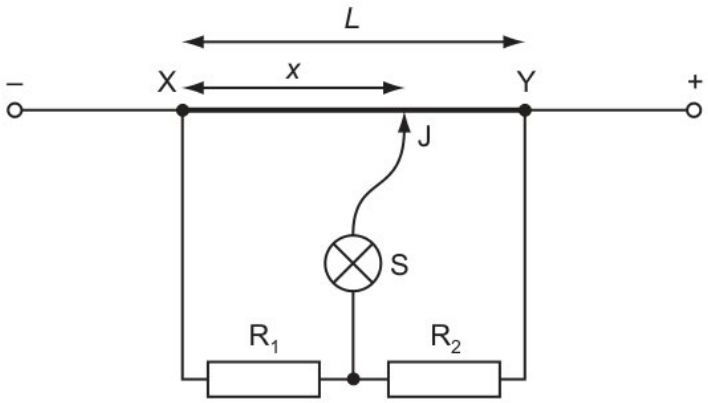
[6]

(ii) (d) 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.



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[20]

(b) a laboratory experiment that uses a Hall probe to test the relationship between B and r. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

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

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[10]

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

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

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[10]

(c) X and Y are connected in series to a cell.

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

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

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through equation = ... *by* **[12]**

9 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.

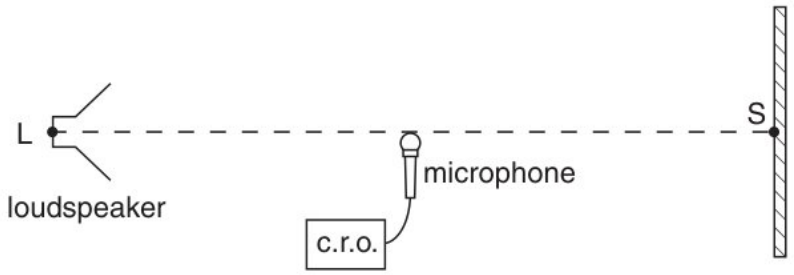
fair six-sided dice with faces labelled $1, 2, 3, 4, 5, 6$ is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X.

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

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

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

(d) (ii)



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

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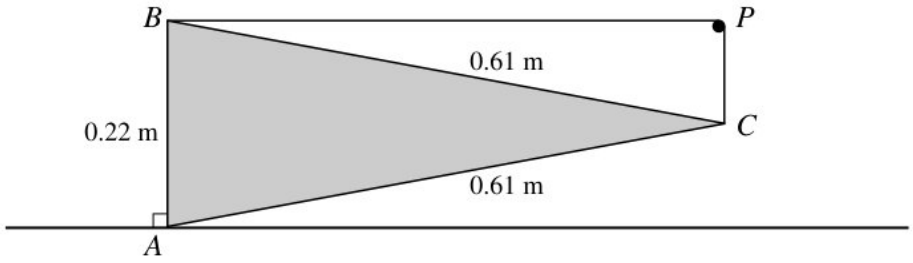
[12]

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

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.



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[5]

(a) (iv) Find the acceleration of the particle during the first 5 seconds of motion.

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

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[12]

(iii) the exact value of the positive constant k for which

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

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[5]

23 Q hears a sound of decreasing frequency.

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

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.

Find the probability density function of Y.

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[4]

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

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

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[6]

(v) exactly at point S

the probability that the marble chosen from bag A is blue, given that the marble chosen from bag B is blue.

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[3]

(b) (i) row of the table gives an angle θ of $90°$?

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

the arc length of C,

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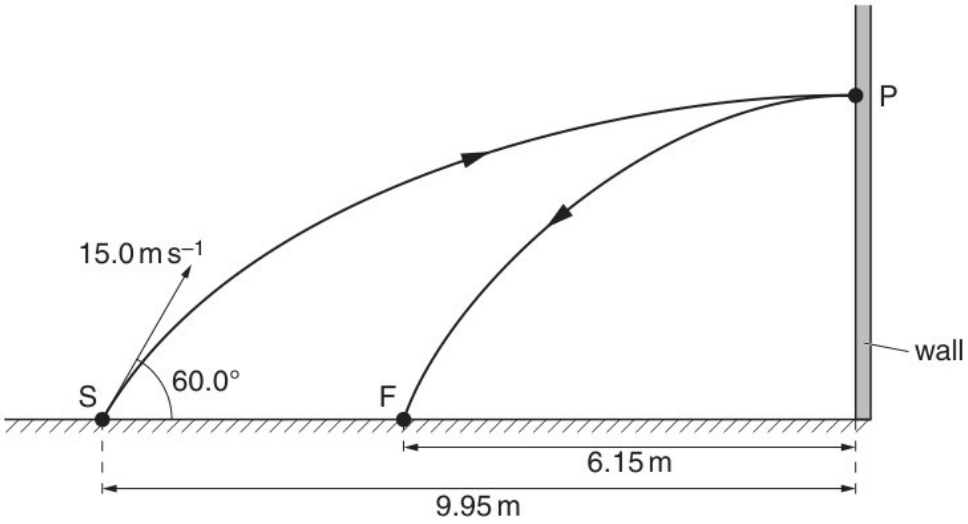
[3]

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



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.

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[5]

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

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.

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

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loses = ... kf **[5]**

(d) (i) 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.

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

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

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[12]

(vi) object is fully submerged in a liquid.

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

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[3]

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

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

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[6]

8 Find the distance OM.

$$p\begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q\begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}.$$

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

the term interference.

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[4]

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

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

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[5]

(a) (i) Using the concept of work done on the car, show that the kinetic energy E_{K} of the car is given by the equation

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

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[2]

(iii) The orbit has a period of 25 hours.

Velocity is proportional to wavelength.

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mass round = ... hk **[5]**

(c) (i) what is meant by a fundamental particle.

specific latent heat.

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}.

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[5]

(ii) 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

eigenvalues $1, -1$ and -2 .

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[5]

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

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

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[3]

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

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

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

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

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[5]

(i) projectile is thrown at an angle to the ground.

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

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[12]

(ii) a vector equation for the line l_1.

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

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 $AC = a$.

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[15]

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

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

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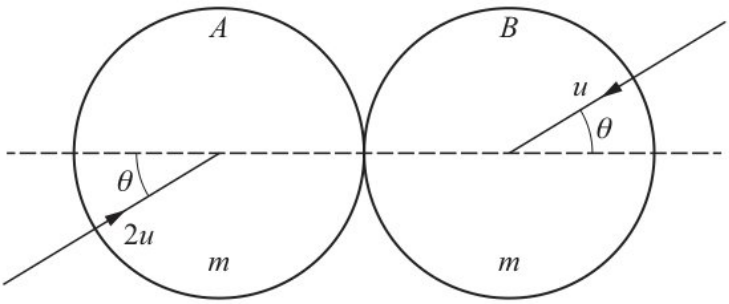
[2]

(i)



Show that if

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[8]

(ii) $\omega = \cos\frac{1}{5}\pi + \mathrm{i}\sin\frac{1}{5}\pi$. Show that $\omega^5 + 1 = 0$ and deduce that

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

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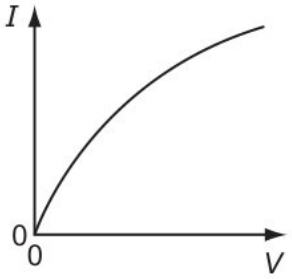
[10]

(c) (iv)



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

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taken. taken. taken. = ... ms **[6]**

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

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

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[8]

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

Hence solve the equation

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[8]

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

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

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

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[3]

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

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

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[12]

(vi) control of variables,

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

statement about light waves and sound waves is correct?

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[5]

(iii) is the reading on the ammeter?

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 .

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[6]

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

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

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

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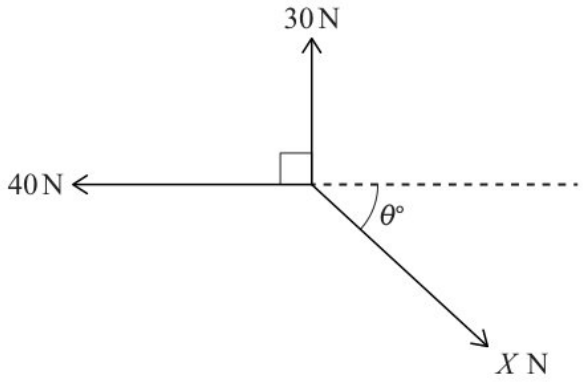
[5]

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

matrix **A** is given by



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[5]

(i) 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.

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

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

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[10]

(a) (ii) Show that the cartesian equation of C is

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

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

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[5]

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

that l_1 and l_2 do not intersect.

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[8]

(iv) 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).

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

specific latent heat.

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[12]

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

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

the ductile material,

ripple tank is used to demonstrate interference between water waves.

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[5]

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

two assumptions of the simple kinetic model of a gas.

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.

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random = ... *yr* **[4]**

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

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

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

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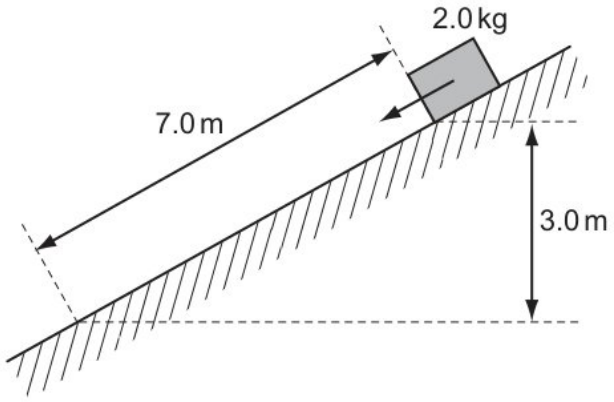
resistivity = ... cs **[5]**

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



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[5]

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

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

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[4]

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

continuous random variable X has probability density function f given by

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

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

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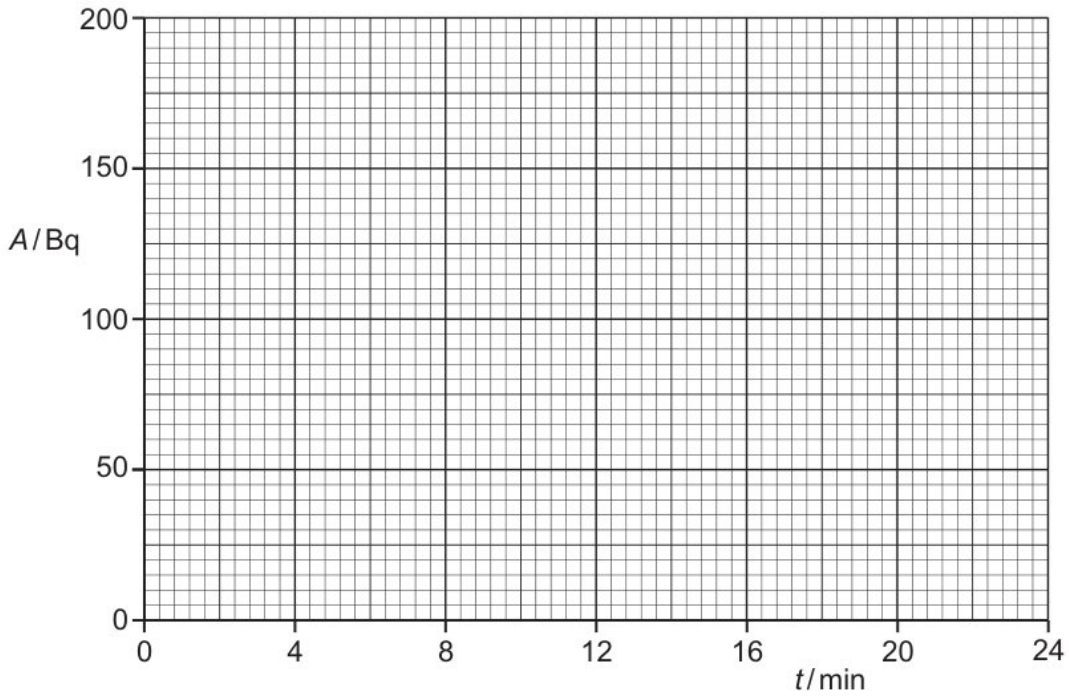
[10]

(v)



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

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[6]

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

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

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[12]

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

is given that a is a positive constant such that

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.

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[12]

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

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

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[6]

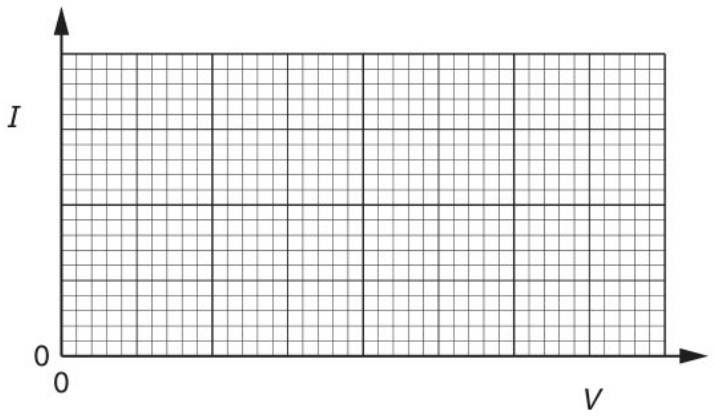
9 Find the values of a and b.

(c) (v) State the work W done by F.

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

through = ... wy **[5]**

(iii) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.



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

[3]

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

The matrix $\mathbf{B}$, where

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

[3]

(b) (iii) the matrix $\mathbf{A}$,

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

[5]

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

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

[10]

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

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

[6]

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

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.

the probability of a Type II error.

[5]

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

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

[6]

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

is the minimum constant acceleration necessary for the aircraft?

[3]

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

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

researcher random = ... xm **[8]**

14 a laboratory experiment to determine the absorption coefficient of glass. You should

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

(b) (i) height of the liquid in the beaker is 0.20 m ± 2%.

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

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horizontal = ... *ah* **[10]**

(iv) Pressure is force per unit area.

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

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places. where = ... *te* **[12]**

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

the period of small oscillations,

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[8]

(ii)

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

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

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.

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[15]

(d) (i) the matrix **A**,

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

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[4]

(iii)

	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

the ductile material,

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.

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[12]

(ii) object is fully submerged in a liquid.

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

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[3]

17 the coordinates of C,

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

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

Prove that, for $n \geqslant 2$,

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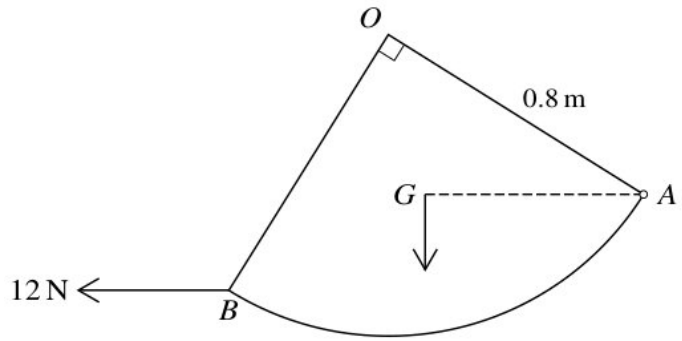
[6]

(iii)



the distribution function of X.

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passes adjacent positioned = ... tp **[6]**

(a) (iv) 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.

Show that $b = 1 - a$.

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

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[10]

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

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

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[5]

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

In the case where $k = 2$,

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

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[10]

(g) (vi) Deduce that the cartesian equation of C is only one of the following two alternatives.

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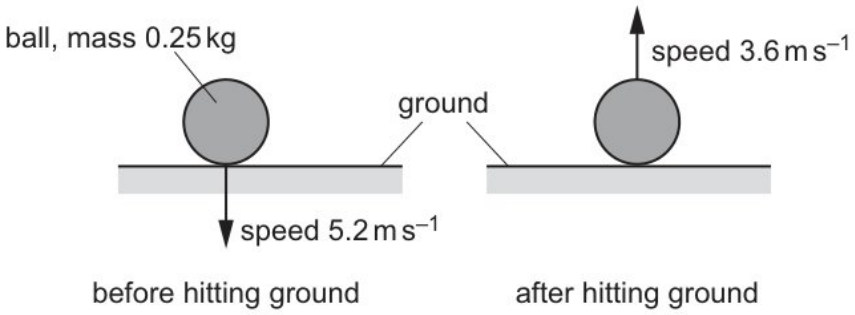
[3]

(v)



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

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.

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[5]

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

control of variables,

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[6]

(e) (iii)

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

Show that the cartesian equation of C is

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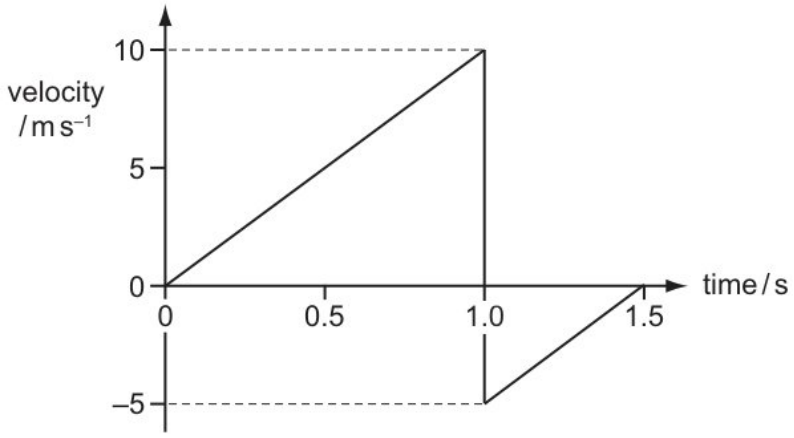
along = ... zu **[2]**

(vi)



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.

the team contains more boys than girls.

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[2]

(i) Show that $\frac{dy}{dx} = 2t^{\frac{1}{2}}\frac{dy}{dt}$ and $\frac{d^2y}{dx^2} = 2\frac{dy}{dt} + 4t\frac{d^2y}{dt^2}$.

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

the value of σ.

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[5]

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

(e) (v) that $\tan 2a = -4a$

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

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[6]

(i) two assumptions of the simple kinetic model of a gas.

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

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[4]

(b) (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.

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

down to up

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[5]

(ii) exactly at point T

the speed of the combined particle after this collision.

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[6]

10 the apparatus used to produce two sources of coherent waves that have circular wavefronts,

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

Calculate the acute angle between the planes.

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[6]

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

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

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

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[6]

(b) (i) - falling with constant speed with the parachute open,

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

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

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[5]

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

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

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

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[15]

(ii) only one of the following two alternatives.

should pay particular attention to

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.

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[8]

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

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

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[5]

(i) 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.

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

single change would double the value of this ratio?

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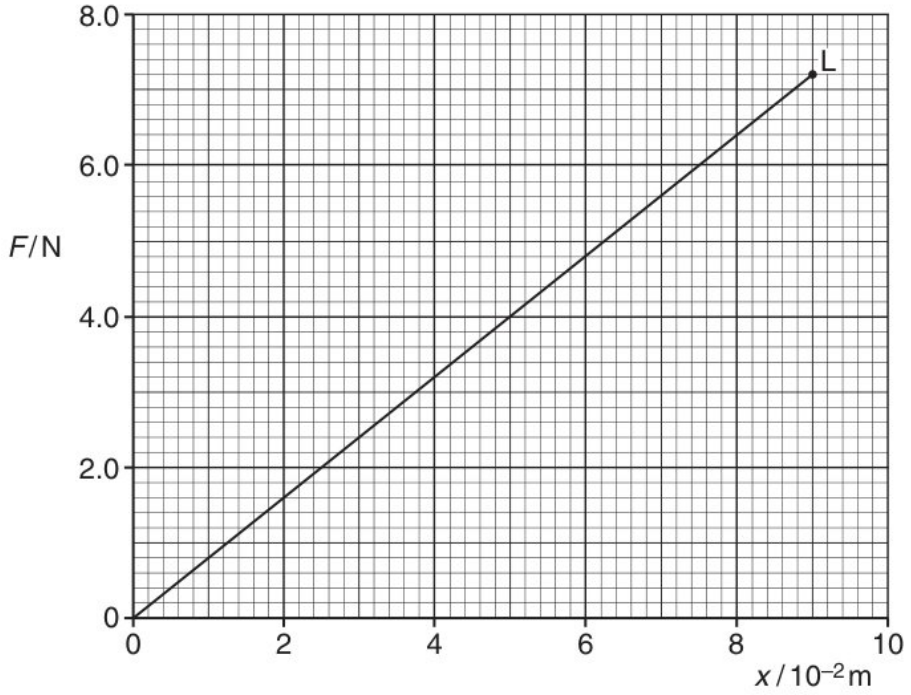
[3]

(e) (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.

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[4]

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

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

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[6]

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

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

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

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.

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

$$\mathbf{A}=\begin{pmatrix} 1 & -1 & -2 & 3 \\ 5 & -3 & -4 & 25 \\ 6 & -4 & -6 & 28 \\ 7 & -5 & -8 & 31 \end{pmatrix}$$

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follows. = ... rj **[8]**

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

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

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[10]

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

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

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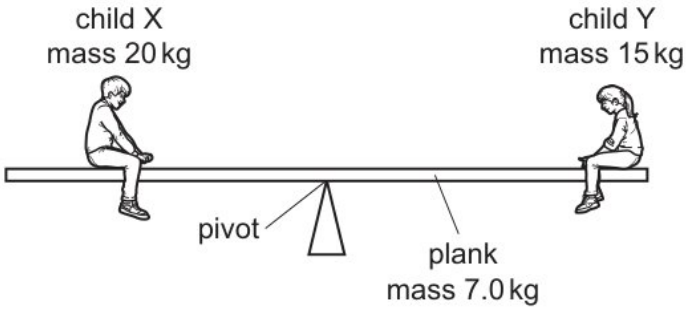
[12]

(iii)



restaurant manager buys 160 of these large bags of pasta.

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[1]

(ii) Show that $m = 0.9$.

statement about light waves and sound waves is correct?

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

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produced. = ... xj **[5]**

17 measuring instrument should be used?

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

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

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

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[3]

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

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

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

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parallel = ... *ga* **[5]**

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

$l_1 : \mathbf{r} = 6\mathbf{i} + 5\mathbf{j} + 4\mathbf{k} + \lambda(\mathbf{i} + \mathbf{j} + \mathbf{k})$ and $l_2 : \mathbf{r} = 6\mathbf{i} + 5\mathbf{j} + 4\mathbf{k} + \mu(4\mathbf{i} + 6\mathbf{j} + \mathbf{k})$

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[15]

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

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.

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[8]

(e) (ii) analysis of the data,

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.

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[8]

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

Express f(x) in partial fractions.

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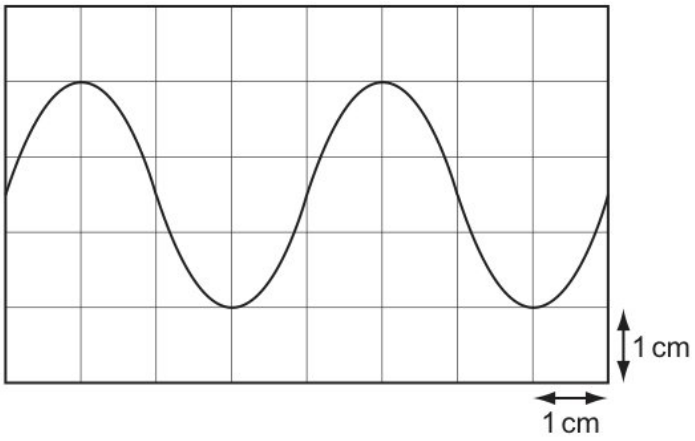
[6]

(iii)



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

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[8]

(v) the eigenvalues of the matrix **C**, where

the acute angle between the planes ABC and ABD.

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[8]

27 the distribution function of X.

Find angle ABC.

is the reading on the ammeter?

(a) (i) curve C has equation

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

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

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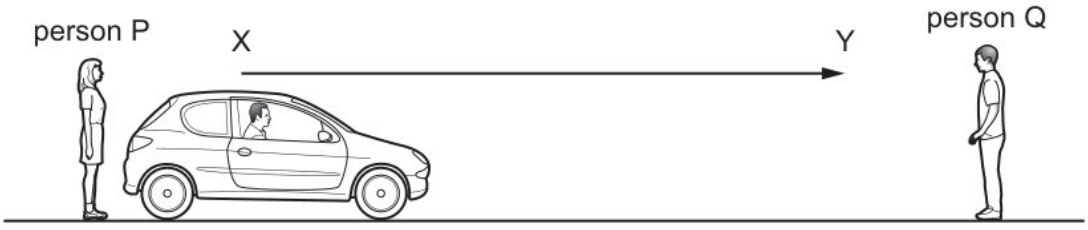
[10]

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



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[6]

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

Without using a calculator, find the exact values of

random variable X is the number of heads obtained.

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[5]

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

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

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freely = ... vh **[2]**

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

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

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[5]

(ii) the period of small oscillations,

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

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[6]

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

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

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.

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ties rope pulls = ... xr **[6]**

(iii) Calculate the modulus of elasticity of the string.

Find angle ABC.

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[6]

11 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.

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

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

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[4]

(vii) Velocity is proportional to wavelength.

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

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

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[8]

(iv) 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 .

the distance AC.

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[12]

(iii) 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.

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

Use implicit differentiation to show that

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[8]

(a) (ii) is its change in momentum?

resistors of equal value are connected as shown.

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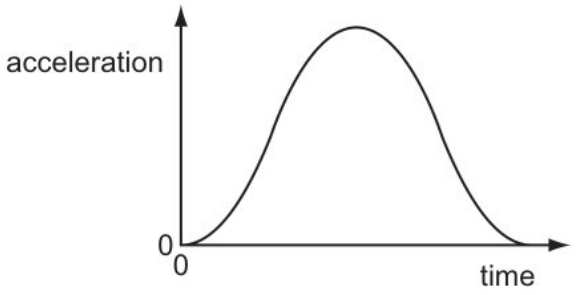
[4]

(iv)



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

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[4]

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

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

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[4]

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

equation gives v in terms of A and u ?

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[5]

(ii) projectile is thrown at an angle to the ground.

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

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[6]

16 (b) turbine at a hydroelectric power station is situated at a vertical distance of 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

(iii) discrete random variable X has the following probability distribution.

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[3]

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

the probability that the marble chosen from bag A is blue, given that the marble chosen from bag B is blue.

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[6]

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

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[6]

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

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

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[3]

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

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[4]

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

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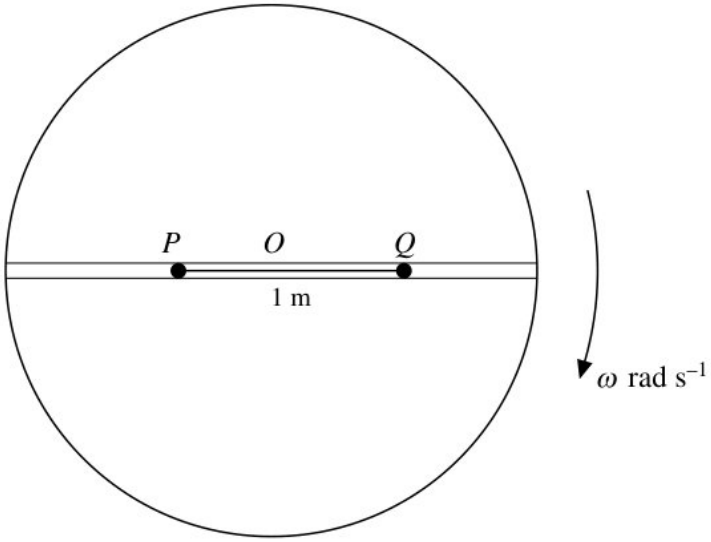
[4]

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

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

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

(b) (ii) Find the frictional and normal components of the contact force acting on B.



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

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[2]

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

Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16\sin^5\theta \, \mathrm{d}\theta$.

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[5]

(a) (i)

only one of the following two alternatives.

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[3]

(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.

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

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[5]

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

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

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

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[5]

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

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

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

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[5]

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

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

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study exactly = ... *ps* **[10]**

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

charge of 4.0 C passes through the resistor.

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[12]

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

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

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many = ... *ou* **[6]**

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

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

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[6]

(d) (i) sheets between a light source and the front of the photocell.

much energy is stored in the compressed column?

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along = ... *yp* **[12]**

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

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

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

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[5]

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

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

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[10]

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

(c) (ii) Find the frictional and normal components of the contact force acting on B.

the value of the constant k,

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curve lines = ... *zr* **[15]**

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

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

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[3]

(d) (iii) Find the modulus of elasticity of the string in terms of W.

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

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[3]

(vi) parametric equations of a curve are

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

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[5]

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

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

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[5]

20 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.

(i) (e) Show that, for $n > 2$,

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

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[4]

(a) process does not require energy to be supplied?

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

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[8]

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

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.

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[12]

(iv) (c) cable has tensions T_1 and T_2 as shown.

Both light waves and sound waves show the Doppler effect.

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[12]

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

Hence solve the equation

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

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until = ... *uu* **[2]**

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

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 $t = 4$.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = -2x\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2$$

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curve = ... *tc* **[8]**

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

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

the position vector of D.

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[2]

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

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

projectile is thrown at an angle to the ground.

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[12]

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

force is caused only by a pressure difference?

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

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change distance = ... qw **[3]**

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

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

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[8]

(a) (iii) 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.

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

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[6]

(i) the value of the constant k,

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

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selected = ... rr **[6]**

(iv) object weighs 6.0 N on Earth.

are the amplitude and the period of wave S ?

curve C has equation

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[5]

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

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

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[8]

(i) only one of the following two alternatives.

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. . . . . .

[15]

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

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[4]

(e) Find the position vector of D.

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

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[6]

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

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[8]

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

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[6]

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

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

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

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[6]

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

(ii) Use de Moivre's theorem to show that

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. . . . . .

with = ... jy **[3]**

(i) the value of n.

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. . . . . .
. . . . . .
. . . . . .

[6]

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

(b) (ii) up to antidown

Without using a calculator, find the exact values of

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

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[4]

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

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

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[10]

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

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

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[6]

(h) (ii) 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.

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.

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times time = ... dz **[5]**

(v) fair tetrahedral die has faces numbered $1, 2, 3, 4$. A coin is biased so that the probability of showing a head when thrown is $\frac{1}{3}$. The die is thrown once and the number n that it lands on is noted. The biased coin is then thrown n times. So, for example, if the die lands on 3 , the coin is thrown 3 times.

for a wire,

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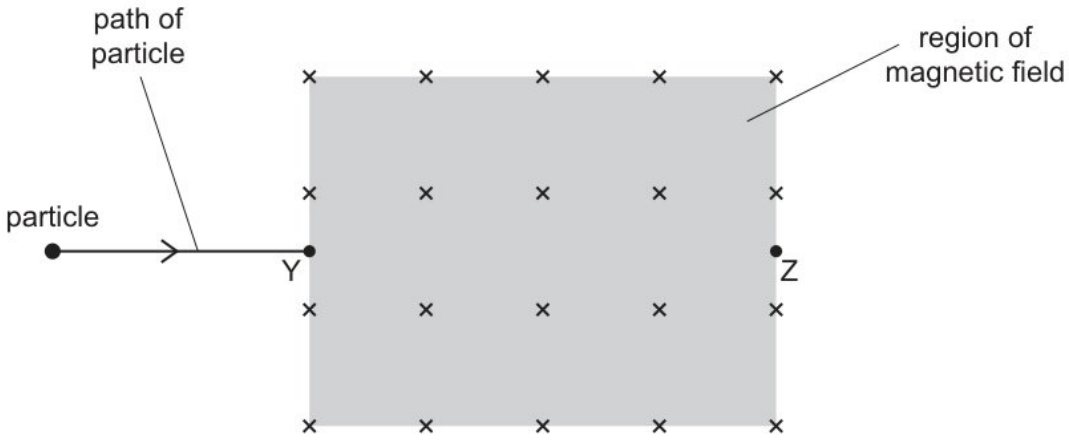
[5]

(iv)



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

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

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[3]

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

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

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

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[8]

(ii) 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.

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

quantities would be measured in order to determine E ?

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[3]

22 Over 50 198 212 217 229 235 242

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

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

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[2]

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

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

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[8]

(iv) 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.

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

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

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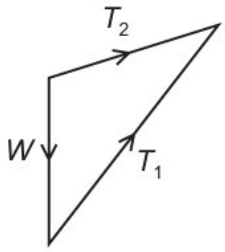
[6]

(b) (ii)



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

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[3]

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

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

the ductile material,

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[5]

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

Obtain a basis for the null space of T .

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[6]

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

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

the geometric effects of multiplying z_1 and z_2 by ω

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

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

curve C has parametric equations

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[5]

(vi) is the value of R ?

specific latent heat.

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[5]

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

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.

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[5]

(vi) the equation for this decay.

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

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

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angle = ... *ie* **[4]**

(b) (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 .

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.

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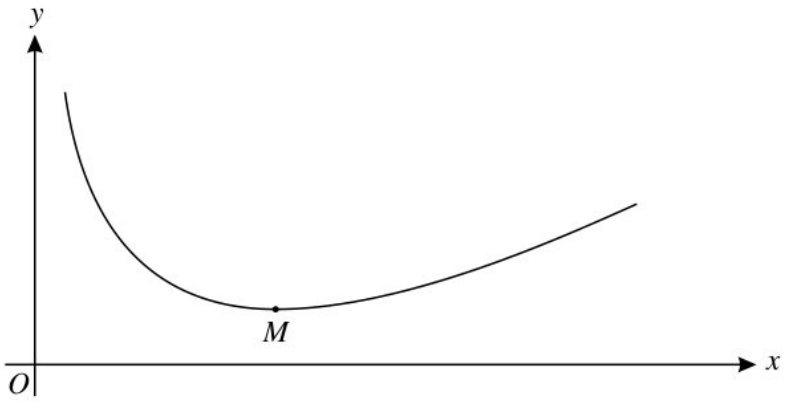
[8]

(iii)



much energy is stored in the compressed column?

the value of μ and the value of X for which the block is on the point of moving up the plane.

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himself fixed = ... *oq* **[5]**

(c) (i) the solution of the differential equation

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

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[5]

(iii) shaded region is bounded by the curve and the two axes.

The waves must be polarised.

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[8]

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

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

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

[4]

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

what is meant by work done.

[6]

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

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

[4]

(c) (ii) aeroplane is flying at a constant speed.

$$\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = -2x\left(\frac{\mathrm{d}y}{\mathrm{d}x}\right)^2$$

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

[5]

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

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

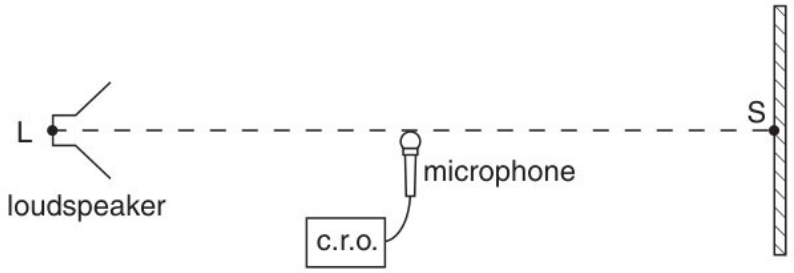
along constant = ... rj **[2]**

(b) (i) relationship is used in the derivation of the equation shown?

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

[6]

(iii)



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

from = ... ba **[6]**

(v) $I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$, where n is a non-negative integer.

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.

Show that the total distance fallen is 1048 m .

[4]

9 $n \geqslant 0$. Show that, for all $n \geqslant 2$,

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

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

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[8]

(i) is the horizontal force exerted by the wall on r r Y ?

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

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

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[8]

(v) Calculate the exact value of I_1 and deduce the exact value of I_3.

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

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[2]

(a) (v) curve C with equation

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

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

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follows. = ... qb **[6]**

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

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

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[15]

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

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

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[4]

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

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}.

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within = ... xn **[2]**

(iii) diagram best represents the electric field surrounding the charges?

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

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

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[6]

26 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.

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

an estimate for the mean length of these 250 leaves.

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[8]

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

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

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[4]

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

Form two simultaneous equations and hence find x and v.

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[12]

(c) (vi) cable car of weight W hangs in equilibrium from its cable at point P.

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[15]

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

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

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[8]

(a) (v) a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1}.

variables x and y satisfy the differential equation

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[4]

(iii) is the total elastic potential energy stored in the four springs?

Find the value of I_2.

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[5]

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

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

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planes. = ... nv **[4]**

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

$$\frac{\mathrm{d}^2v}{\mathrm{d}x^2} + 2\frac{\mathrm{d}v}{\mathrm{d}x} - 15v = 24\mathrm{e}^{-x}$$

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upward = ... hn **[5]**

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

thermistor is connected to a cell with negligible internal resistance.

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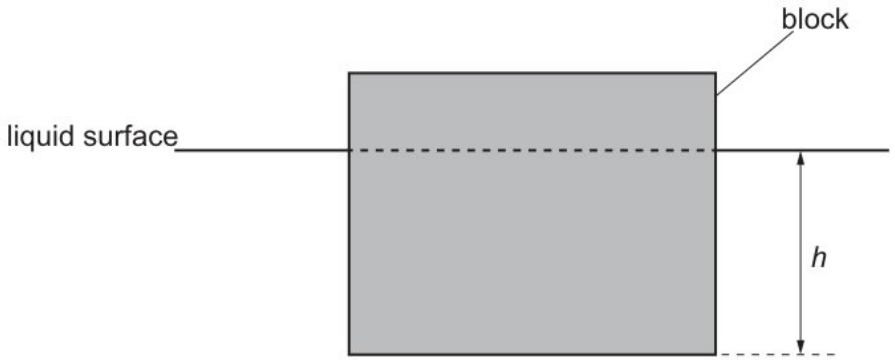
[12]

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

(d) (iii)



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

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[12]

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

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

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.

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[10]

(c) (vi) the solution of the differential equation

the value of V.

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

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[6]

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

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.

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[6]

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

the probability density function of Y,

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produced = ... rf **[8]**

(i) 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.

throws three coins at the same time.

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

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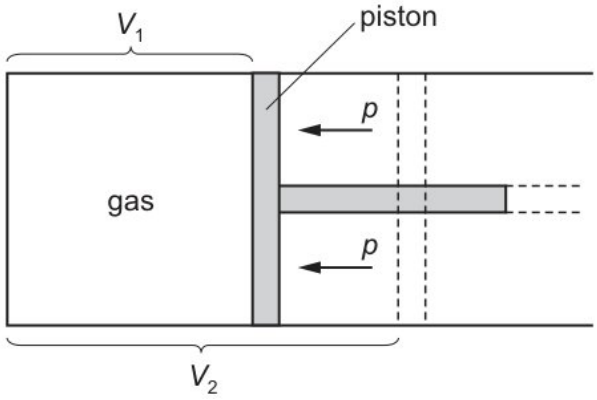
diagram. = ... qy **[6]**

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

is the horizontal force exerted by the wall on r r Y ?



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[5]

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

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

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[3]

9 (a) Find the weight of the lamina.

(i) the particular solution of the differential equation

Find the exact coordinates of this point.

[8]

(iv) Find the x-coordinate of M.

[5]

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

[5]

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

(vi) diagram shows the force-extension graph produced.

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

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

[5]

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

the distribution function of X.

this = ... de **[10]**

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

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

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

[4]

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

[3]

(f) only one of the following two alternatives.

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

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

particles = ... mz **[4]**

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

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

[10]

27 much energy is stored in the compressed column?

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

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

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with = ... kd **[10]**

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

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

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

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lowest = ... nr **[3]**

(c) up the probability distribution table for X.

are the amplitude and period of the wave?

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[6]

(vi) (a) 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.

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.

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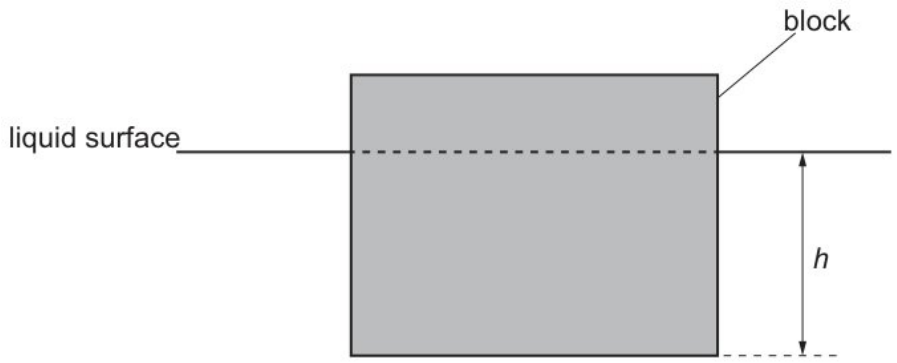
[5]

(b)



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.

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[10]

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

is the force exerted on the wall by the water?

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

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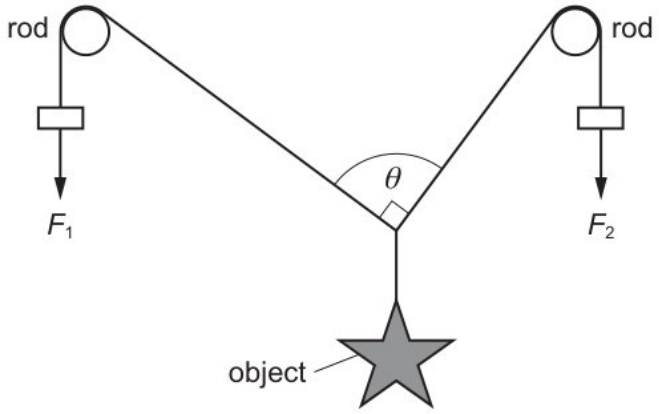
[2]

(d) 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.

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



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[8]

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

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

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simple = ... bj **[15]**

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

(a) (i) the ratio $H : D$.

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

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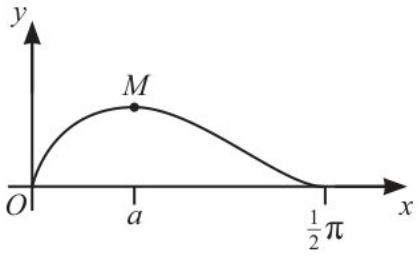
[6]

(iii)



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

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[5]

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

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

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

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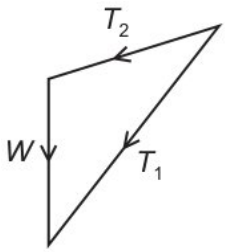
that = ... yb **[5]**

(b) (vi)



Show that, for $n > 2$,

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[4]

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

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

analysis of the data,

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[12]

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

the expected value and variance of Y.

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.

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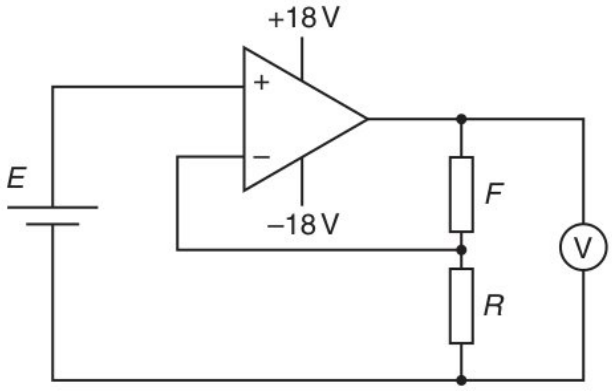
[10]

(iii)



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

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[12]

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

the coordinates of any stationary points on C.

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Wayne, = ... hy **[5]**

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

is given that

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

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[12]

(i) is the reading on the ammeter?

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

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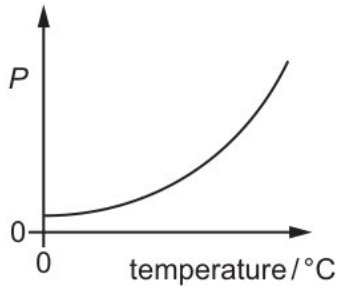
[5]

(e) (ii)



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

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

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[2]

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

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

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[4]

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

(e) (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

cable has tensions T_1 and T_2 as shown.

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[15]

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

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 $y = 3$.

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[2]

(b) (iv) specific latent heat.

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

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[8]

(vi) 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 $\frac{\mathrm{d}y}{\mathrm{d}x} = 2t^{\frac{1}{2}}\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 2\frac{\mathrm{d}y}{\mathrm{d}t} + 4t\frac{\mathrm{d}^2y}{\mathrm{d}t^2}$.

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[4]

(a) (i) 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

is the speed of the block after falling this distance?

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[5]

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

Frequency is inversely proportional to wavelength.

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[6]

(ii) cubic polynomial p(x) is defined by

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

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sleep = ... *yb* **[4]**

23 (c) the expected value and variance of Y.

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.

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

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that = ... *su* **[6]**

(i) the matrix **A**,

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[8]

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

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

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[6]

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

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

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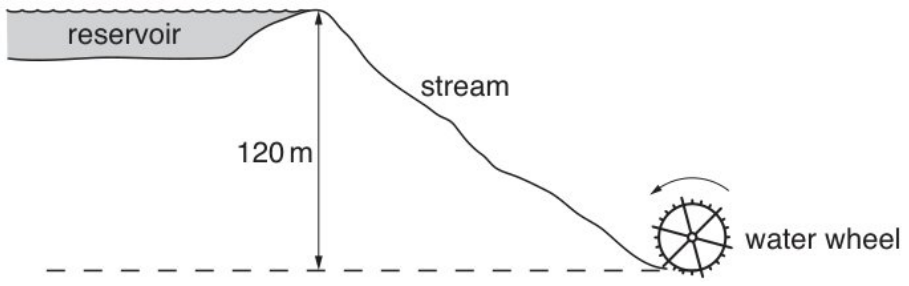
[8]

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

a vector equation for the line l_1.

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



(i) Use the equation of a suitable regression line to estimate the number of hours of sunshine on a day when the mid-day temperature is 2°C.

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[5]

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

points A, B, C have position vectors

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[12]

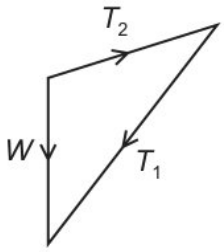
9 the set of values of x for which the expansion in part (b) is valid.

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

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

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

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



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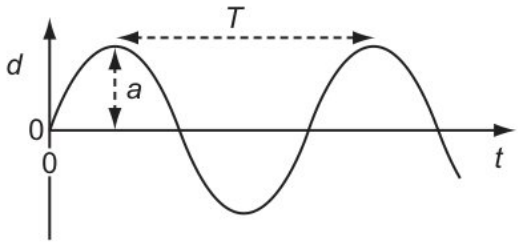
[15]

(ix)



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

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[8]

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

the probability that more than 7 study Art or Music.

force is caused only by a pressure difference?

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[6]

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

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.

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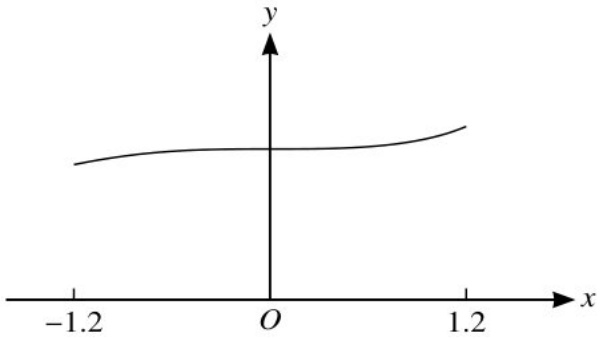
[6]

(vi)



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

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[4]

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

(b) (iii) - falling with constant speed with the parachute open,

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.

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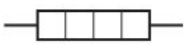
[4]

(iv)



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

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[6]

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

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.

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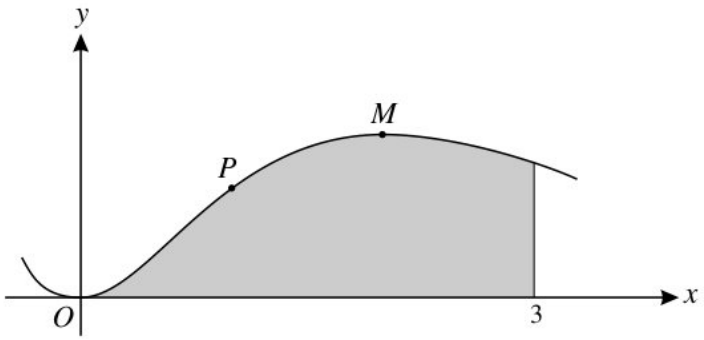
[3]

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



Show that the mass of P is 0.8 kg .

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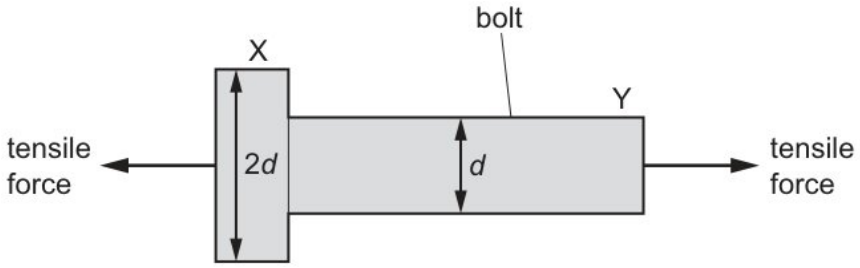
[1]

(d) (i)



the principle of superposition.

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[10]

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

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

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

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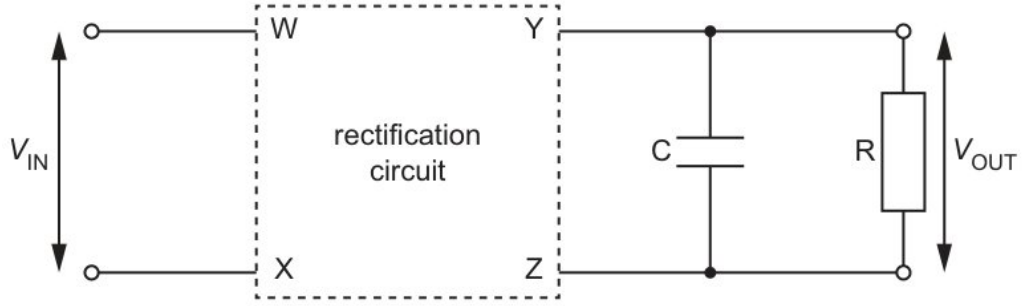
[5]

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



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.

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

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

Without using a calculator, find the exact values of

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[10]

(iii) the instant when the rule is horizontal, what is the resultant moment about the pivot?

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

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[8]

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

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.

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[3]

(i) marble is now chosen at random from bag B.

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

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that = ... zi **[4]**

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

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

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[3]

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

the equations of the asymptotes of C.

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

(d) (ii) moment of a force.

the value of x.

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.

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[4]

(iii) a large college, all students who study Science also study exactly one of Art or Drama or Music. 20% of these students study Art, 45% study Drama and 35% study Music.

resistance of a metal cube is measured by placing it between two parallel plates, as shown.

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 $\frac{8}{3}Ma^2$.

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[6]

(iv) Show that there is no point on C for which $\frac{1}{3} < y < 3$.

Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

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different = ... rg **[4]**

(b) (ii) gas is compressed so that its temperature increases to $3T$.

electric potential difference across a component.

Given that $\mathrm{E}(X) = 1.2$, find the value of a.

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[5]

(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 .

For the case where $\theta = 15$ and the plane on which B rests is smooth, find the acceleration of B.

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[8]

16 light elastic string has natural length 2 m and modulus of elasticity 39 N . The ends of the string are attached to fixed points A and B which are at the same horizontal level and 2.4 m apart. A particle P of mass m kg is attached to the mid-point of the string and hangs in equilibrium at a point 0.5 m below AB (see diagram).

(c) (ii) row correctly identifies the properties of all electromagnetic waves?

the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

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[10]

(i) the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

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[6]

(a) (i) light elastic string has natural length 2 m and modulus of elasticity 39 N . The ends of the string are attached to fixed points A and B which are at the same horizontal level and 2.4 m apart. A particle P of mass m kg is attached to the mid-point of the string and hangs in equilibrium at a point 0.5 m below AB (see diagram).

are the amplitude and the period of wave S ?

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[8]

(iv) the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

the value of μ and the value of X for which the block is on the point of moving up the plane.

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[5]

(iii) that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

$$\sum_{r=1}^{n} \frac{1}{(2r+1)(2r+3)}$$

a laboratory experiment that uses a Hall probe to test the relationship between B and r. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

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[8]

(b) (iii) Find the value of $(\alpha+1)(\beta+1)(\gamma+1)$.

vertical forces that the ground exerts on a stationary van are shown.

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[5]

(ii) Find the area of the triangle ABC.

that, when $t = 0, x = \frac{\mathrm{d}x}{\mathrm{d}t} = 0$.

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summarised = ... *ei* **[10]**

(e) (iv) the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

your answer correct to 2 decimal places.

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[2]

(ii) the exact value of $\text{cosec}^2 15° - \sec^2 15°$.

the graph of $y = |2x - 3|$.

is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

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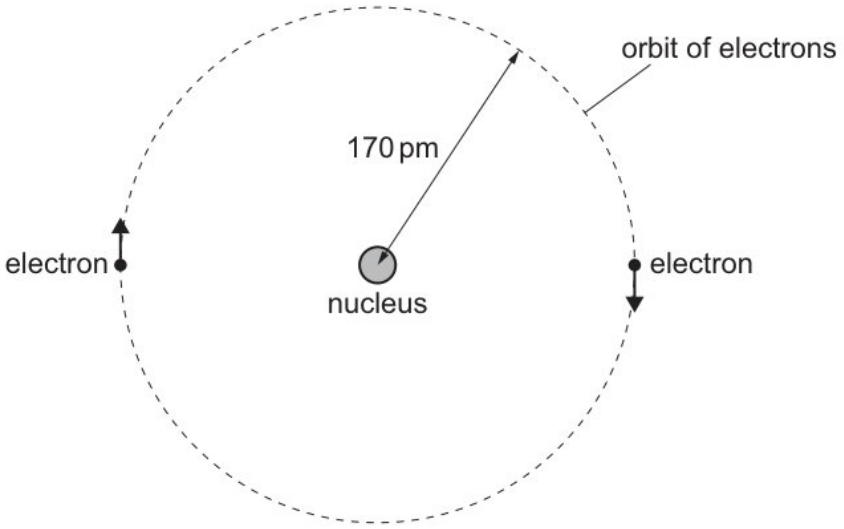
[6]

(v)



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.

The waves must be coherent.

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circuit = ... *vb* **[6]**

(iii) 1 Which quantity is a scalar quantity?

Carry out a goodness of fit test at the 10% significance level.

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less = ... *ie* **[1]**