11 $\dfrac{\text{force}}{\text{length} \times \text{speed}}$

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reaching = ……… xe **[4]**

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

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

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[4]

(b)

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

point D is the reflection of A in l.

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[6]

(a) what is meant by centre of gravity.

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[1]

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

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[10]

22 (d) 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.

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[5]

(a) none of them

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[10]

(g) is the angle θ ?

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

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another = ... fp [8]

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

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[6]

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

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[5]

10   the probability generating functions, $G_X(t)$ of X and $G_Y(t)$ of Y.

$$f(t) = \begin{cases} 0 & t < 0 \\ \lambda e^{-\lambda t} & t \geqslant 0 \end{cases}$$

Hence solve the equation

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

(a) 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.

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load along = ... bp **[3]**

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

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before they = ... he **[6]**

(c) Find the rank of **A** and show that $\left\{ \begin{pmatrix} 2 \\ 2 \\ -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 3 \\ 0 \\ 1 \end{pmatrix} \right\}$ is a basis for the null space

of the transformation.

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[**3**]

(d) displacement = velocity × time

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[**5**]

(e) for a wire,

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

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[**12**]

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

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[**4**]

23 Find the probability that a box is rejected.

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[3]

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

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

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[3]

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

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[6]

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

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

(a) diagram shows two waves R and S.

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[5]

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

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

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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[**10**]

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

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

what is meant by the de Broglie wavelength.

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[**8**]
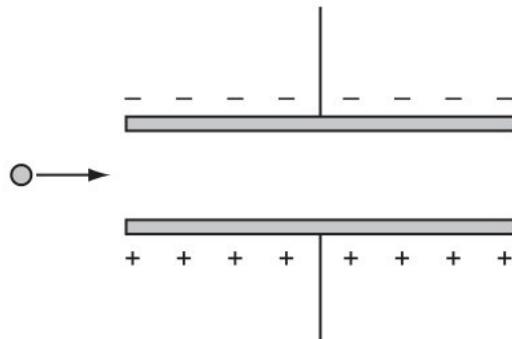
(c) company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

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**]

20   how the pattern of interfering waves may be observed.

object weighs 6.0 N on Earth.

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

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[**8**]

32   For boys aged 16 years in Jimpuri, 25% have a weight between 65 kilograms and k kilograms, where k is greater than 65 . Find k.

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

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[**6**]

   (iii)   be written as a quadratic equation in x.

          Find the x-coordinate of M.

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[**8**]

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

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[6]

17 load is pulled along horizontal ground for a distance of 76 m , using a rope. The rope is inclined at 5° above the horizontal and the tension in the rope is 65 N .

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[8]

21 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).

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

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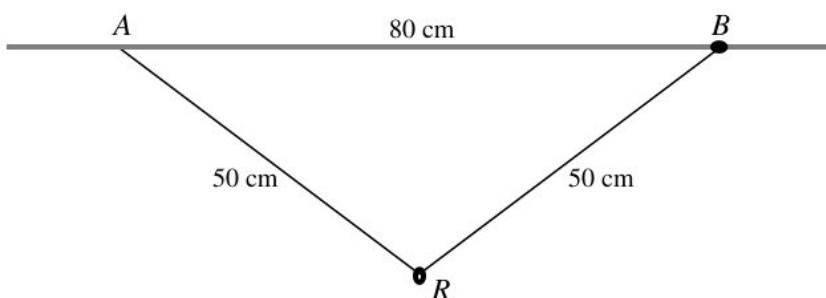
[6]

18 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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[2]

15

Show that the tension in the string is 10 N .

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random, cars, = ... yy [**6**]

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

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places = ... bo [**5**]

9   State what happens to the electron and to the positron.

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

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

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[**3**]

9   state the corresponding eigenvalue.

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between = ……………… mp **[10]**

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

the probability generating functions, $G_X(t)$ of X and $G_Y(t)$ of Y.

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[10]

23 Show that the mass of P is 0.8 kg .

(c) Find the tension in the string.

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[15]

(e) for a wire,

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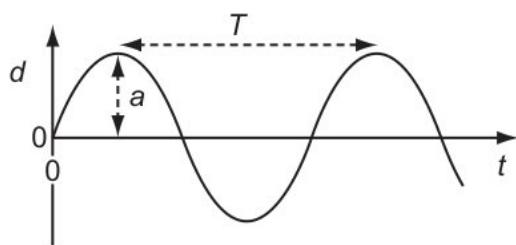
[4]

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

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.

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[5]

(b)

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]

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

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[4]

17 lamina is freely suspended at A and hangs in equilibrium.

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

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

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

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[**10**]

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

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[**4**]

13 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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front Elsie = ... md [**10**]

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

[**5**]

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

[**3**]

(d) car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

[**12**]

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

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

[**4**]

(a) 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.

[**12**]

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

Find the coordinates of the turning points of C.

(d) Find the matrix product $\mathbf{A} \begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation

$$\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}.$$

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

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[**8**]

(b) be written as a quadratic equation in x.

the value of $\int_0^{\frac{2}{3}\pi} \sin\left(\frac{1}{2}x\right) dx$.

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

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[**12**]

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

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[**4**]

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

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[**20**]

9   Saturday, 600 competitors took part. The times taken to complete the puzzle were normally distributed with mean 32.4 minutes and standard deviation 2.5 minutes.

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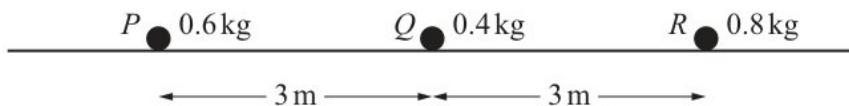
10   the complex numbers z for which $\frac{z+4}{z+4i}$ is real and $|z| = \sqrt{10}$. Give your answers in the form $z = x + iy$, where x and y are real.

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[**6**]

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

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

P ● 0.6 kg   Q ● 0.4 kg   R ● 0.8 kg

←——— 3 m ———→←——— 3 m ———→

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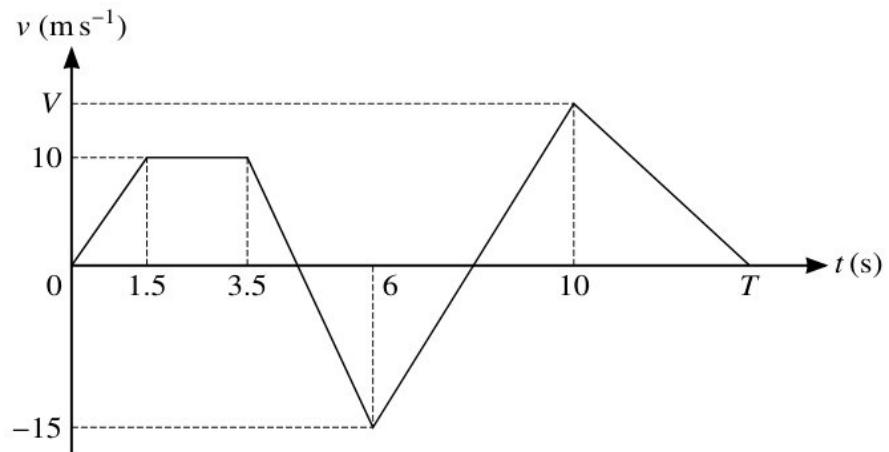
[**6**]

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

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.

$v\,(\mathrm{m\,s^{-1}})$

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[**6**]

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

amplitude $\propto$ intensity

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

team of 4 is to be randomly chosen from 3 boys and 5 girls. The random variable X is the number of girls in the team.

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

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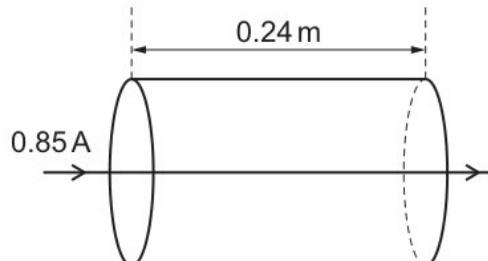
[**5**]

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

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[**6**]

17   a basis for the null space of T .

Wavelength is proportional to amplitude.

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[**3**]

13 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.

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[**2**]

17 the particular solution of the differential equation

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[**3**]

31 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.

Find the values of a and b.

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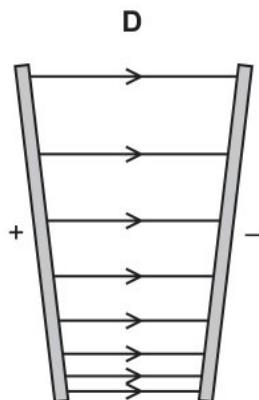
[**10**]

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

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[**10**]

7

D

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

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[5]

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

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[4]

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

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

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

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[5]

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

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[**10**]

15 measurements to be taken,

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[**2**]

13 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.

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[**10**]

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

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

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

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[**8**]
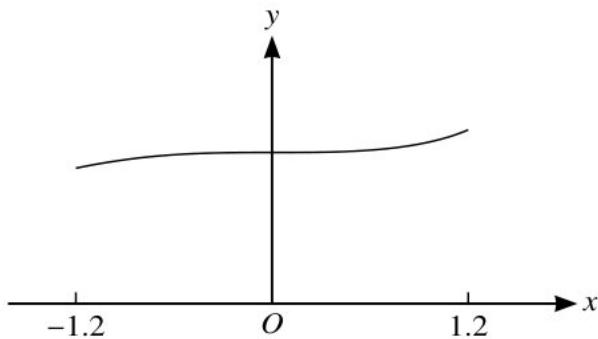
16   particles P and Q are projected vertically upwards from horizontal ground at the same instant. The speeds of projection of P and Q are 12 m s^{-1} and 7 m s^{-1} respectively and the heights of P and Q above the ground, t seconds after projection, are h_P m and h_Q m respectively. Each particle comes to rest on returning to the ground.

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[4]

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

[5]

25   In the case where $k = 1$,

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

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) Use the iterative formula $x_{n+1} = \frac{1}{\sin x_n}$ to determine this root correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

the exact value of a.

Wavelength is proportional to amplitude.

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[8]

(b) 400 nm to 700 nm

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.

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[3]

8 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .

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

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[4]

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

(b) 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]
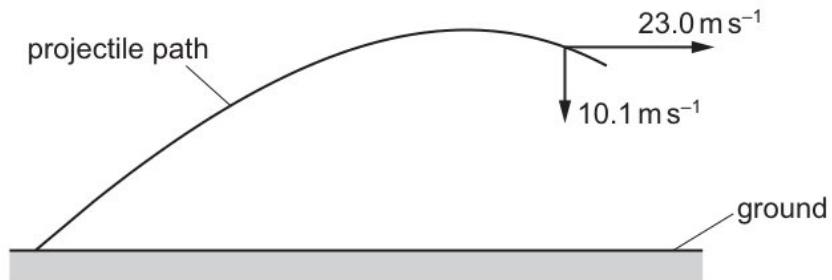
(d) the value of μ.

the coordinates of any stationary points on C.

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[8]

(c) is the reading on the ammeter?

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.

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number made = ... ua **[10]**

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

(a) what is meant by centre of gravity.

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[3]
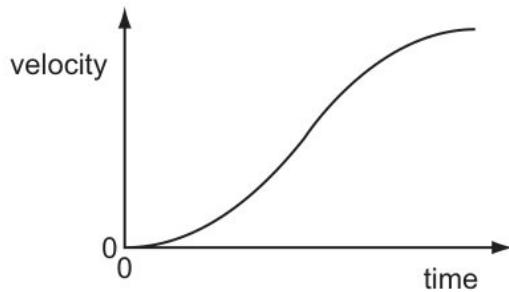
(b) the particular solution of the differential equation

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[6]

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

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[8]

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

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[5]

15   forces, of magnitudes F N, $3F$ N, G N and 50 N , act at a point P, as shown in the diagram.

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

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

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

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

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[8]

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

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[3]

14 equation gives v in terms of A and u ?

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[6]

18 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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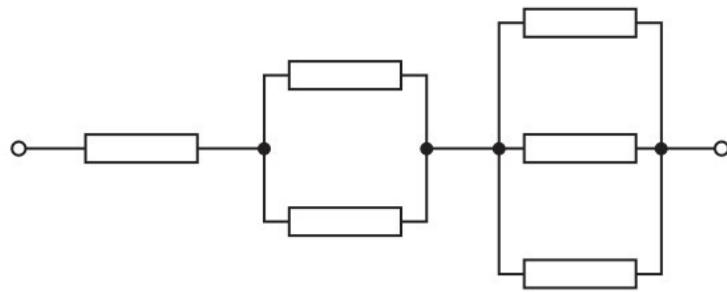
[8]

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

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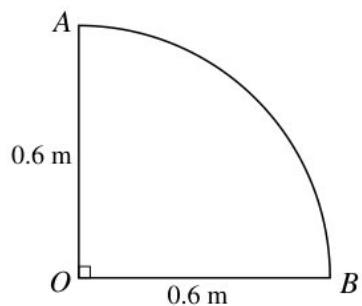
[6]

21

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

the period of small oscillations,

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[4]

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

the term interference.

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[10]

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

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[**6**]

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

(d) only one of the following two alternatives.

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[**5**]

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

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[**15**]

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

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.

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[**2**]

13 (c) marks of the pupils in a Physics examination are summarised as follows.

only one of the following two alternatives.

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[**3**]

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

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[**2**]

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

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[**5**]

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

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

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

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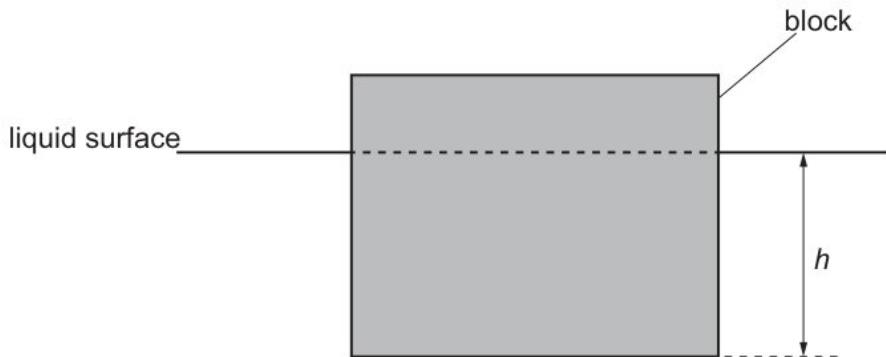
[**5**]

(f) if there are no restrictions,

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[**12**]

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

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[**6**]

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

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

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[**6**]

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

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.

the experimental observations that show radioactive decay is

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

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[3]

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

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[6]

(a) 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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[6]

(e) a positron and a neutrino

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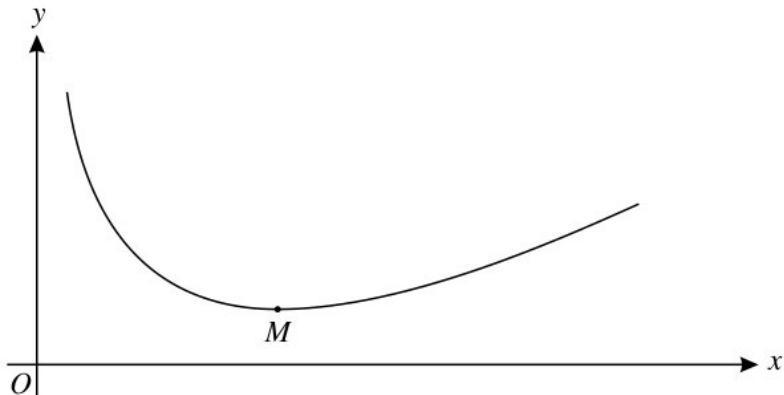
Prove that, for $n \geqslant 2$,

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

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[4]

18

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

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[**5**]

16   the Young modulus.

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[**6**]

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

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

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

Show that the total distance fallen is 1048 m .

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[**4**]

(h) support at end X exerts a force F vertically upwards on the plank.

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[4]

(c) an electron and an antineutrino

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

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[8]

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

the speed of the aeroplane.

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

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.

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

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group = ... rr **[12]**

(a) Find the value of k such that $P(k < X < 610) = 0.3$.

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[4]

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

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[**8**]

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

is the ratio $\frac{\text{tension in wire } X}{\text{tension in wire } Y}$?

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

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[**8**]

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

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[**6**]

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

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diameter = ... ng [**4**]

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

(a) only one of the following two alternatives.

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

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[**10**]

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

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

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[**6**]

9   an electron and a neutrino

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

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faulty = ... hd [**8**]

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

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

(e) Find the angle between the vertical and the side AO of the lamina.

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[**4**]

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

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[**3**]

17 no unique solution.

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

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[**6**]

14 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.

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.

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

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[**4**]

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

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

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

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[**12**]

(e) 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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[**8**]

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

light elastic string of natural length 1.2 m and modulus of elasticity 24 N is attached to fixed points A and B on a smooth horizontal surface, where $AB = 1.2$ m. A particle P is attached to the mid-point of the string. P is projected with speed 0.5 m s^{-1} along the surface in a direction perpendicular to AB (see diagram). P comes to instantaneous rest at a distance 0.25 m from AB.

up the probability distribution table for X.

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[**8**]

(d) all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is 10.3°C.

resistors of equal value are connected as shown.

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[**5**]

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

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[**12**]

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

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

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

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[**10**]

(b) Different isotopic nuclei have different proton numbers.

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[**3**]

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

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zero. = ... vj [**6**]

13   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

to the value α.

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[**5**]

11   that when $t = 0, x = \frac{dx}{dt} = 0$

that $\frac{dy}{dx} = -\sqrt{1 - t^2} + \left(1 - t^2\right) \operatorname{sech}^{-1} t$.

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

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

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

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[**6**]

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

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

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motion moving = ... vz [**12**]
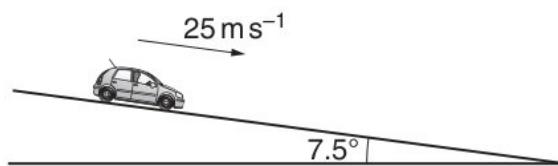
(c) is the grand-daughter product?

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....37..

[**3**]

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

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[**4**]

14

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

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

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from = ... jz [**2**]
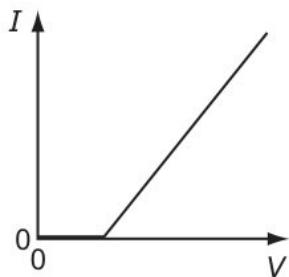
19 $\dfrac{\text{force}}{\text{length} \times \text{speed}}$

The matrix $\mathbf{B}$, where

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[**2**]

13

Form two simultaneous equations and hence find x and v.

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[**6**]

16   your answer correct to 2 decimal places.

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

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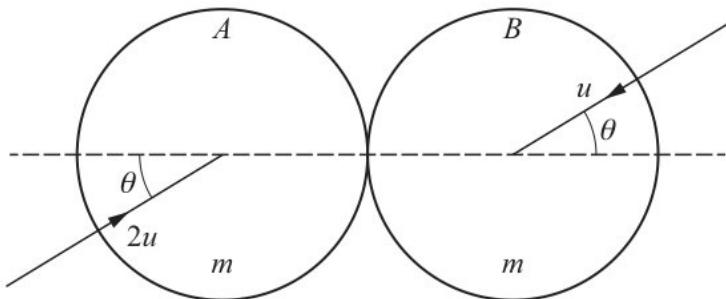
(g) Use the iterative formula $x_{n+1} = \tan^{-1}(x_n + \pi)$ to determine x correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

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[**10**]

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

force is caused only by a pressure difference?
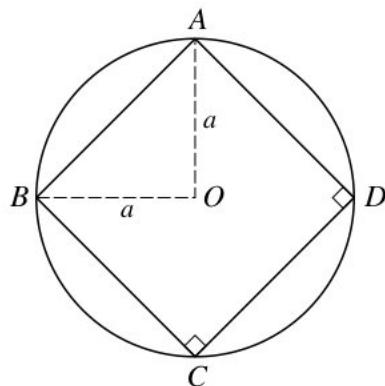
The vector **e** is an eigenvector of the matrix **A**, with corresponding eigenvalue λ, and is also an eigenvector of the matrix **B**, with corresponding eigenvalue μ. Show that **e** is an eigenvector of the matrix **AB** with corresponding eigenvalue $\lambda\mu$.

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[8]

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

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

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

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

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[5]

(d) analysis of the data,

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

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[**6**]

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

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

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

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[**1**]

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

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[**10**]

19 (h) charge of 4.0 C passes through the resistor.

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[**5**]

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

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

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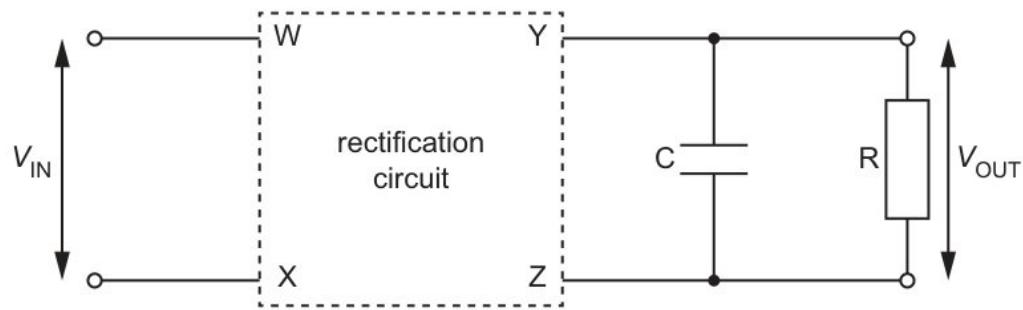
[**5**]

(a) up to antidown

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[**8**]

(b)

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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[**8**]

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

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

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

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.

much energy is stored in the compressed column?

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[3]

18   Prove that, for $n \geqslant 2$,

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[4]

21   obtain the roots of the equation

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[10]

10   Find the position vector of D.
     the graph of $y = \mathrm{f}(x)$,

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[4]

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

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where $= \ .... \ gh$ **[6]**

19   many images of the slit does he see?

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[12]

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

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[5]

7   copper wire is 6.4 m long and has a resistance of $0.92\,\Omega$.

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

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[2]

13   which mark on the rule must a 50 g mass be suspended so that the rule balances?

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

(a)

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

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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[5]

(f) Find the deceleration of the tractor at the instant it begins to climb the hill.

4 astronauts are chosen from a certain number of candidates. If order of choosing is not taken into account, the number of ways the astronauts can be chosen is 3876 . How many ways are there if order of choosing is taken into account?

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[20]
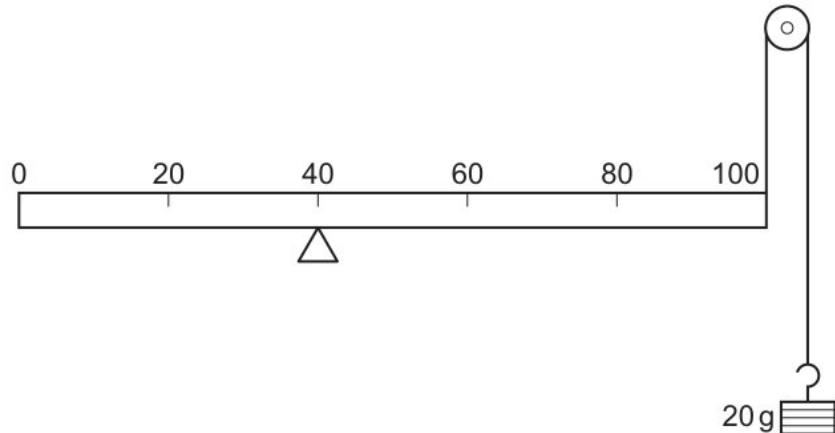
16   the general solution of the differential equation

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

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[6]

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

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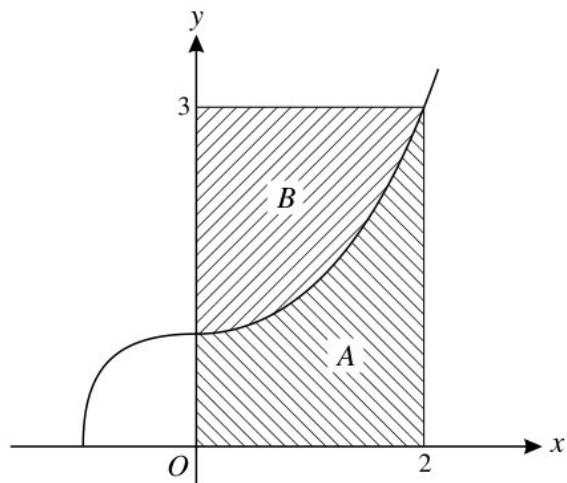
[3]

12   The waves must have equal amplitudes.

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[12]

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

Show that $b = 1 - a$.

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

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

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

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[10]

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

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

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.

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

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standard 59.1 days = ... li **[3]**

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

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value = ... md **[4]**

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

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[10]

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

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

(a) the general solution of the differential equation

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[4]

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

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[**6**]

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

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[**15**]

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

is the horizontal force exerted by the wall on r r Y ?

displacement $=$ velocity $\times$ time

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[4]

21 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.

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

(a) procedure to be followed,

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[**4**]

(b) 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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lines = ... qn [**6**]

(d) control of variables,

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[**6**]

(c) the probability generating functions, $G_X(t)$ of X and $G_Y(t)$ of Y.

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

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[**4**]

50

29   student wishes to investigate projectile motion.

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[**8**]

15   (d)

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

eigenvalues $1, -1$ and -2 .

Find the tension in the string in terms of W.

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[**5**]

(c)   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**]

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

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

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[**5**]

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

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

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

Page 50

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

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[12]

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

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[10]

13   The matrix **B**, where

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[3]

21   quantities would be measured in order to determine E ?

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[2]

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

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[4]

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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted
$$\log_2(x+5) = 5 - \log_2 x$$

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

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[5]

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

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binomial = ... am **[6]**

(a) 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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[12]

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

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

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.

(b) 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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these = ... *sl* [**8**]

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

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

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[**6**]

(d) 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.

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 $\omega \mathrm{rads}^{-1}$ about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

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[**10**]

9 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.

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

(b) Find a vector equation for the line of intersection of the planes.

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[**10**]

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

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[**10**]

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

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

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

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[**10**]

11   Find the value of I_2.

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[**4**]
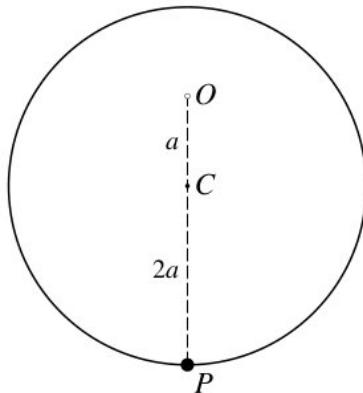
26 8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, dx$ for $n > 0$.

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

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[**8**]

25

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

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

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Find revolution = ... *da* [**5**]

12 constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135$ mm s^{-1}.

Find the area of the region enclosed by C.

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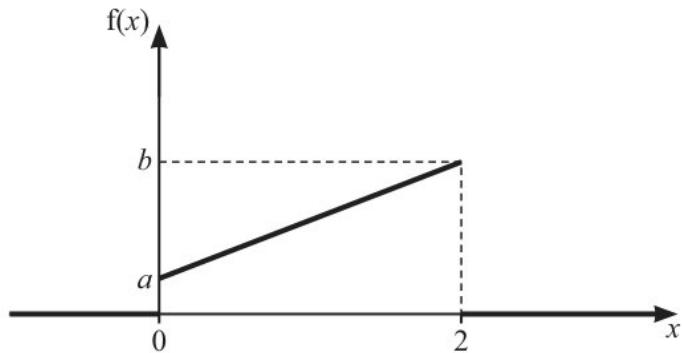
[**3**]

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

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exact value places. = ... yk **[15]**

7   the SI base units of resistivity.

(c) Show that the cartesian equation of C is
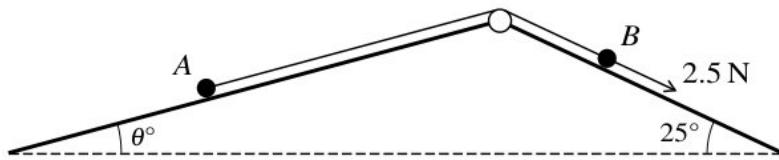
polynomial $3x^3 + pax^2 + 7a^2x + qa^3$ is denoted by f(x) where p, q and a are constants and $a \neq 0$

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[8]

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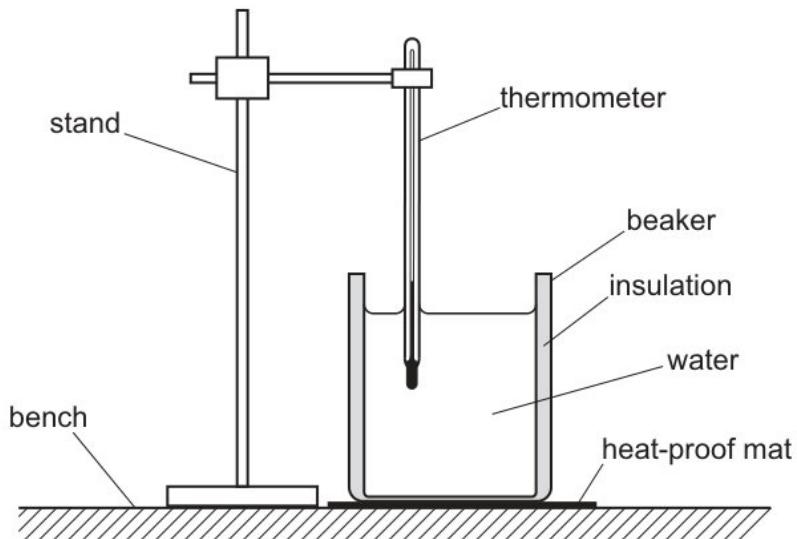
is suggested that these results are consistent with a distribution having probability density function f given by

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[3]

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

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[5]

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

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[6]

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

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Find curve your $=$ .... it [2]

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

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[**3**]

12 particle P of mass 0.2 kg is released from rest at a point O on a smooth horizontal surface. A horizontal force of magnitude te^{-v} N directed away from O acts on P, where v m s^{-1} is the velocity of P at time t s after release. Find the velocity of P when $t = 2$.

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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[**15**]

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

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[**10**]

16 is the reading on the ammeter?

random variable X has the distribution Po(1.5).

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[**5**]

23   battery is marked 9.0 V .

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$[\mathbf{5}]$

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

line l passes through B and C.
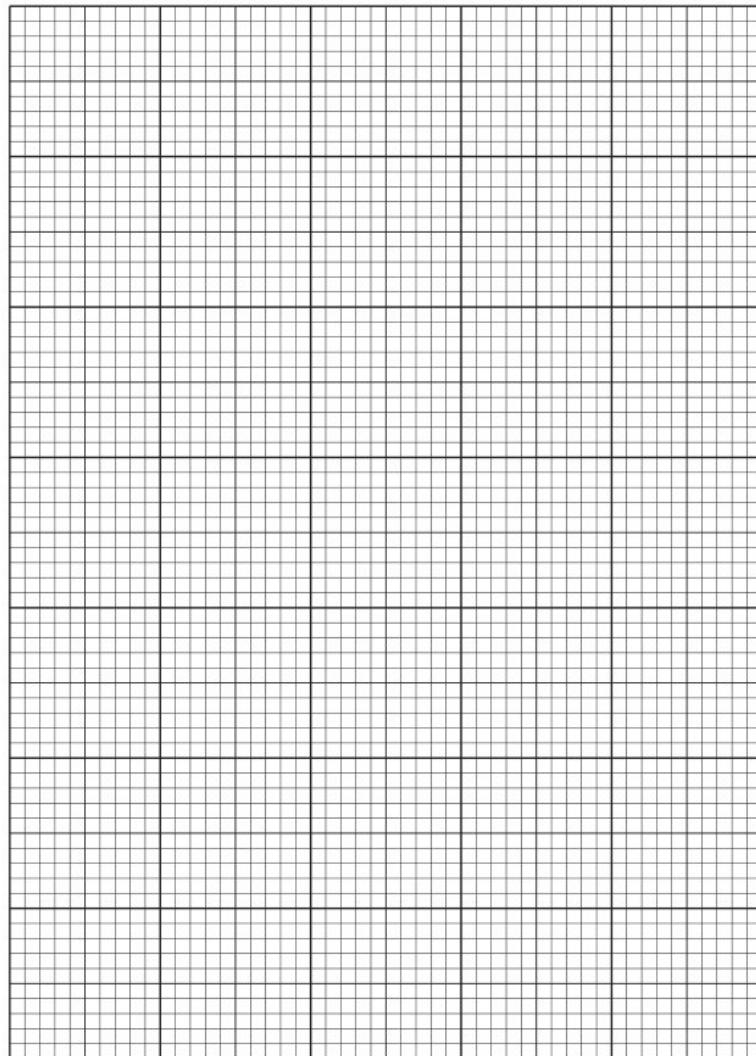
that for $n \geqslant 2, \quad I_n = -1 + n(n-1)I_{n-2}$

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

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$[\mathbf{5}]$

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

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

Calculate the speed of the star relative to the Earth.

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[4]

13   random variables X and Y have the independent distributions N(44, 16) and N(30, 9) respectively.

Show that, for $n > 2$,

1.26   1.24   1.17   1.23   1.18   1.25   1.19   1.20   1.21   1.18

eigenvalues $1, -1$ and -2 .

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

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[**5**]

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

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loudspeaker $= .....\ lp$ [**5**]

19 the value of $\frac{\mathrm{d}y}{\mathrm{d}x}$ at P,

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[**5**]

14 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.

(b) Calculate the length AG.

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

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[**6**]

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

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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[**6**]

(e) In the case where $k = 2$,

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[**4**]
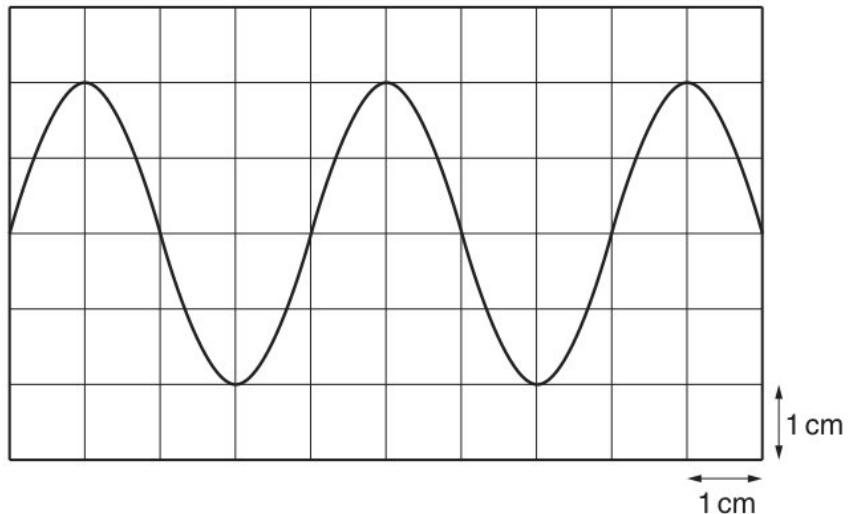
15 sample has an activity of 180 Bq at time $t = 0$.

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[**3**]

13 a, b and c are integers to be determined.

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

1 cm

1 cm

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[4]

(a) find corresponding eigenvectors.

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

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[8]

(d) curve C with equation

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

64

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

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      ....
                                                                                                    [6]

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

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

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                                                                                                    [6]

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

      (d) the probability density function of Y,

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                                                                                                    [8]

      (a) Find the value of I_2.

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

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                                                                                                    [8]

(c) 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 x-coordinate of M.

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[**12**]

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

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[**10**]

(b) down to up

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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[**12**]

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

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

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[**6**]

(i) be written as a quadratic equation in x.

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[6]

16 many images of the slit does he see?

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through = ... ey [15]

9 continuous random variable X has probability density function f given by

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[5]

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

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

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[6]

17 the distance AC.

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[5]

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

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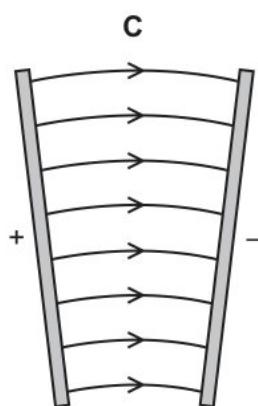
[15]

14 State the name of this type of reaction.

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showing $=$ ..... mv **[6]**

24 is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m. Calculate the acceleration of P when it is at instantaneous rest and $x > 0$.

(d) the term interference.

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[12]

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

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[4]

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

Find the area of the triangle ABC.

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[5]

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

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

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

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[12]

(b) anywhere between point R and point S

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

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[5]

36 Find the cartesian equation of Π_1.

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.

(c) 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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[4]

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

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[3]

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

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[15]

18 point D is the reflection of A in l.

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

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[3]

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

(c) why Kieran is incorrect.

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[2]

(b)

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

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[5]

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

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[12]

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

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[5]
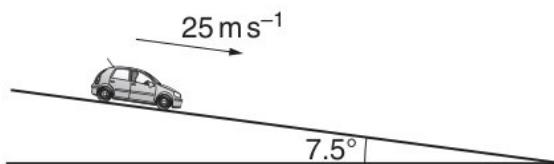
9   Show that $\cos\theta = \frac{2}{3}$.

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[**3**]

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

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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[**15**]

23 single change would double the value of this ratio?

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

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[**3**]

(b) the equation representing this decay.

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

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[**6**]

(d) 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.

Show that the cartesian equation of C is

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[**5**]

11 eigenvectors $\begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$. Find the eigenvalues of the matrix $\mathbf{AB}$, and state corresponding eigenvectors.

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.

one similarity and one difference between an electron and positron.

Find the value of I_2.

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

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

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[**6**]

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

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[**20**]

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

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

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

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[**15**]

(h) activity of a radioactive sample.

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[**5**]

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

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[**10**]

24 which mark on the rule must a 50 g mass be suspended so that the rule balances?

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

student investigates the cooling of a liquid in a beaker.

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[**5**]

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

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

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[**12**]

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

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[**8**]

24 (b) Carry out the test.

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

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[**6**]

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

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Fig. currents $= ....$ gd [**8**]

(d) 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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[**20**]

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

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[**10**]

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

measuring instrument should be used?

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

There will always be 9.0 V across the battery terminals.

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[**5**]

11 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}.

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[**4**]

25 any assumption that you make, test at the 10% significance level whether the greengrocer's claim is supported by this evidence.

(b) 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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survey. = ... sk [**12**]

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

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.

$$\mathbf{A} = \begin{pmatrix} \frac{3}{2} & 3 & 8 \\ 0 & 3 & 4 \\ 0 & 0 & -1 \end{pmatrix}.$$

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[**5**]

(d) diagram shows the electric field between the plates?

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[**3**]

16   is the angle θ ?

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[**12**]

18   a, b and c are integers to be determined.

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[**5**]

27   is the magnitude of F when the child stands at X and when the child stands at Y ?
is given that
monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.
thermistor is connected to a cell with negligible internal resistance.

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[**8**]

16   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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…………………………………………………………………………………………
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…………………………………………………………………………………………

[**6**]

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

(b) t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the
temperature θ_R of the laboratory is measured using a thermometer.
$\mathrm{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant
State one other feature of this orbit.

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[**8**]
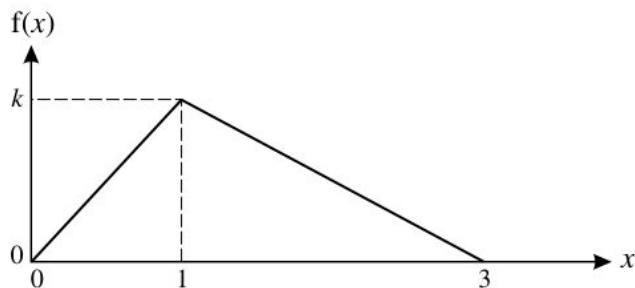
(e) Nucleus X undergoes β^- decay to form nucleus Z.

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

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[**6**]

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

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[**3**]

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

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

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[**4**]

(c) all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is 10.3°C.

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[**6**]

(g) that $v = y^3$, show that

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[**6**]

(a) Find the value of I_2.

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[**8**]

7   car of mass 1400 kg is travelling on a straight, horizontal road at a constant speed of 25 m s^{-1}. The output power from the car's engine is 30 kW .

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

diagram correctly represents the forces acting at point P ?

Find the angle that this tangent makes with the x-axis.

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[**6**]

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

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

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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[**4**]

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

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[8]

23 Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

the time taken for the ball to reach its maximum height

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

Find the values of F and θ.

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[6]

18 Deduce that the cartesian equation of C is

the probability density function of Y,

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[6]

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

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[6]

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

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

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

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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[**8**]

14 curves C_1 and C_2 have polar equations

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

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[**12**]

19 6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

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

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[**5**]

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

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[**3**]

17   Find the values of p and q.

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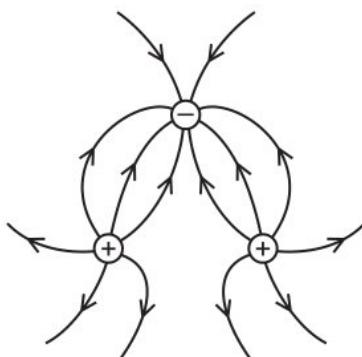
the probability that fewer than 6 rolls of this dice are required to obtain an A .

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

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minutes, test = ... xb [**5**]

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

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

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[**12**]

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

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

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These = ... dq [**6**]

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

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

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[**4**]

8 Show that, for $n > 2$,

the coordinates of any stationary points on C

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

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

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[**6**]

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

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[**4**]

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

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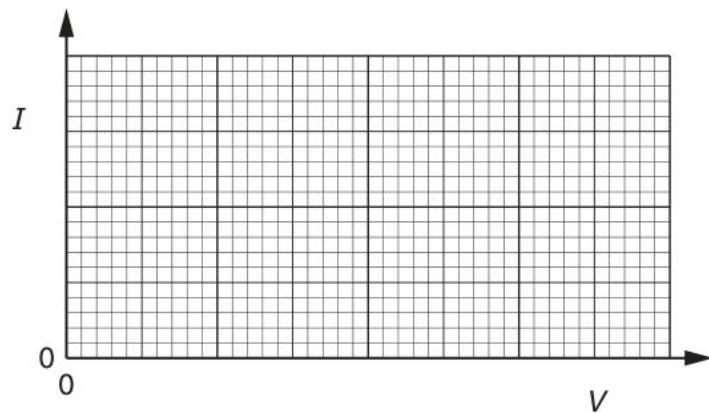
that mean = ... uy [**10**]

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

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circle particle = ... ez **[2]**

(a)

identical uniform smooth spheres A and B, each with mass m, are moving on a horizontal surface with speeds $2u$ and u respectively when they collide. Immediately before the collision, the spheres are moving parallel to each other in opposite directions such that their directions of motion each make an angle θ with the line of centres (see diagram). As a result of the collision, B moves in a direction which is perpendicular to its initial direction of motion. The coefficient of restitution between the spheres is e.

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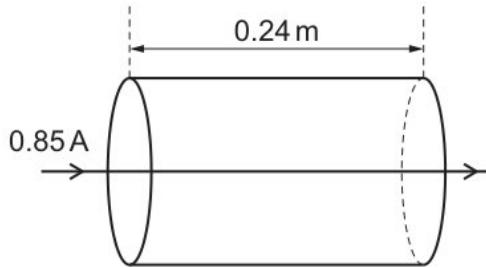
[12]

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

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[5]

22

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

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[15]

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

variables x and y satisfy the differential equation

1.1 shows a thin coil of cross-sectional area A and length l connected to a resistor of resistance S and two terminals.

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

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factor = ... qn **[8]**

(b) to the value α.

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[5]

10   4 astronauts are chosen from a certain number of candidates. If order of choosing is not
      taken into account, the number of ways the astronauts can be chosen is 3876 . How many
      ways are there if order of choosing is taken into account?

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                                                                                                    [5]

16   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.

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

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                                                                        particle = ... pl **[6]**

      (e) exactly at point T

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                                                                                                    [6]

      (c) 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.

           magnetic flux density.

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

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                                                                                                    [3]

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

(c) 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.

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[6]

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

6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.
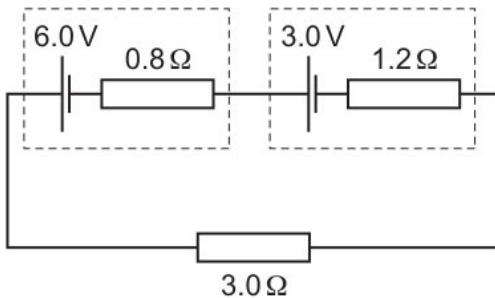
a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1}.

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[4]

21 by calculation that $0.9 < a < 0.95$.

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

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.

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

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

the equation representing this decay.

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

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radius system = ... *oa*   [**8**]

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

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

the value of $\frac{dy}{dx}$ at P,

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[**6**]

18   why Kieran is incorrect.

B contains 5 red marbles and 3 blue marbles.

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[**5**]

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

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[**3**]

19 Find the exact value of the arc length of C.

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[5]

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

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[6]

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

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

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[1]

(a) student investigates an electrical circuit.

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

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[6]

(e) P hears a sound of increasing frequency.

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[**6**]

(c) flows out of a pipe and hits a wall.

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[**6**]

25 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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[**8**]

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

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

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[**1**]

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

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.

the exact volume of the solid generated

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[6]

(c) find corresponding eigenvectors.

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[4]

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

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

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Young = ... ya **[12]**

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

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

the exact solutions of the equation $f(x) = 1$.

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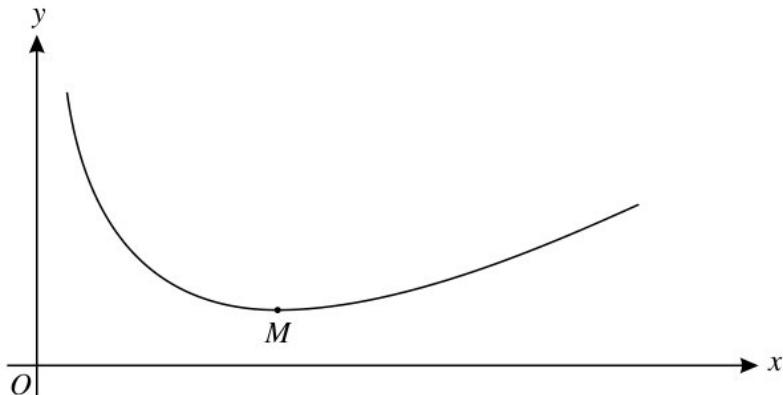
[6]

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

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[**8**]

17

the value of θ.

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

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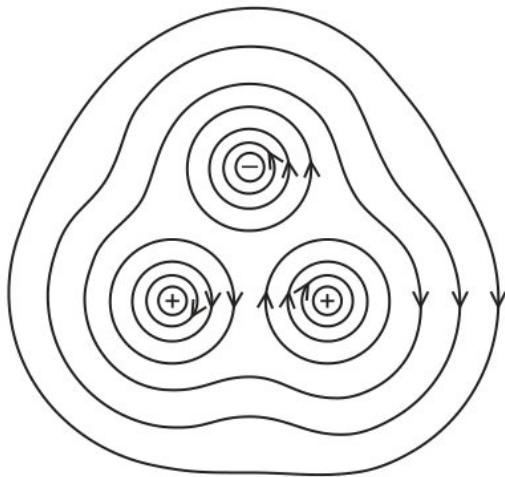
[**6**]

10   matrix **A** is given by

[**5**]

93

13 marks of the pupils in a certain class in a History examination are as follows.

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

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

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[**5**]

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

the probability of a Type II error.

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[**6**]

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

(d) student is being weighed. The student, of weight W, stands 0.30 m from end A of a uniform plank AB , as shown in Fig. 3.1.

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

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

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[**3**]

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

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

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 .

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[**10**]

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

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[**2**]

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

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

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[**6**]

17 Find the cartesian equation of Π_2.

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

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[2]

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

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[8]

7 P and Q collide and stick together.

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[2]

19 the particular solution of the differential equation

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[4]

22 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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[**2**]

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

(a) find corresponding eigenvectors.

process does not require energy to be supplied?

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

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trees = ... ip [**20**]

(c) Find the rank of **A** and show that $\left\{ \begin{pmatrix} 2 \\ 2 \\ -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 3 \\ 0 \\ 1 \end{pmatrix} \right\}$ is a basis for the null space

of the transformation.

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[**12**]

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

be written as a quadratic equation in x.

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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[**3**]

(f) the exact value of a.

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

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

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[**15**]

14   For boys aged 16 years in Jimpuri, 25% have a weight between 65 kilograms and k kilograms, where k is greater than 65 . Find k.

an electron and an antineutrino

the characteristic equation of **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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[**6**]

34   a, b and c are integers to be determined.

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finding = ... qe [**15**]

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

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[**5**]

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

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

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

the solution of the differential equation

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ground = ... cz [**3**]
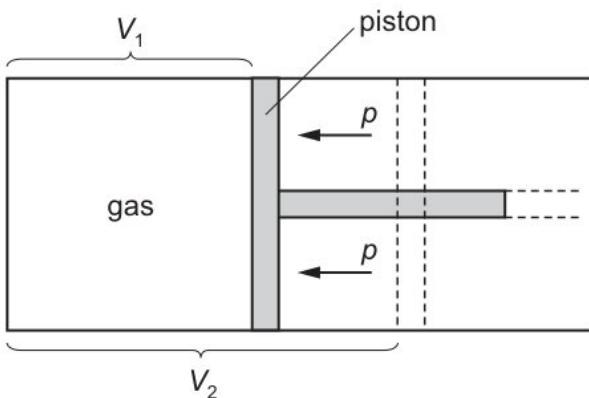
14 does this mean?

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[**6**]

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

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[**4**]

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

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

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[5]

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

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[8]

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

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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[6]

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

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

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

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shows $= $ ...... yb **[6]**

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

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[8]

(d) a normal distribution, calculate a 95% confidence interval for the population mean. Find the probability density function of Y.

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

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[8]

13   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.

(a) 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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[3]

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

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[**3**]

8 all solutions in the interval $0° \leqslant \theta \leqslant 180°$.

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[**5**]

12 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.

supermarket is open 7 days a week.

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……………………………………………………………………………………………

[**12**]

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

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

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[**5**]

15 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.

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

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

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ramp = ... *en* [**8**]

12 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).

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.

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

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[**4**]

(b) 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.

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[**1**]

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

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

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

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[**3**]

(a) only one of the following two alternatives.

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[**6**]

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

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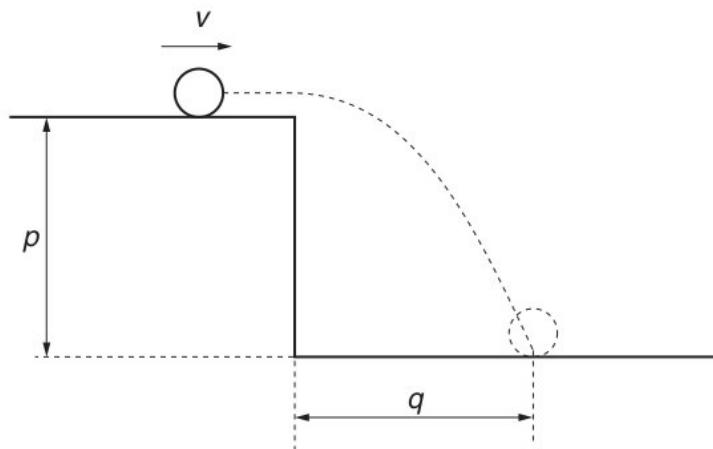
[**4**]

30   Find the speed of P when it passes through L.

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[**4**]

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

Find a set of corresponding eigenvectors.

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[5]

7

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

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

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

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[2]

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

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

four graphs represent a progressive wave on a stretched string. Graphs $\mathbf{A}$ and $\mathbf{B}$ show how the displacement d varies with distance x along the string at one instant. Graphs $\mathbf{C}$ and $\mathbf{D}$ show how the displacement d varies with time t at a particular value of x.

Show that $m = 0.9$.

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[**8**]

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

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

Find the probability density function of Y.

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[**4**]

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

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

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

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[**4**]

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

$$(x+1)\frac{\mathrm{d}y}{\mathrm{d}x} = y(x+2)$$

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

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[10]

21 many different colour arrangements are there of the 10 books?

the probability that the mass of pasta in a randomly chosen large bag is less than 2.65 kg .

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

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[3]

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

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[8]

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

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[10]

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

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[5]

14   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.

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

a result of the collision, A moves in a direction which is perpendicular to the line of centres.

(b) wavelength of light is 550 nm .

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[3]

(d) what is meant by the accuracy of a measured value.

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[6]

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

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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that radius = ... rc **[20]**

108

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

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Show = ... yt [**4**]

19   amplitude $\propto$ (intensity)^2

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

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

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

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[**10**]

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

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[**2**]

22   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.

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[**15**]

Page 108

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

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

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[**12**]

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

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[**6**]

23 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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[**5**]