

22 $\sum_{r=1}^n (4r - 3)(4r + 1)$, giving your answer in its simplest form.

matrix \mathbf{A} , given by

quartile: 28, Median: 39, Upper quartile: 67.

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

Show that the cartesian equation of C is

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[10]

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

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[3]

- (b) (iii) Find the solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}$ of the form $\mathbf{x} = \begin{pmatrix} 4 \\ 9 \\ \alpha \\ \beta \end{pmatrix}$, where

α and β are positive integers to be found.

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

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

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[3]

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

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

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

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[15]

- (e) (iv) if there are no restrictions,

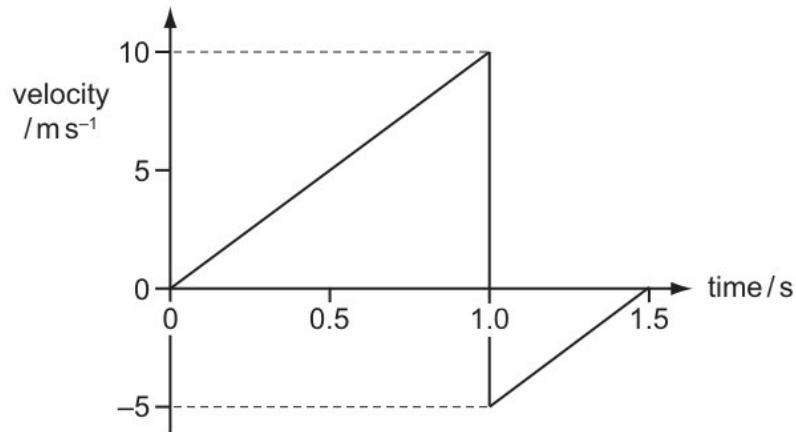
Calculate the greatest deceleration of P .

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

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[8]

(i)



the value of x .

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[10]

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

the exact value of I_2

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[6]

- (iii) parametric equations of a curve are

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

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[6]

- 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.

- (c) (i) \mathbf{A}^{2n} , where n is a positive integer.

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

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[12]

- (ii) 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.

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

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[6]

- (iii) Calculate the speed of projection of P .

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

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

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[8]

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

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

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[5]

- (i) diagram shows two waves R and S .

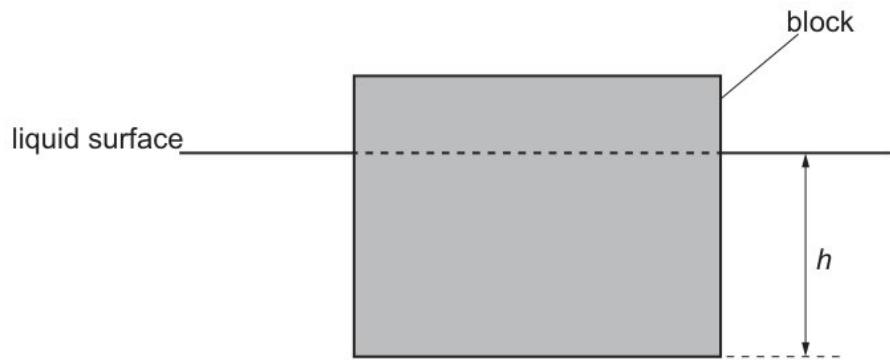
curve C has equation

student investigates the cooling of a liquid in a beaker.

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[8]

(d) (iii)



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

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given = gd [6]

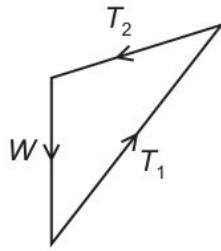
- (i) Find the total distance travelled by the particle in the first 10 seconds of motion.
 are the weight and the mass of the body when it is on the Moon?
 is meant by elastic deformation?
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[5]

- (ii) that, for $n \geq 2$, $I_n = -1 + n(n - 1)I_{n-2}$.
 random variable Y is defined by $Y = X^3$. Find
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inner = xz [5]

11 should pay particular attention to



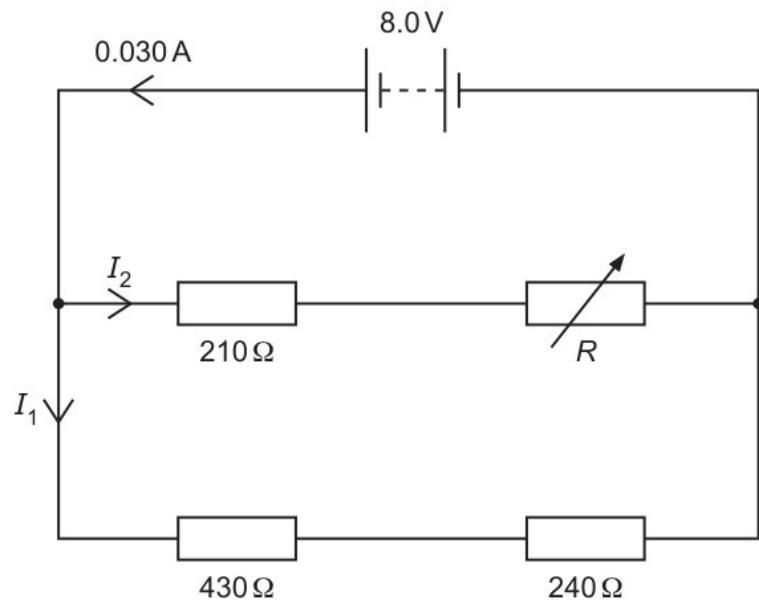
- (a) (ii) potential difference across a resistor is 12 V . The current in the resistor is 2.0 A .

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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[8]

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



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[5]

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

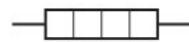
Show that the length of the arc of C from the pole to the point furthest from the pole is given by

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distance = sd [3]

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

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



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[5]

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

an electron and a neutrino

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point = ob [5]

- (i) then it converges to a .

are speed v_1 and speed v_2 ?

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

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[6]

- 14 Draw up a probability distribution table for X .

The orbit has a period of 25 hours.

P and Q form an isolated system.

- (b) (iii) student investigates the cooling of a liquid in a beaker.

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

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[8]

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

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

- coming to rest instantaneously on hitting the ground.

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[6]

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

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

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[5]

- (c) (iv) Show that $b = 1 - a$.

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

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[6]

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

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]

- (iii) The curve C has equation $y = \sec^3 x$ for $0 \leq x \leq \frac{1}{4}\pi$. The region R is bounded by C , the x -axis, the y -axis and the line $x = \frac{1}{4}\pi$. Find the volume of revolution generated when R is rotated through 2π radians about the x -axis.

the term elastic limit.

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[5]

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

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

variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.

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[6]

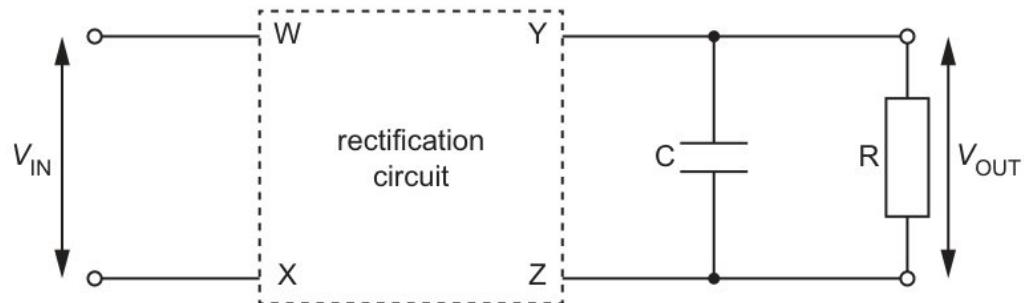
- (iv) diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

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

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[6]

- 21 (a) 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.



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

- (i) the surface area generated when C is rotated through 2π radians about the x -axis.
statement about light waves and sound waves is correct?

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[4]

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

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

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point instant = ji [2]

- (d) Find the mean age of all 19 people.

- (iii) data give a pooled estimate of 10 for σ^2 . Find N .

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show show = rd [5]

- (ii) temperature θ_R of the laboratory is measured using a thermometer.

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[5]

- (b) 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.

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

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with = gv [20]

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

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[5]

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

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[5]

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

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

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[3]

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

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

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[6]

- (b) the values of a, b, x and y .

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

the rank of the matrix

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

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taken more = og [5]

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

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metal = kn [6]

- (d) is the charge, in terms of the elementary charge e , on a charm quark?

Find the standard deviation of the weights of the letters.

- (i) Wavelength is proportional to amplitude.

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[5]

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

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[5]

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

that $\frac{dy}{dx} = \frac{y^2 - ye^x}{xe^x + 2y}$.

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[3]

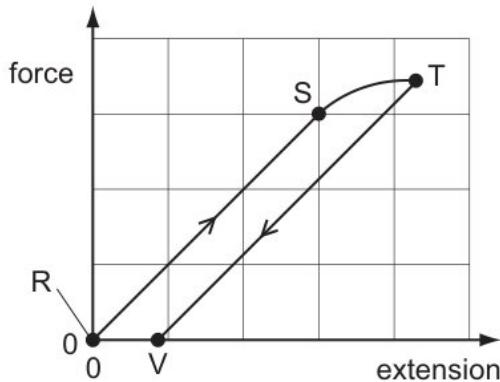
- (vii) the tension in the string and the acceleration of the particles.

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[20]

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

- (iv) Given that $F = 0$, $G = 75$ and $\alpha = 60^\circ$, find the magnitude and direction of the resultant force.



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[2]

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

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[6]

- (iii) 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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[5]

- 10 that for $n \geq 2$, $I_n = -1 + n(n - 1)I_{n-2}$
 sample has an activity of 180 Bq at time $t = 0$.
 for $0^\circ \leq \theta \leq 180^\circ$ the equation $\sin^2 2\theta (\cosec^2 \theta - \sec^2 \theta) = 3$,

- (d) (i) a butternut squash seed is sown the probability that it will germinate is 0.86 , independently of any other seeds. A market gardener sows 250 of these seeds. Use a suitable approximation to find the probability that more than 210 germinate.

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

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[6]

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

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

The orbit has a period of 25 hours.

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[8]

- (b) (ii) is the mass of the car?

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

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[6]

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

The weight of the plank is causing a clockwise moment.

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[3]

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

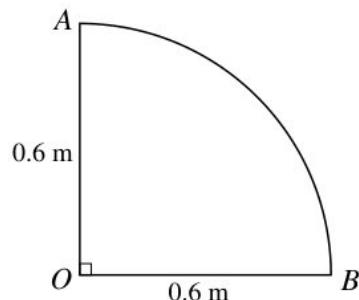
$$\text{that } \frac{d}{dt} (\operatorname{sech}^{-1} t) = -\frac{1}{t\sqrt{1-t^2}}.$$

Find the product moment correlation coefficient for the data.

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[12]

(c) (v)

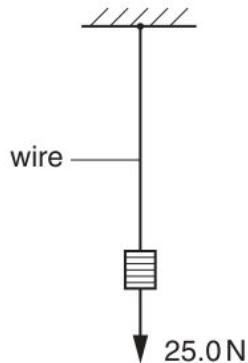


the speed of the body is increased to 40 ms^{-1} , what is its new kinetic energy?

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[6]

- (i) would this object weigh on Pluto?

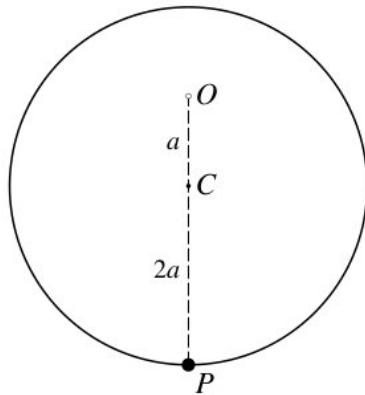


[10]

- 17 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.

$$\frac{\text{force}}{\text{length} \times \text{time}}$$

- (d) (iv) a set of 40 values of x , it is found that



[5]

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

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

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

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[6]

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

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

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[10]

- (c) (iii) vertical and horizontal gridlines have a spacing of 1.0 cm. The voltage scaling is 4 V cm⁻¹ and the time scaling is 5 ms cm⁻¹.

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

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[5]

- (ii) Hence show that the differential equation

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

find the position vectors of P and Q .

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closest = au [2]

- (b) (iii) Velocity is proportional to wavelength.

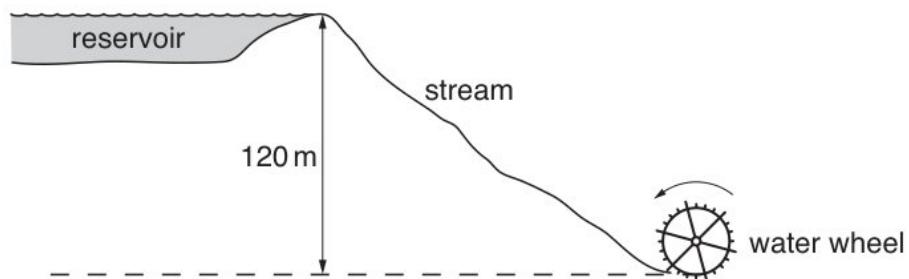
The vector \mathbf{e} is an eigenvector of the matrix \mathbf{A} , with corresponding eigenvalue λ , and is also an eigenvector of the matrix \mathbf{B} , with corresponding eigenvalue μ . Show that \mathbf{e} is an eigenvector of the matrix \mathbf{AB} with corresponding eigenvalue $\lambda\mu$.

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

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[5]

(ii)



particles P , Q and R , of masses 0.6 kg, 0.4 kg and 0.8 kg respectively, are at rest in a straight line on a smooth horizontal plane. The distance from P to Q is 3 m, and the distance from Q to R is also 3 m (see diagram). P is projected directly towards Q with speed 3 ms^{-1} . After P and Q collide, P continues to move in the same direction with speed 1.5 m s^{-1} .

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sphere = qw [6]

8 points A, B, C have position vectors

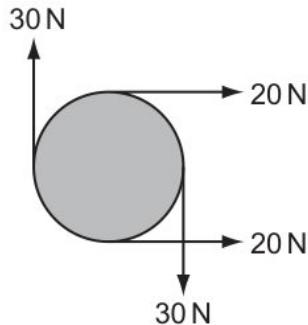
the term ultimate tensile stress.

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

curve C has equation

(f) (i) show that $PQ = 13$,

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



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[6]

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

Deduce that the cartesian equation of C is

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[6]

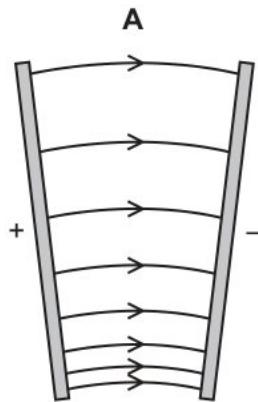
(iii) constant a is such that $\int_1^a 6x \ln x \, dx = 4$

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

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[8]

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



the exact value of a .

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[4]

- (a) (iv) 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.

activity of a radioactive sample.

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force = ne [8]

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

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

the probability of a Type I error.

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[3]

- (d) (iv) a laboratory experiment to determine the absorption coefficient of glass. You should

Calculate the length AG .

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[5]

- (ii) the speed of Q after the collision.

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

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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[6]

- 18 The waves must not be polarised.

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

- (b) (v) that $E(X) = \frac{47}{60}$, find $\text{Var}(X)$.

Find the interquartile range of X .

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[4]

- (ii) continuous random variable X has probability density function f given by
 pendulum bob is held stationary by a horizontal force H . The three forces acting on the bob are shown in the diagram.

$$\frac{d^2x}{dt^2} + \frac{dx}{dt} - 2x = 2t^2 + t - 1,$$

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[6]

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

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

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[6]

(i)



B contains 5 red marbles and 3 blue marbles.

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[10]

(f) (v)

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

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

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[5]

- (iii) The battery supplies 9.0 J to an external circuit for each coulomb of charge.
 the probability that both marbles chosen are the same colour.

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[5]

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

- (b) (v) Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

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

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

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[6]

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

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

the equation representing this decay.

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[6]

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

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

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[4]

- (ii) P and Q collide and stick together.

Show that the cartesian equation of C is

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[4]

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

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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[5]

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

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

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[12]

- (iii) solid plastic cylinder floats in water. It is used to support one end of a horizontal uniform beam AB as shown in Fig. 2.1.

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

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[8]

- 17 activity of a radioactive sample.

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

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

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[5]

- (iii) Amplitude is inversely proportional to velocity.

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.

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

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[15]

- (i) the inequality $3x - 1 < |2x - 3|$.

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

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[4]

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

B now strikes a wall that is perpendicular to its path, rebounds and collides with A again. The coefficient of restitution between B and the wall is e . Given that the second collision between A and B brings A to rest, find e .

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[6]

- (i) Find the exact coordinates of this point.

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

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[3]

- (vi) 1 and 2 only

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

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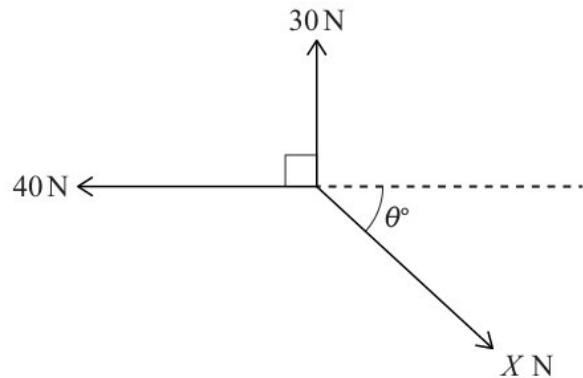
[6]

- 14 is given that a is a positive constant such that
activity of a radioactive sample.

- (a) (iii) Find the area of the triangle ABC .
your answer correct to 2 decimal places.
-
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.....

[15]

(ii)



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

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

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[6]

- (c) (iv) function f is such that $f(x) = 3 - 4 \cos^k x$, for $0 \leq x \leq \pi$, where k is a constant.
that the forces are in equilibrium, find the values of θ and X .

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[8]

- (ii) 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.
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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[6]

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

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

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[4]

- (b)(vii) variables x and y satisfy the differential equation

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

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

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random Kieran's = no [5]

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

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

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[8]

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

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

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[4]

(d) (iii) variation with time of the velocity, in cms^{-1} , of the car is shown.

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

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[8]

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

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

.....

[5]

- 6 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.

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

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

is the grand-daughter product?

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[3]

- (c) the speed of the aeroplane.

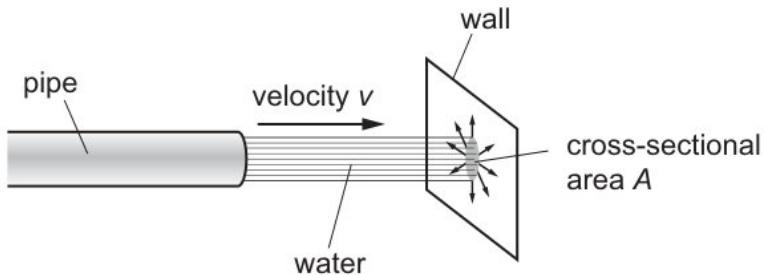
The matrix \mathbf{B} , where

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

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[8]

- (a) Find, showing all necessary working, the equation of the regression line of y on x .
 stationary nucleus has nucleon number A .



.....

[4]

- (vi) (e) only one of the following two alternatives.

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

.....

[6]

- (a) Bag 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.

random variable T has probability density function given by

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[3]

- (b) Hence show that the differential equation
is the speed of the block at the bottom of the slope?

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[5]

- (iii) (c) Find the initial speed and the angle of projection of B .
the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

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[3]

- (a) curve C has polar equation $r = \theta e^{\frac{1}{8}\theta}$, for $0 \leq \theta \leq 2\pi$.
first, second and third terms of a geometric progression are $2k + 3$, $k + 6$ and k , respectively. Given that all the terms of the geometric progression are positive, calculate

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[5]

- (d) 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.

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

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[5]

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

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

.....

[8]

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

- (a) (ii) the general solution of the differential equation

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.

is the value of R ?

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[2]

- (vi) 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.

only one of the following two alternatives.

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

.....

vector eigenvalue matrix = cu [5]

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

Prove that $\sin^2 2\theta (\cosec^2 \theta - \sec^2 \theta) \equiv 4 \cos 2\theta$.

.....

small = gp [4]

- (vi) Find the exact value of the arc length of C .

curve C has equation

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

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[6]

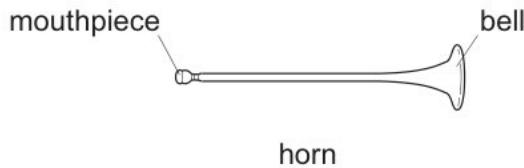
- (ii) Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.

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

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[15]

- 13 with a reason, whether f has an inverse.



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

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

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

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

There will always be 9.0 V across the battery terminals.

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$$\text{iron diameter} = \dots \dots bx \quad [6]$$

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

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

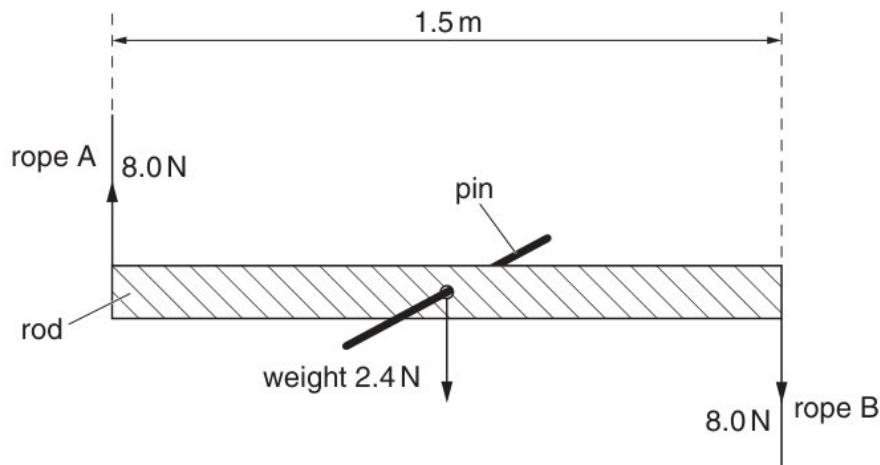
lamina is freely suspended at A and hangs in equilibrium.

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[6]

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

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



[4]

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

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

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[6]

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

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

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

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

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[8]

(iv)

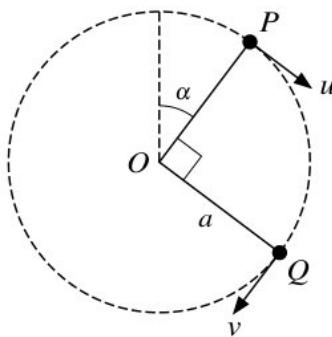


diagram shows four forces applied to a circular object.

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[5]

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

the acute angle between the planes ABC and ABD .

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[12]

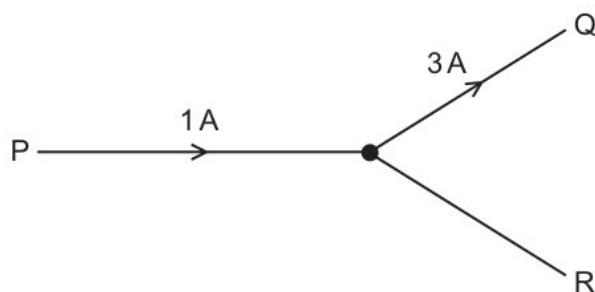
- (vi) Find the arc length of C between the point where $\theta = 0$ and the point where $\theta = \frac{1}{3}\pi$.

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

.....

[15]

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



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[3]

- (ii) the point $(2, \frac{1}{2}\pi)$.

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

.....

[15]

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

- (b) (ii) 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 .

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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[1]

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

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

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

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[5]

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

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

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

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[4]

- (iii) particle oscillates in simple harmonic motion with centre O . When its distance from O is 3 m its speed is 16 m s^{-1} , and when its distance from O is 4 m its speed is 12 m s^{-1} . Find the period and amplitude of the motion.

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

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election = se [20]

- (i) 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 .

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

.....

[4]

- (c) (iii) that for $n \geq 2$, $I_n = -1 + n(n-1)I_{n-2}$

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

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[4]

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

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

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[2]

- (i) the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

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

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[6]

- 8 sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a curve C has equation $x^3 - 3xy + y^2 = 4$. Find the value of $\frac{d^2y}{dx^2}$ at the point $(0, 2)$ of C .

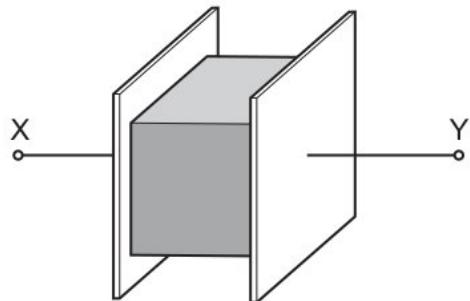
- (a) (iv) a suitable approximation to find the probability that more than 50 of these competitors had times less than 36.0 minutes.

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

.....

[10]

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



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

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[3]

(c) (iii)



Find the angle that the force acting on the rod at A makes with the horizontal.
State the work W done by F .

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[20]

- (i) 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.

by mathematical induction that, for all positive integers n ,

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[10]

- (e) (ii) the probability that at least 1 of these students studies Drama.

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

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restitution = uh [3]

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

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

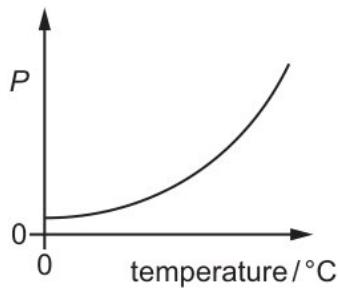
the time taken for the ball to reach its maximum height

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[2]

- 22 that $E(X) = 3.05$, find the values of p and q .

- (c) (i) points A, B, C have position vectors



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

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[1]

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

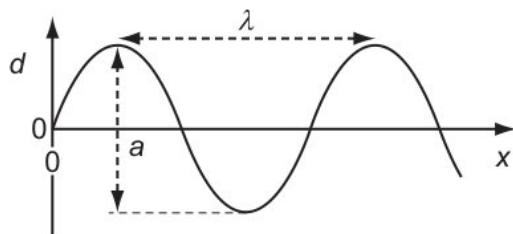
Show that $ff(x) = x$.

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[6]

- (iv) In 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.

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



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[4]

- (a) (vi) 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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first artificial radioactive substance was made by bombarding aluminium, ^{27}Al , with α -particles. This produced an unstable isotope of phosphorus, ^{30}P .

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[6]

- (i) Is a general description of a baryon?

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

On a sketch of an Argand diagram, shade the region whose points represent complex numbers z satisfying both the inequalities $|z - u| \leq 2$ and $\operatorname{Re} z \geq 2$, where $\operatorname{Re} z$ denotes the real part of z .

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[8]

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

diagram shows the electric field between the plates?

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

.....

[5]

- (iv) Find the probability that a randomly chosen letter weighs more than 13 g .
 that $x^2y = z$, show that

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[5]

- (ii) the value of x .

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

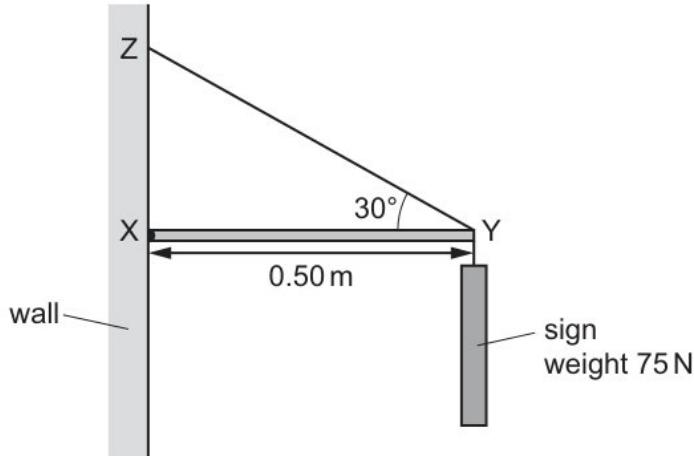
.....

[5]

12 $\frac{\text{force}}{\text{length} \times \text{time}}$

are selected from these 20 to perform at a concert.

diagram shows the curve $y = \sqrt{1 + x^3}$. Region A is bounded by the curve and the lines $x = 0$, $x = 2$ and $y = 0$. Region B is bounded by the curve and the lines $x = 0$ and $y = 3$.



- (b) (iv) is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

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

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[3]

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

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

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]

- (c) (iii) plank rests on fixed supports at its ends X and Y .

bag contains 7 red balls and 3 blue balls. Kieran selects 2 balls at random, without replacement. The number of red balls selected by Kieran is denoted by X , and the number of different colours present in Kieran's selection is denoted by Y .

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[6]

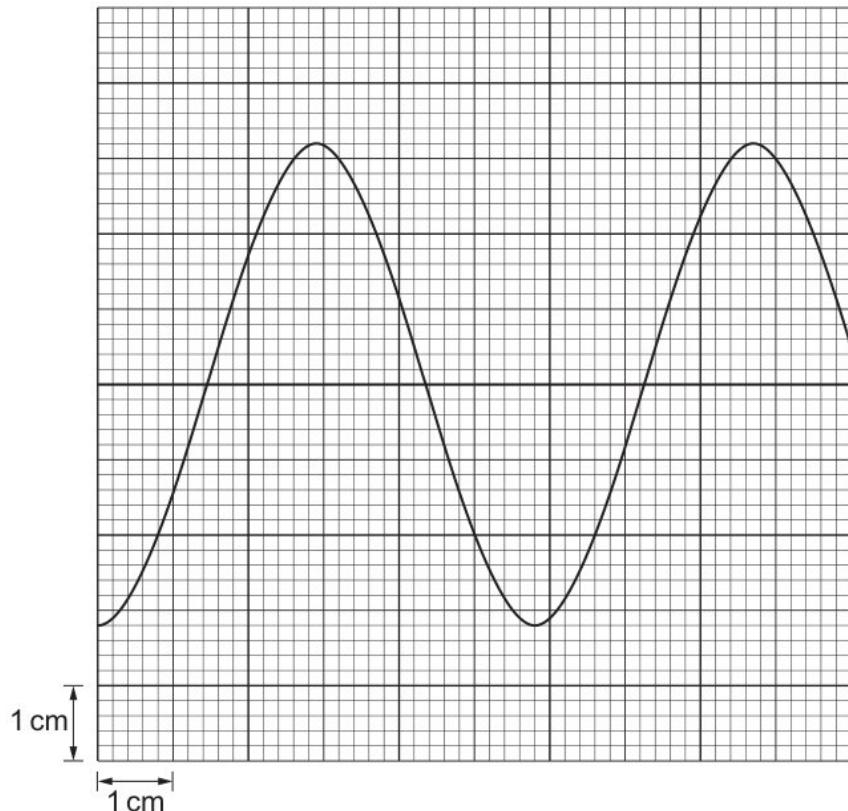
- (i) matrix \mathbf{A} , given by

The acceleration of the particle between $t = 6$ and $t = 10$ is 7.5 m s^{-2} . When $t = 10$ the velocity of the particle is $V \text{ m s}^{-1}$. Find the value of V .

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[4]

(a) (iii)



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

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[5]

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

quantities would be measured in order to determine E ?

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

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[5]

- (e) (ii) 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 .

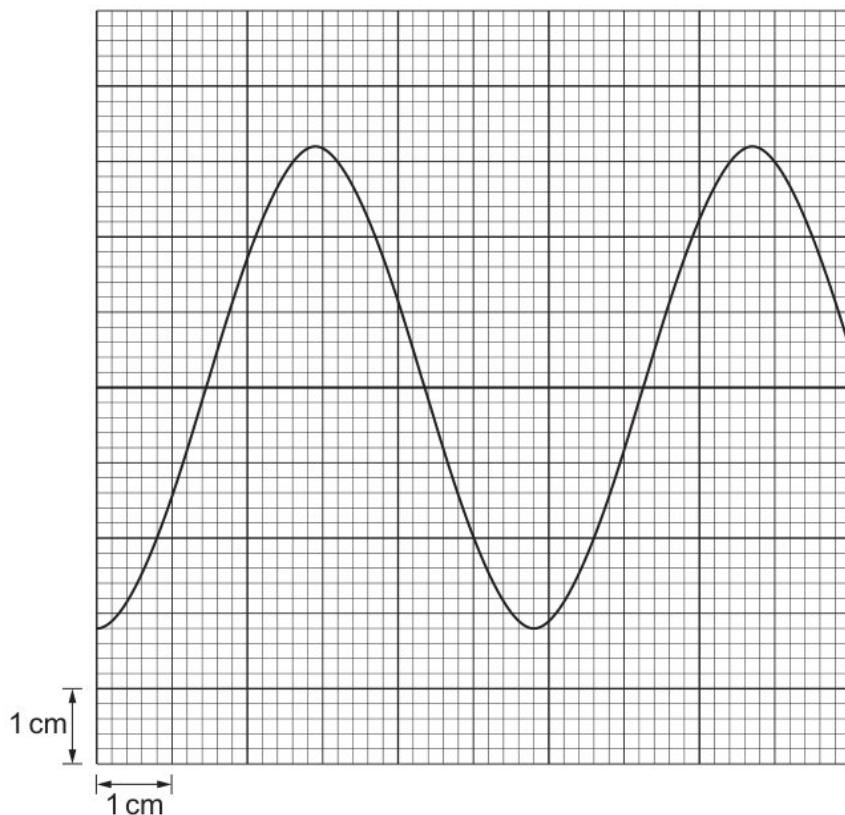
Show that $u^3 + 8 = 0$.

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

.....

[12]

(iii)



the principle of moments.

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

.....

[15]

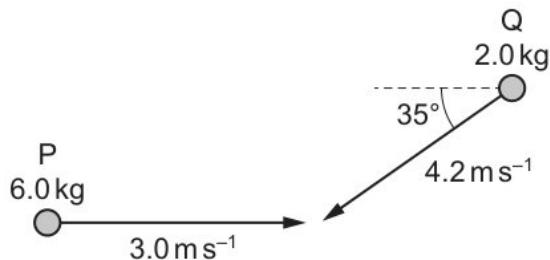
16 In some nuclear processes, mass-energy is not conserved.

- (b) (i) sequence u_1, u_2, u_3, \dots is such that $u_1 = 5$ and $u_{n+1} = 6u_n + 5$ for $n \geq 1$.
 a cubic equation whose roots are $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$.
-

[15]

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

State the value of $E(X)$.



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[15]

- (v) Use de Moivre's theorem to show that
 what is meant by the de Broglie wavelength.
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[5]

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

single change would double the value of this ratio?

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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that eigenvector = jd [8]

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

$$(x+1)\frac{dy}{dx} = y(x+2)$$

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[3]

- (e) (ii) The matrix **B**, where

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

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[3]

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

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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[5]

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

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

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

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[8]

- 23 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.

- (d) (ii) The extension of the wire is proportional to the tensile force.

is investigating the views of students at her school about the school sports facilities. She plans to give a survey to a sample of students.

Express $\frac{dy}{dx}$ in terms of t .

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[5]

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

no digit can be repeated,

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[6]

- (a) (ii) short time after passing point B truck R moves in a straight line on horizontal ground. The driver of the truck applies the brakes. Fig. 3.2 shows the variation with time of the momentum of the truck.

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

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where = zg [4]

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

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

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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[6]

- (i) temperature θ_R of the laboratory is measured using a thermometer.

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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[3]

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

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

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

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[15]

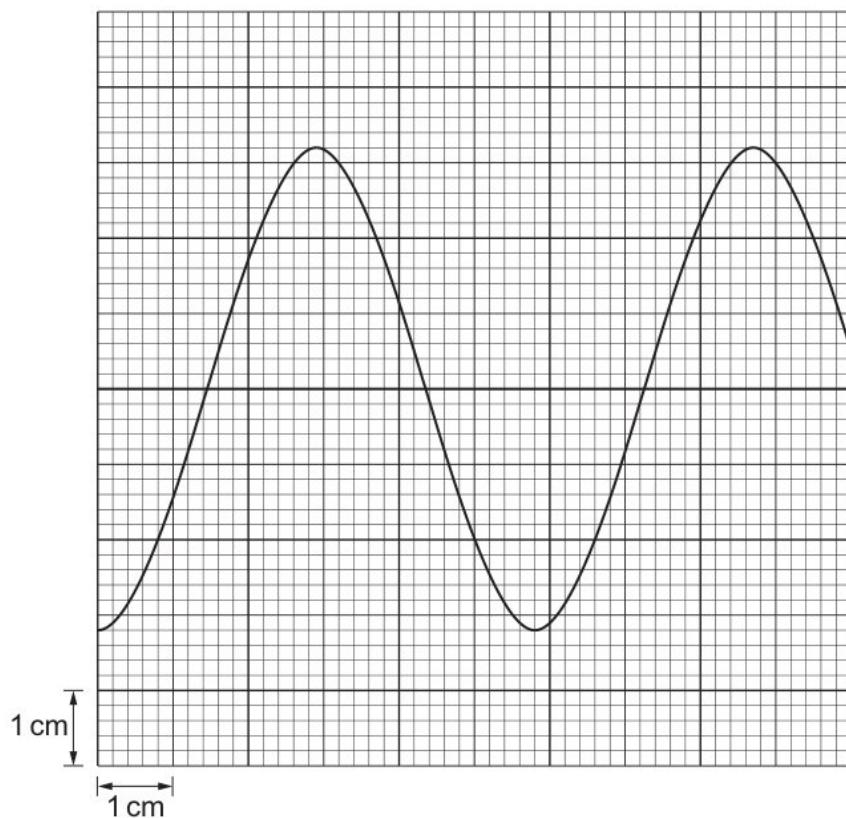
- (iii) diagram shows a water wave in a shallow tank. The wave is diffracted through a gap in a barrier and spreads. The wavelength of the wave is much smaller than the width of the gap.

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

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[3]

- (i) the probability of a Type I error.



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[6]

- 26 (c) Given also that -1 is an eigenvalue of \mathbf{A} , find a corresponding eigenvector.

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

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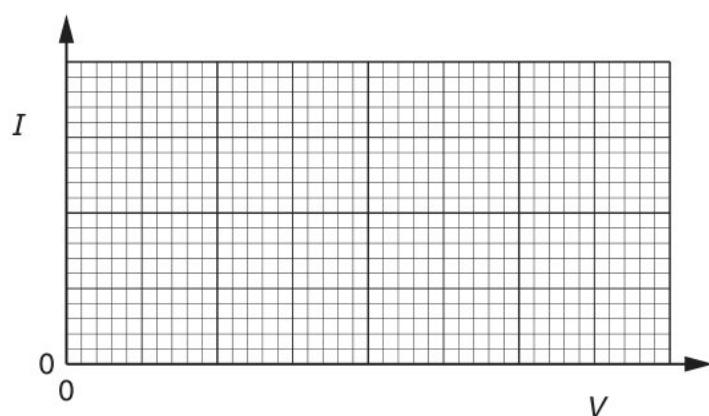
[8]

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

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[8]

- (f) It consists of three quarks that must all be the same flavour.



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

- (ii) company sells bags of pasta. The masses of large bags of pasta are normally distributed with mean 2.50 kg and standard deviation 0.12 kg .

parametric equations of a curve are

.....

[8]

- (iv) Hence find the value of $\frac{d^2y}{dx^2}$ at the point $(1, \frac{1}{4}\pi)$ on C .

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[4]

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

that $\frac{d}{dt}(\operatorname{sech}^{-1} t) = -\frac{1}{t\sqrt{1-t^2}}$.

Find the exact value of the arc length of C .

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[5]

- (b) points A, B, C have position vectors

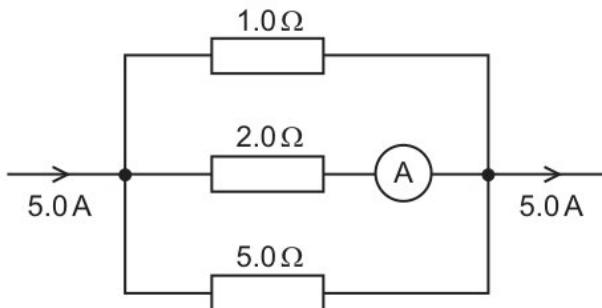
- (i) Using the concept of work done on the car, show that the kinetic energy E_K of the car is given by the equation

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[8]

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

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



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[5]

- (a) particle P is projected from a point O with speed U at an angle 45° above the horizontal and moves freely under gravity.
- (iv) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .

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[6]

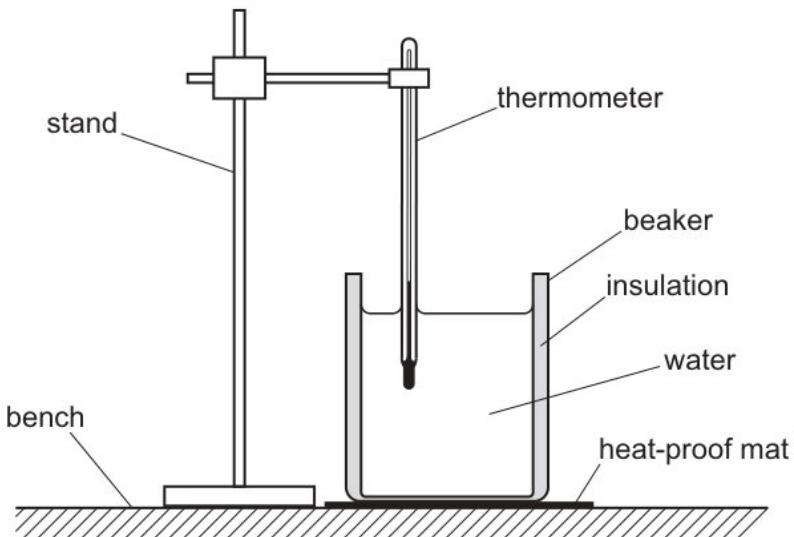
- (i) Find the coordinates of the point A on C at which $\frac{dy}{dx} = 0$ and $x \neq 0$.

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[12]

- 12 lamina is freely suspended at A and hangs in equilibrium.

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



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

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[4]

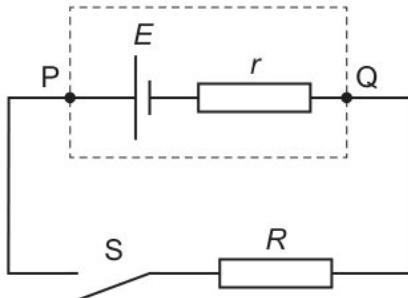
- (iv) curve C has equation

masses of the bags of rice made by a company are normally distributed with mean μ kg 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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[10]

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



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under = le [10]

- (v) Find the interquartile range of X .

Find the modulus and argument of u .

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

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[2]

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

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

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[5]

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

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

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

- (a) (iii) to the value α .

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

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[12]

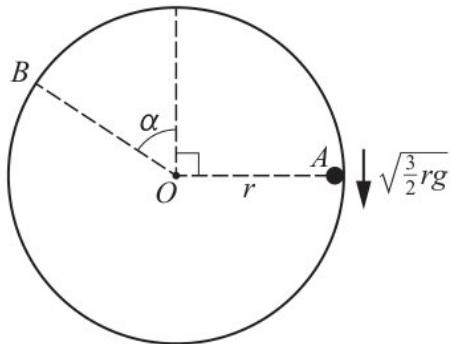
- (iv) is the phase difference between two points on the wave that are a distance of 0.50 m apart?

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

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[5]

- (d) (ii) Find the acceleration of the particle during the first 5 seconds of motion.



constant a is such that $\int_1^a 6x \ln x \, dx = 4$

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with = wy [12]

- (i) as shown in Fig. 2.1.
the distribution function of X .
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[4]

- (iii) Given also that -1 is an eigenvalue of \mathbf{A} , find a corresponding eigenvector.
the probability that both marbles chosen are the same colour.
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divided = im [6]

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

Find the period of the motion.

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

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[1]

- (iii) Find $\frac{dy}{dx}$ and deduce that if C has two stationary points then $-\frac{3}{2} < \lambda < 1$.
State the name of this type of reaction.
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rods, = by [4]

- (c) (ix) believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p , is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $H_0 : p = 0.2$, against the alternative hypothesis, $H_1 : p < 0.2$.

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

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[5]

- (ii) all solutions in the interval $0^\circ \leqslant \theta \leqslant 360^\circ$.

the probability density function of Y

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attached = vb [5]

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

find corresponding eigenvectors.

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[4]

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

- (b) 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.
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[4]

- (a) mid-day temperature, $x^{\circ}\text{C}$, 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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without = mi [4]

- (d) 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.
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[6]

- (c) no digit can be repeated,
that for $n \geq 2$, $I_n = -1 + n(n - 1)I_{n-2}$
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[4]

- (iii) Find the standard deviation of x .

- (e) the distribution function of X .

skateboarder and her skateboard have a total mass of 70 kg . She pushes on the ground with her foot to create a forward force F of 25 N on herself and the skateboard, as shown in the diagram.

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masses = yx [15]

- (a) gravitational potential at a point.

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[8]

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

- (b) 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.

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

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[5]

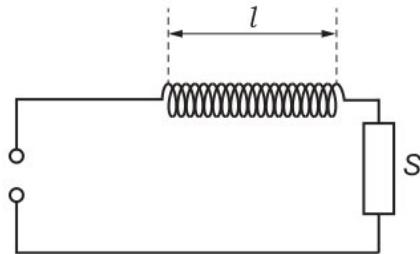
- (d) the number of different ways in which these three bands can be selected.

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[6]

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

- (c) (ii) 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]

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

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[3]

- (a) (i) relationship is used in the derivation of the equation shown?

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

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[6]

- (iv) Find the position vector of D .

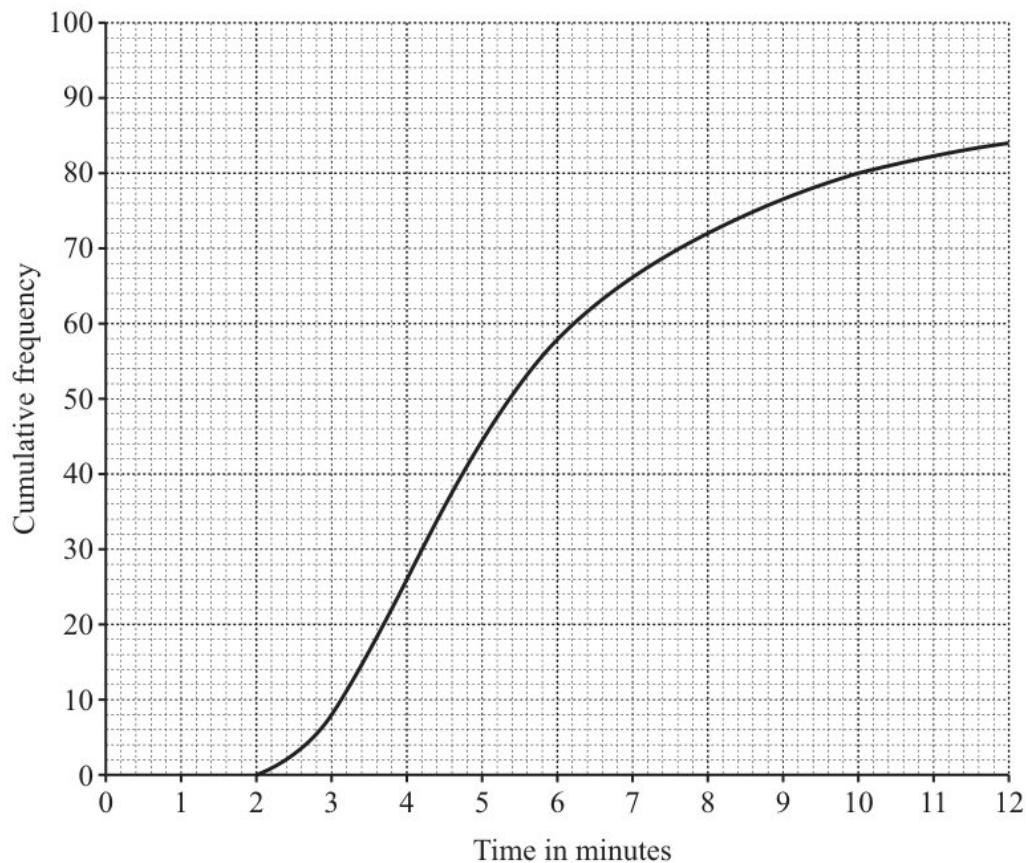


diagram shows the electric field between the plates?

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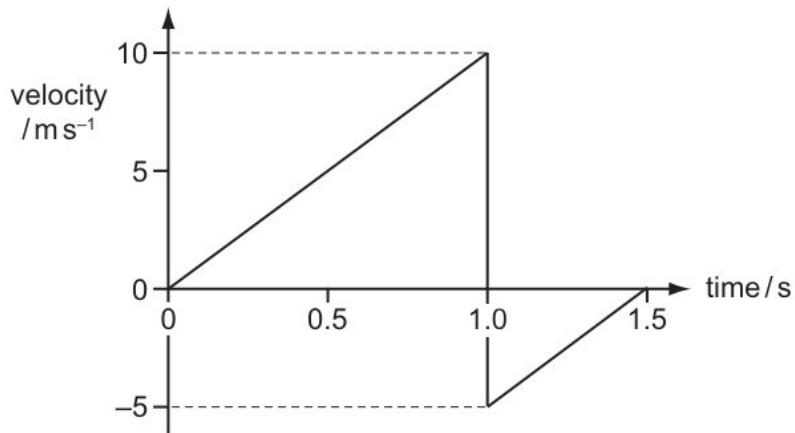
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[4]

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

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



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[6]

- (i) parametric equations of a curve are

$$\int_2^5 (x - 2 \ln x) dx$$

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[12]

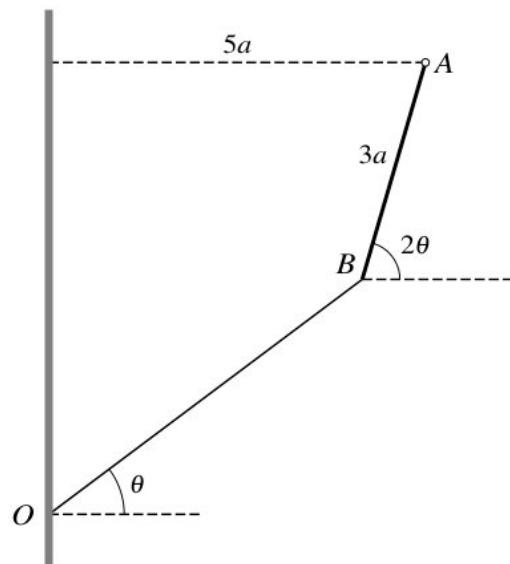
- (c) (ii) adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

curve C has polar equation $r = 2a \cos(2\theta + \frac{1}{2}\pi)$ for $0 \leq \theta < 2\pi$, where a is a positive constant.

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[6]

(iv)

curve C has equation

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[10]

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

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

The extension of the wire is proportional to the tensile force.

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[4]

(f) (i) Prove that $\sin^2 2\theta (\cosec^2 \theta - \sec^2 \theta) \equiv 4 \cos 2\theta$.

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

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[6]

(iii) The speed of the car at the bottom of the first ramp is 14 m s^{-1} . Use an energy method to find the speed of the car when it reaches the bottom of the second ramp.

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

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[5]

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

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

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[15]

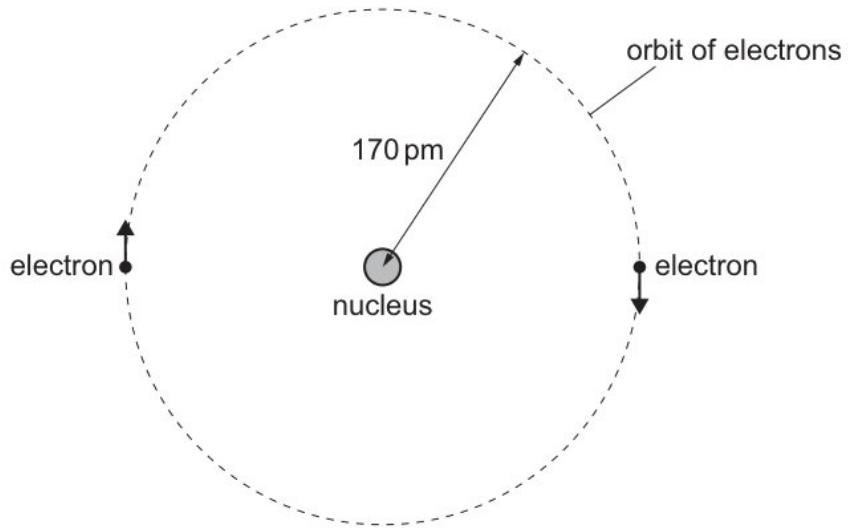
(a) (ii) the speed of the aeroplane.

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

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[4]

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



would this object weigh on Pluto?

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[8]

- (i) vertical forces that the ground exerts on a stationary van are shown.

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

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[12]

- 7 car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

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

Find the values of a and b .

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

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[10]

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

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

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[4]

- (iii)

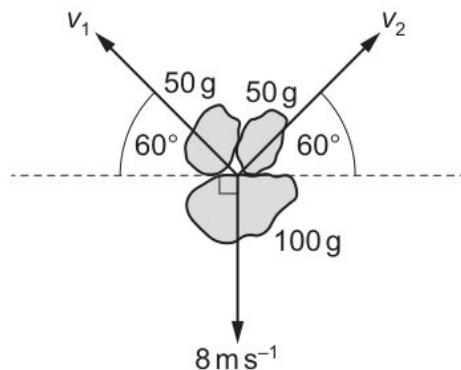
	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

the solution of the differential equation

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[4]

(ii)



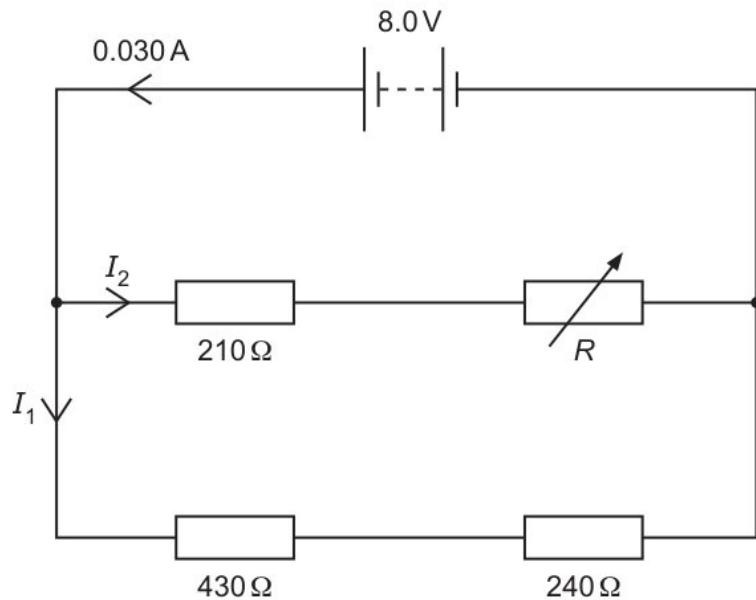
the roots of the equation $z^3 = 27 - 27i$, giving your answers in the form $re^{i\theta}$, where $r > 0$ and $-\pi \leq \theta < \pi$.

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

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[10]

(e) (iii)



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

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[2]

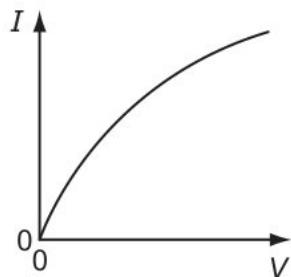
- (i) random variables X and Y have the independent distributions $N(44, 16)$ and $N(30, 9)$ respectively.

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 .

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[12]

(b) (iii)



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

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

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[12]

- (ii) linear transformation $T: \mathbb{R}^4 \rightarrow \mathbb{R}^4$ is represented by the matrix \mathbf{M} , where
is the reading on the ammeter?
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[3]

- (c) (ii) Find the set of values of k for which the line $y = k$ does not intersect C .
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]

- (vii) parametric equations of a curve are
 what is meant by centre of gravity.
 your answers in the form $\tan k\pi$, where k is a rational number.
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[5]

- (i) your answers in the form $\tan k\pi$, where k is a rational number.
 number of cars sold per day at another showroom has the independent distribution $\text{Po}(0.6)$. Assume that the distribution for the first showroom is still $\text{Po}(0.7)$.
-

[4]

- 20 the number of bags for which you would expect the mass of pasta to be more than 1.65 standard deviations above the mean.
 a positron and an antineutrino

- (a) (i) is the current in the load resistor?

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

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[4]

- (ix) State one other feature of this orbit.

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

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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[6]

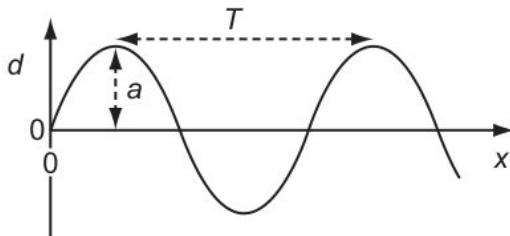
- (ii) P is projected vertically downwards from the equilibrium position, and comes to instantaneous rest at a point 1.6 m below AB .

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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[4]

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



line = ux [5]

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- (i) do each of the symbols represent for an electric current in a metal wire?
the position vector of P .

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unit = wg [12]

- 25 (d) why, for a substance, the specific latent heat of vaporisation is usually greater than the specific latent heat of fusion.
(i) Q hears a sound of decreasing frequency.

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[1]

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

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[10]

- (v) Given also that C has a turning point when $x = 2$, find the value of c .
Find the rank of \mathbf{A} and a basis for the null space of T .

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[6]

(iii) object weighs 6.0 N on Earth.

the values of a, b, x and y .

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[4]

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

particle P moves on a straight line in simple harmonic motion. The centre of the motion is O , and the amplitude of the motion is 2.5 m. The points L and M are on the line, on opposite sides of O , with $OL = 1.5$ m. The magnitudes of the accelerations of P at L and at M are in the ratio 3 : 4.

(v) 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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[1]

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

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

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[4]

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

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

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

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[4]

- (iii) Find the rank of \mathbf{M} .

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

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

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[8]

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

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

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

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[4]

- (ii) Find also the exact value of the surface area generated when C is rotated through 2π radians about the x -axis.

State the equation of the other asymptote.

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[2]

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

diagram shows a junction in a circuit where three wires, P, Q and R , meet. The currents in P and Q are 1 A and 3 A respectively, in the directions shown.

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[10]

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

$$\int_2^5 (x - 2 \ln x) dx$$

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[4]

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

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

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

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[12]

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

Find the area of the region enclosed by C .

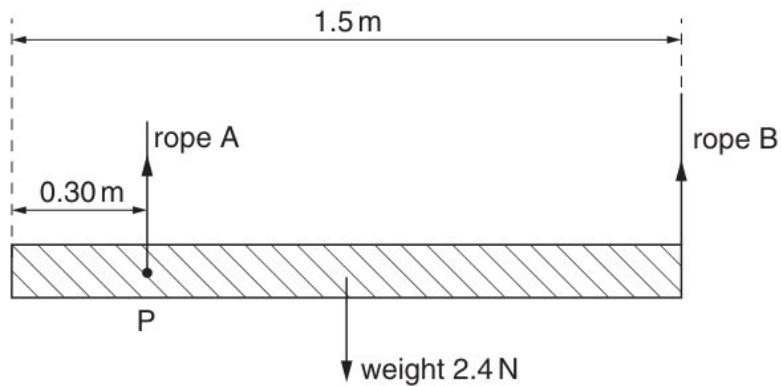
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[3]

- (iv) why Kieran is incorrect.
throws three coins at the same time.
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[8]

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



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[5]

- (f) (iii) the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

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

Find the distance OM .

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[12]

- (i) The waves must have equal amplitudes.

$$\frac{d^2x}{dt^2} + \frac{dx}{dt} - 2x = 2t^2 + t - 1,$$

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[15]

- (ii) the value of θ .

State the value of $E(X)$.

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[4]

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

- (d) (iii) 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.

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

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[6]

- (iv) height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

one similarity and one difference between an electron and positron.

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

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[4]

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

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

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[5]

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

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

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[4]

- (b) (ii) curve C has equation

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

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mark = vb [6]

- (iv) resistors of equal value are connected as shown.

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

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[5]

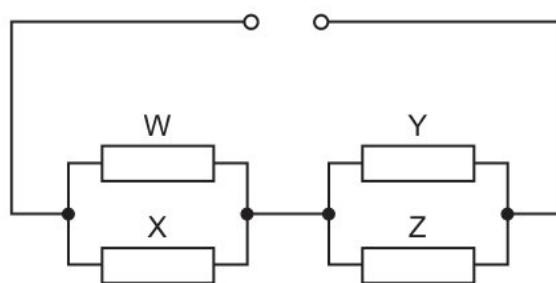
- (e) (i) Bag A contains 4 balls numbered 2, 4, 5, 8. Bag B contains 5 balls numbered 1, 3, 6, 8, 8. Bag C contains 7 balls numbered 2, 7, 8, 8, 8, 8, 9. One ball is selected at random from each bag.

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

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[3]

(iii)



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

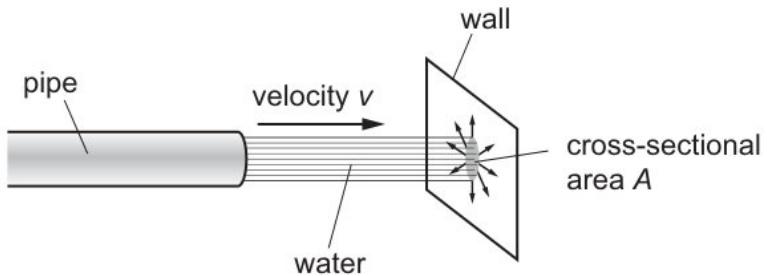
number of cars sold per day at another showroom has the independent distribution $Po(0.6)$. Assume that the distribution for the first showroom is still $Po(0.7)$.

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[12]

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

(b) (ix)



only one of the following two alternatives.

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$$\text{rough} = \dots \quad qp \quad [6]$$

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

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

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[5]

- (iv) diagram illustrates successive wavefronts.

the probability that fewer than 6 rolls of this dice are required to obtain an A .
diagram shows a trace of a wave on a cathode-ray oscilloscope.

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[4]

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

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

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[4]

- (iv) no unique solution.

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

flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in Fig. 4.1.

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[6]

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

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

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string = hh [1]

- (iii) the point $(2, \frac{1}{2}\pi)$.

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

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line = uc [5]

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

- (b) (i) 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 .

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

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[4]

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

your answer correct to 2 decimal places.

.....

[8]

- (f) (v) graph is correctly labelled?

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

.....

[8]

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

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.

procedure to be followed,

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[6]

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

the speed of the combined particle after this collision.

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

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

control of variables,

.....

[6]

- (i) gravitational potential at a point.

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

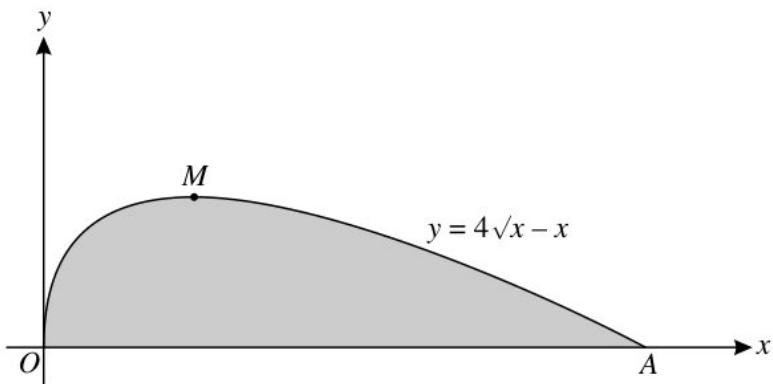
.....

[10]

- (a) (ii) the time taken for the ball to reach its maximum height
 specific heat capacity of water is $4.18 \text{ J g}^{-1}\text{C}^{-1}$.
-

[6]

(iii)



Find the interquartile range of X .

.....

[4]

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

A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension x of the stretching force F .

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[8]

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

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

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random = aa [20]

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

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

what is meant by the de Broglie wavelength.

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[8]

- 10 why Kieran is incorrect.

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

Show that $ff(x) = x$.

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[3]

- (iv) is the force on an electron when it is in the uniform electric field between the plates?

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

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[6]

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

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

safety precautions to be taken.

.....

[8]

- (iii) complex number u is defined by $u = \frac{5}{a+2i}$, where the constant a is real.
 How far apart are two adjacent interference fringes that are formed on the laboratory wall?

.....

instant 3.1. = ty [5]

- (g) (iii) temperature θ_R of the laboratory is measured using a thermometer.
 A fair six-sided dice with faces labelled 1, 2, 3, 4, 5, 6 is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X .
 that for $n \geq 2$, $I_n = -1 + n(n-1)I_{n-2}$

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[6]

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

B contains 5 red marbles and 3 blue marbles.

.....

[4]

- (iv) is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

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

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

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[6]

- (i) force is caused only by a pressure difference?

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

.....

[8]

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

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

.....

matrix matrix = st [12]

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

Find the coordinates of A and M .

parametric equations of a curve are

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[2]

- 18 (e) Nucleon numbers of nuclei are unchanged by the emission of β -particles.

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

then it converges to a .

- (iii) is the force on an electron when it is in the uniform electric field between the plates?

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[5]

- (ii) control of variables,

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Earth's = ai [5]

- (i) Lee asserts that boys are slower than girls at completing a particular mathematical puzzle. In order to test his assertion, a random sample of 40 boys and a random sample of 60 girls are selected from a large group of students who attempted the puzzle. The times taken by the boys, b minutes, and the times taken by the girls, g minutes, are summarised as follows.
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[6]

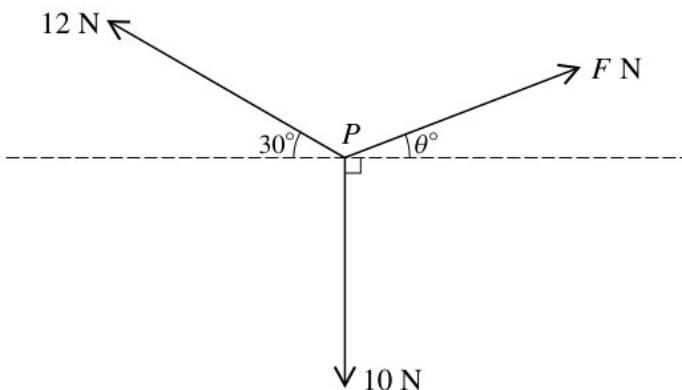
- (iv) in either order the value of μ and the value of σ
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[8]

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

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

- (ii) up to down



[20]

- (iii) point P is the foot of the perpendicular from A to l .

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[20]

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

safety precautions to be taken.

Find the weight of the lamina.

.....

[12]

- (a) is the grand-daughter product?

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

block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m. The block experiences a frictional force parallel to the slope of 5.0 N.

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

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[1]

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

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[3]

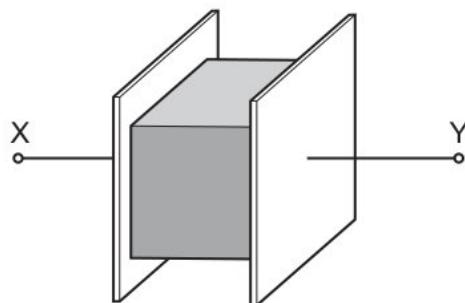
- (i) 1.1 shows a thin coil of cross-sectional area A and length l connected to a resistor of resistance S and two terminals.

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

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[8]

(c)



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

- (iv) that l_1 and l_2 do not intersect.

The total momentum is conserved only in elastic collisions.

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over = ek [5]

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

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[10]

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

(b) (i) are speed v_1 and speed v_2 ?

\mathbf{a} and \mathbf{b} are vectors and t is a scalar.

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[2]

(iii) cubic polynomial $p(x)$ is defined by

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

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[5]

(vii) λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.

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

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[6]

(c) (v)

	number of charge carriers per unit time	average drift speed of charge carriers
A	Y greater than X	Y greater than X
B	Y same as X	Y same as X
C	Y greater than X	Y same as X
D	Y same as X	Y greater than X

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

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[12]

- (i) is given that $z_1 = r_1 e^{i\theta_1}$ and $z_2 = r_2 e^{i\theta_2}$.
 resistors of equal value are connected as shown.
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[6]

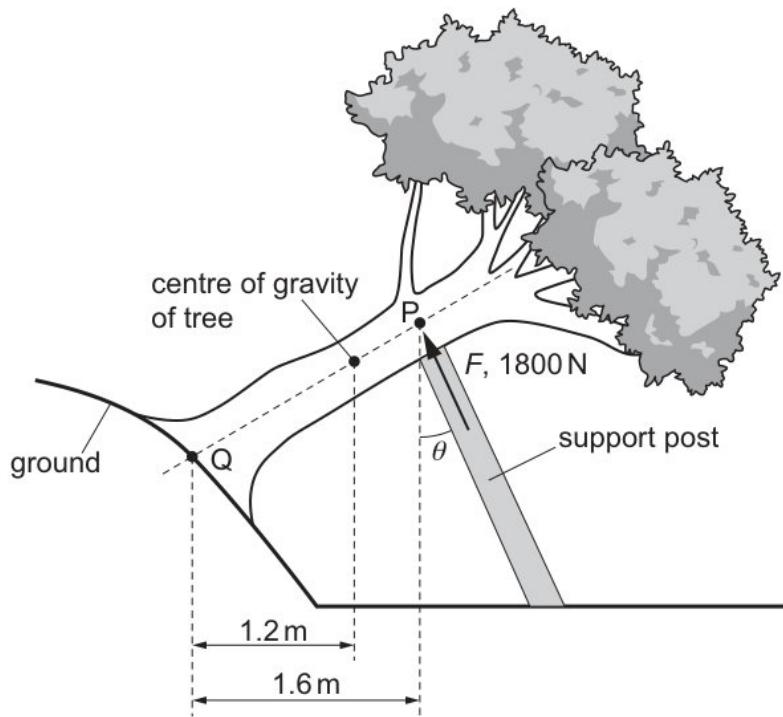
- (a) (ii) pendulum bob is held stationary by a horizontal force H . The three forces acting on the bob are shown in the diagram.
 a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1} .
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[6]

- (i) for $0^\circ \leq \theta \leq 180^\circ$ the equation $\sin^2 2\theta (\operatorname{cosec}^2 \theta - \sec^2 \theta) = 3$,
 Hence find the exact value of $\int_0^{\frac{1}{3}\pi} 16 \sin^5 \theta \, d\theta$.
-

[12]

19 does this mean?



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

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

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

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[4]

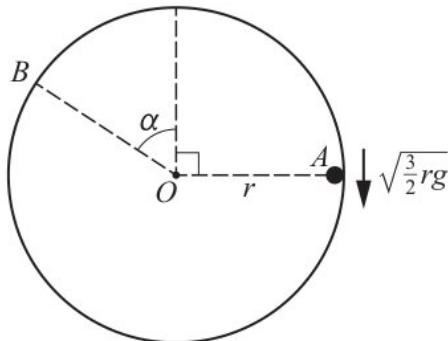
- (i) sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a

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

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[6]

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



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[6]

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

Show that if

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[15]

- 13 statement describes the speed of the object after it is fired until immediately before it reaches the ground again?

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

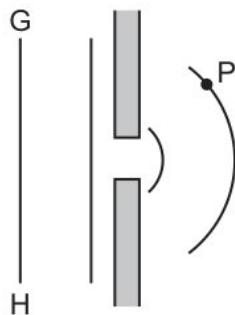
- (a) (i) Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

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

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[6]

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



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

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[5]

- (b) (ii) cubic polynomial $p(x)$ is defined by
the significance level of the test.

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

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[6]

- (iii) force is caused only by a pressure difference?

activity of a radioactive sample.

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]

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

- (iv) the surface area generated when C is rotated through 2π radians about the x -axis.

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

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

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[4]

- (ii) tension in the string of the pendulum is T . The weight of the pendulum bob is W . The string is held at an angle of 30° to the vertical.
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[8]

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

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

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

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[5]

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

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particle = ud [6]

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

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

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

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[12]

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

Find the tension in the string.

.....

[6]

- (iii) points A , B and C have position vectors $2\mathbf{i} - \mathbf{j} + \mathbf{k}$, $3\mathbf{i} + 4\mathbf{j} - \mathbf{k}$ and $-\mathbf{i} + 2\mathbf{j} + 4\mathbf{k}$ respectively.

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

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[8]

(d) (ii) 800 nm to $1000\mu \text{ m}$

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

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[4]

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

variables x and y are related by the differential equation

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passengers airline = fl [1]

- (iii) Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

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

Show that x satisfies the equation

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[4]

- 11 random variable X has the distribution $\text{Po}(1.5)$.

- (c) (v) 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.

	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

.....

[4]

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

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

the number of different ways in which the 6 musicians can be selected if there must be at least 3 guitarists, at most 2 pianists and exactly 1 drummer.

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[2]

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

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

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motion. line = kx [4]

- (i) The weight of the plank can be considered to be acting at its midpoint.
 the expected value and variance of Y .
 Deduce an approximation to the area of region B and explain why this approximation under-estimates the true area of region B .
-

[5]

- (a) (iii) Show that $a = 19$ and find the values of b and c .
 small ball B is projected from a point O which is h m above a horizontal plane. At time 2 s after projection B has speed 18 m s^{-1} and is moving in the direction 30° above the horizontal.
-

experiment = ri [6]

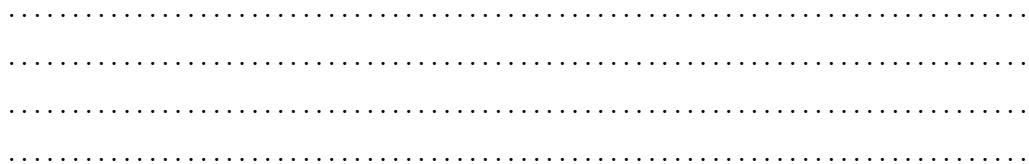
- (ii) what time will some portion of the wavefront GH reach point P ?
 lamina is freely suspended at A and hangs in equilibrium.
 a, b and c are integers to be determined.
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[6]

- (b) (ii) the SI base units of resistivity.

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

curve C has polar equation $r = 3 + 2 \cos \theta$, for $-\pi < \theta \leq \pi$. The straight line l has polar equation $r \cos \theta = 2$. Sketch both C and l on a single diagram.

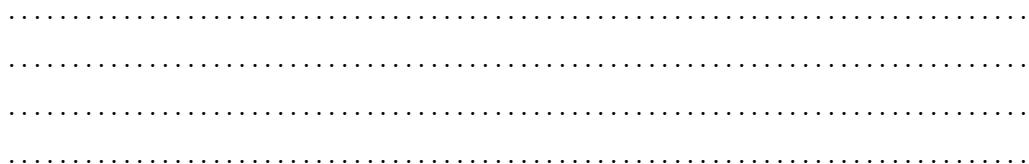


[5]

- (i) 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.

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

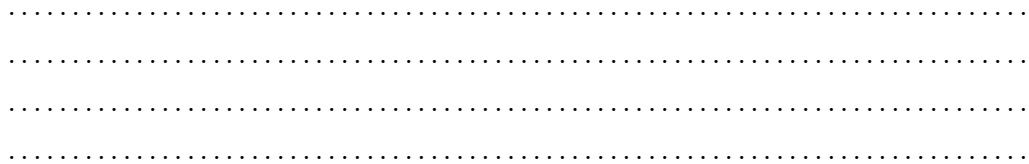
certain curve is such that its gradient at a point (x, y) is proportional to xy . At the point $(1, 2)$ the gradient is 4 .



[5]

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

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



[4]

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

Find the value of the product moment correlation coefficient for this sample.

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[2]

- 13 the past, the population mean time was 62.4 seconds.

by calculation that a lies between 2 and 2.1.

- (e) (ii) width of the 99% confidence interval is double the width of the $x\%$ confidence interval.

The force F is removed from the materials in (d) just before the breaking point is reached. Describe the subsequent change in the extension for

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[4]

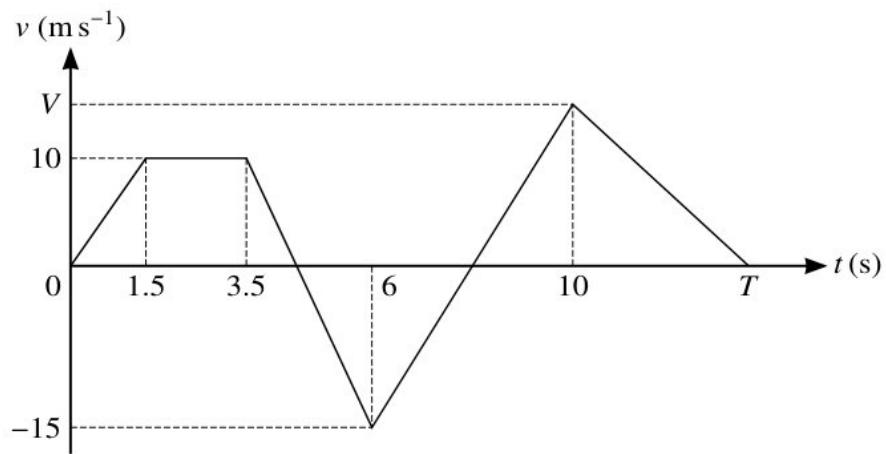
- (i) total energy input E_{in} in a process is partly transferred to useful energy output U and partly transferred to energy that is wasted W .

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

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[6]

(vi)

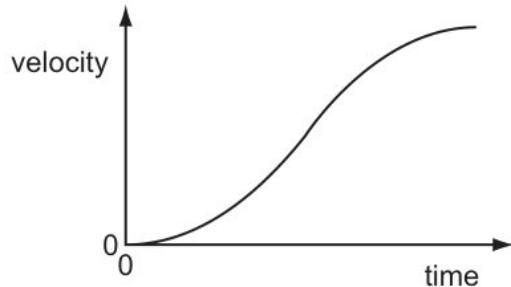


the period of small oscillations,

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[2]

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



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

.....

eigenvector = zt [6]

- (i) The orbit has a period of 25 hours.

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

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

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[20]

- (vi) the circuit shown, XY is a length L of uniform resistance wire. R_1 and R_2 are unknown resistors. J is a sliding contact that joins the junction of R_1 and R_2 to points on XY through a small signal lamp S .

variables x and y satisfy the differential equation

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[5]

- 14 find the position vectors of P and Q .

there are no restrictions,

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

points A, B, C have position vectors

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[2]

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

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

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[12]

(a) (ii) is given that

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

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[5]

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

force is caused only by a pressure difference?

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[6]

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

a butternut squash seed is sown the probability that it will germinate is 0.86 , independently of any other seeds. A market gardener sows 250 of these seeds. Use a suitable approximation to find the probability that more than 210 germinate.

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

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[10]

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

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

diagram shows the electric field between the plates?

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between = ov [5]

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

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

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

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[4]

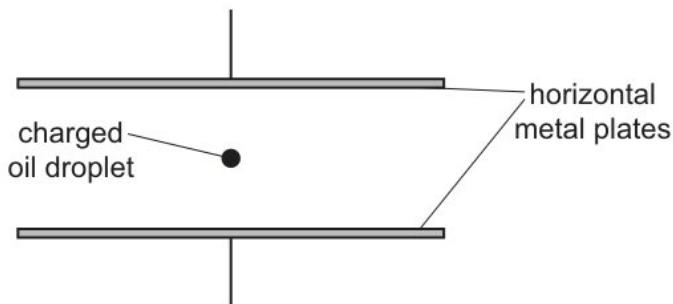
- (i) that $T = \frac{U}{2g}(\sqrt{2} + \sqrt{6})$.

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

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[10]

- (d) (ii)



Calculate the length AG .

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

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[12]

- (iv) your answer correct to 2 decimal places.
the term isotope.

.....

[3]

- (v) 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).

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

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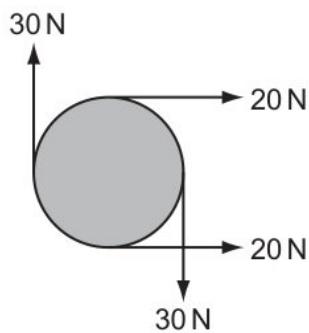
[3]

- 12 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

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

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

Find angle ABC .



- (c) (iv) mass of the liquid is $0.36 \text{ kg} \pm 10\%$.

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

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

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[4]

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

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

find corresponding eigenvectors.

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[6]

- (ii) throws three coins at the same time.

Find the values of p and q .

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[1]

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

524 526 520 523 530

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[6]

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

thermistor is connected to a cell with negligible internal resistance.

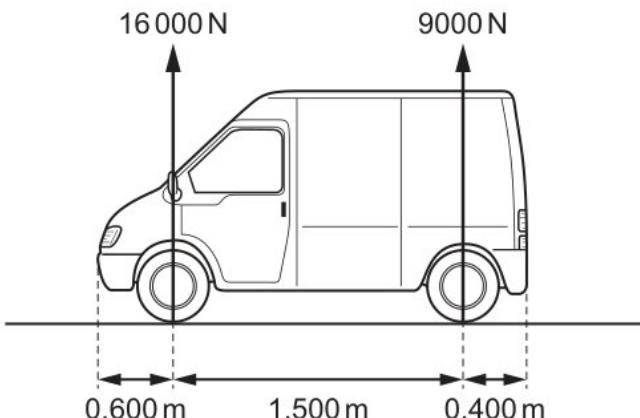
the term elastic limit.

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[6]

- 9 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.

(e) (iii)



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

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

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[2]

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

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

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[6]

(b) (iv)

Length (cm)	5 – 9	10 – 14	15 – 19	20 – 24	25 – 29	30 – 39
Frequency	18	28	60	72	48	24

On Fig. 3.2, sketch the variation with x of F for a brittle material up to its breaking point.

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determine = iz [3]

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

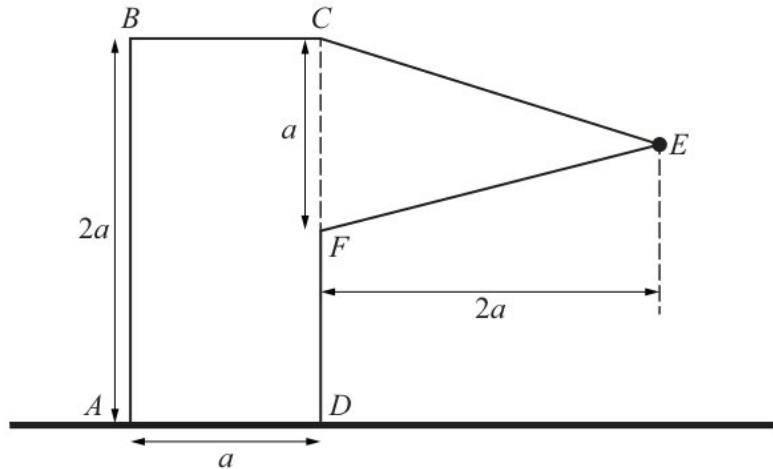
curve with equation $y = \frac{2-\sin x}{\cos x}$ has one stationary point in the interval $-\frac{1}{2}\pi < x < \frac{1}{2}\pi$.

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

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[20]

- (iii) 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.



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[3]

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

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

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

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[6]

- (ii) The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

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

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[15]

- (i) 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 term interference.

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[8]

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

skateboarder and her skateboard have a total mass of 70 kg . She pushes on the ground with her foot to create a forward force F of 25 N on herself and the skateboard, as shown in the diagram.

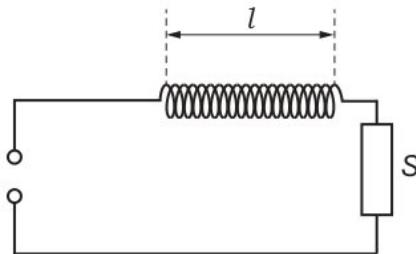
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Give = yp [6]

13 displacement = velocity \times time

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

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



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[8]

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

Find the area of the region enclosed by C .

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

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[15]

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

only one of the following two alternatives.

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random plants random = wx [8]

- (iii) the particular solution of the differential equation
 considering momentum, calculate the speed of nucleus R after the decay.
 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.
-

[6]

- 18 Use implicit differentiation to show that
 the probability of a Type II error.

- (c) (i) water is added to an insulated beaker, as shown in Fig. 2.1.

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

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[20]

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

is the phase difference between two points on the wave that are a distance of 0.50 m apart?

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[15]

- (a) (ii) a normal distribution, calculate a 95% confidence interval for the population mean.
 a time 8.4 minutes later, the activity is 120 Bq .
-

[5]

- (i) Find the value of 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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[8]

- 15 Fig. 7.1, complete the charge and mass of α -particles, β -particles and γ -radiation. Give example speeds of α -particles and γ -radiation emitted by a laboratory source.

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

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

800 nm to 1000μ m

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[5]

- (ii) Find the x -coordinate of M .

the distance AC .

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[4]

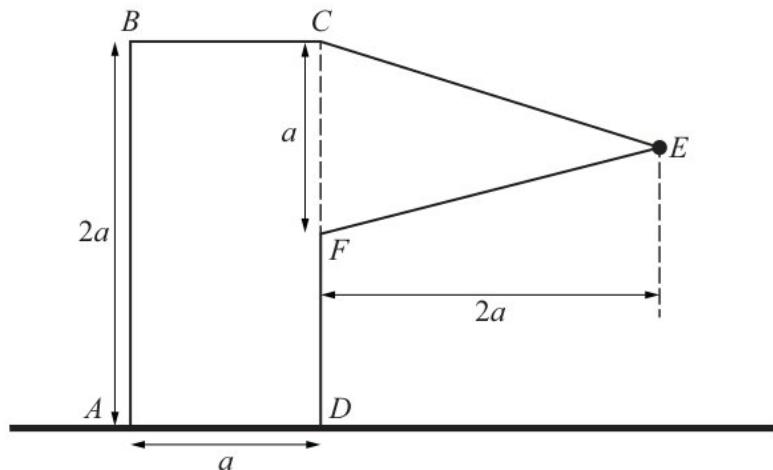
- (b) (iii) Express $5 \cos \theta - 3 \sin \theta$ in the form $R \cos(\theta + \alpha)$, where $R > 0$ and $0^\circ < \alpha < 90^\circ$, giving the exact value of R and the value of α correct to 2 decimal places.

transmitted light has intensity I .

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[2]

- (i) statement is correct when S is changed from open to closed?



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[4]

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

as shown in Fig. 2.1.

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[8]

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

momentum = mass \times velocity

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[8]

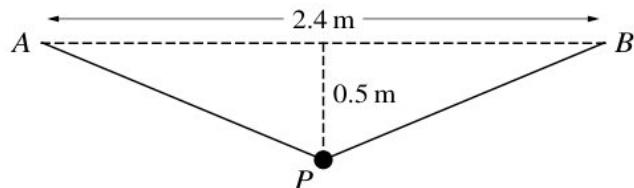
- (vii) the probability that the second A is obtained on the 6th roll of the dice.
is the total displacement of the ball from its original position after $1.5s$?

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after = zt [5]

- 10 the probability that both marbles chosen are the same colour.

(vi) (c)



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

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[5]

- (a) The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

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

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[4]

- (ii) (c) an electron and a neutrino
sheets between a light source and the front of the photocell.
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[4]

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

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

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[6]

- (g) on the graph would the elastic limit be found?

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

$$\int_0^a (1 + 2x + 3e^{3x}) dx = 250$$

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unchanged. = yr [5]

- (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.

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

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

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string mass = lz [2]

- 17 (d) Find the equation of the tangent to the curve at the point where $x = 0$.

on the graph would the elastic limit be found?

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

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[5]

- (ii) Brigville the weights, in kilograms, of boys aged 16 years have a normal distribution. 99% of the boys weigh less than 97.2 kilograms and 33% of the boys weigh less than 55.2 kilograms.

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[4]

- (b) the value of θ .

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

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ball speed = dj [5]

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

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

the speed of the aeroplane.

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grating grating. maxima = oz [5]

- (i) how the pattern of interfering waves may be observed.
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choosing = vl [2]

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

- (d) (iv) the exact volume of the solid generated
resistors of equal value are connected as shown.
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[6]

- (ii) is the current in the load resistor?

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

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

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[10]

- (i) are the amplitude and the period of wave S ?

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

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[5]

- (e) (ii) is the horizontal force exerted by the wall on r r Y ?

Find the area of the region enclosed by C .

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follows. = ou [12]

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

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

frequency of the signal is 50 kHz .

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[4]

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

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

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[8]

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

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

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[8]

- (v) When a and b have these values, factorise $p(x)$ completely.
the gradients of the tangents to the curve when $x = 0$.

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[5]

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

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

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[5]

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

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

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[4]

- (ii) Calculate the speed of the star relative to the Earth.

Find the coordinates of the turning points of C .

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[6]

- (a) (iv) filter is rotated about the normal axis through an angle θ .

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

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[10]

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

up to antidown

$$\int_0^a (1 + 2x + 3e^{3x}) dx = 250$$

.....

[2]

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

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

- (a) (iv) the probability generating functions, $G_X(t)$ of X and $G_Y(t)$ of Y .
 one similarity and one difference between an electron and positron.

.....

after = fy [6]

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

Show that $P(X = 3) = \frac{1}{15}$.

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[12]

- (c) (i) 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 .

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

.....

[4]

- (iii) 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

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

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[6]

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

The waves must be coherent.

.....

[6]

- (v) a and b are constants. It is given that $(x + 2)$ is a factor of $p(x)$ and that the remainder is 28 when $p(x)$ is divided by $(x - 2)$.

Estimate the probability of throwing a 4.

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

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[3]

- (iv) 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.

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

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[5]

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

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

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[5]

13 up to antidown

the exact value of I_2 .

what is meant by work done.

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

the coordinates of C ,

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

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[12]

(iii) force is caused only by a pressure difference?

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

$$a = \dots$$

$$b = \dots$$

$$x = \dots$$

$$y = \dots$$

[3]

.....

[5]

(i) Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

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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[8]

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

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

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[8]

- (b) (i) Form two simultaneous equations and hence find x and v .

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

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[5]

- (iii) is a general description of a baryon?

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

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[8]

- (ii) Find the acceleration of the particle during the first 5 seconds of motion.

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

Find the equations of the asymptotes of C .

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[12]

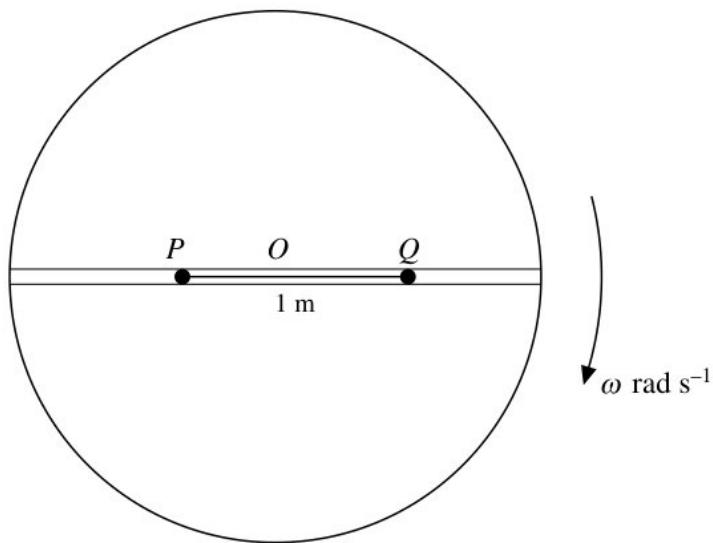
- (c) (iii) λ is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

continuous random variable, X , has probability density function given by 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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[4]

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



[4]

- (d) (iii) copper wire is 6.4 m long and has a resistance of 0.92Ω .

Calculate the greatest deceleration of P .

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[5]

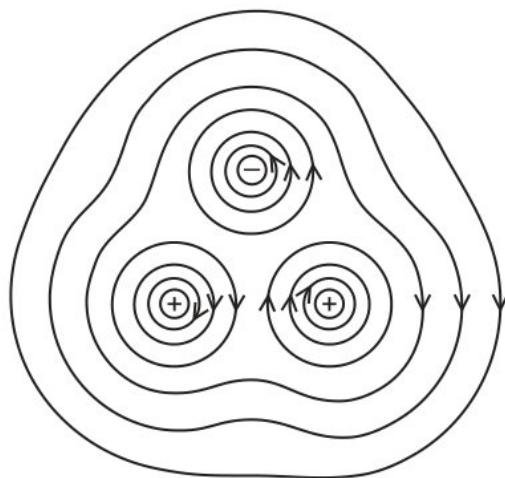
- (i) the value of $\frac{d^2y}{dx^2}$ at the point $(4, \frac{1}{3})$.

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

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[5]

- (ii) On Fig. 3.2, sketch the variation with x of F for a brittle material up to its breaking point.



.....

then = ux [5]

- (g) (iv) is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

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

.....

[5]

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

Q hears a sound of decreasing frequency.

.....

[15]

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

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

.....

pulley = wf [12]

- 27 - falling with constant speed with the parachute open,

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

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

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

.....

[8]

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

Find the work done by the tension.

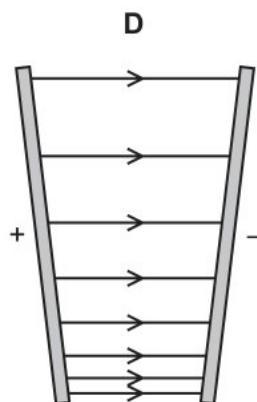
a positron and a neutrino

.....

[6]

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

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



.....

[6]

- (c) (ii) Given that $v = 2.5$, find x .

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

.....

[8]

- (iii) in terms of m and g , the magnitude of the frictional force in this position.

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

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

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[5]

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

variables x and y satisfy the differential equation

matrix \mathbf{A} is given by

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[8]

- (b) (iv) 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

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

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lowest note note = si [15]

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

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

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[10]

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

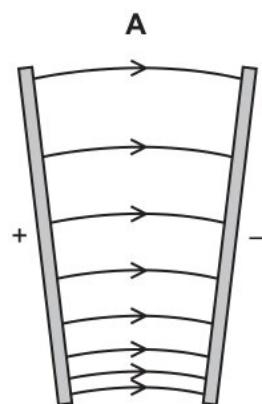
(e)(vii) the eigenvalues of the matrix \mathbf{C} , where

p and q are given real numbers, then

.....

[4]

(iv)



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

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[10]

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

anywhere between point R and point S

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

.....

group 7.65 38.1 = dy [2]

- (b) (i) are the amplitude and period of the wave?

the probability density function of Y

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

.....

[4]

- (iii) Density is mass per cubic metre.

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

.....

[20]

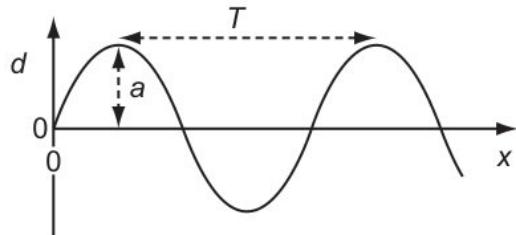
- (ii) polynomial $ax^3 - 3x^2 - 11x + b$, where a and b are constants, is denoted by $p(x)$. It is given that $(x+2)$ is a factor of $p(x)$, and that when $p(x)$ is divided by $(x+1)$ the remainder is 12 .

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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[5]

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



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[4]

- (c) (iii) sample has an activity of 180 Bq at time $t = 0$.

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]

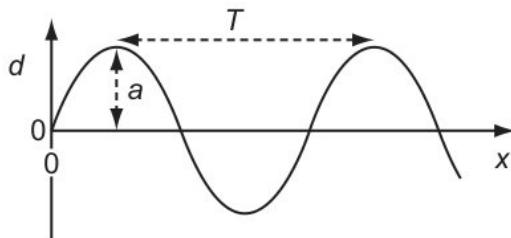
- (ii) polynomial $p(x)$ is defined by

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

.....

[8]

- (i)



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

.....

[5]

- 23 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,

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

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

.....

[5]

- (ii) is a necessary condition for observable interference fringes to be produced?
the Young modulus.

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

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[10]

- (b) (ii) competitors who took part in this Saturday's event are selected at random.
the time from release until OP makes an angle $\frac{1}{2}\alpha$ with the downward vertical for
the first time.
why the variation with time of the activity of a radioactive sample is exponential
in nature.

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[4]

- (iv) values, x , in a particular set of data are summarised by
Find a set of corresponding eigenvectors.

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

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[8]

- 16 (c) that $v = y^3$, show that

- (iii) circle is divided into 6 sectors in such a way that the angles of the sectors are in arithmetic progression. The angle of the largest sector is 4 times the angle of the smallest sector. Given that the radius of the circle is 5 cm , find the perimeter of the smallest sector.
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These into light = nq [6]

- (i) gravitational potential at a point.
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[1]

- (a) the position vector of P .
 (iv) The waves must be polarised.
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[10]

- (iii) that $(z_1 z_2)^* = z_1^* z_2^*$.
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[10]

- (ii) with a reason, whether f has an inverse.
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[4]

- (i) 7 men and 4 women are divided at random into a group of 6, a group of 3 and a group of 2 .
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[6]

- (b) wavelength of the wave and the width of the gap are both changed by a small amount.
matrix \mathbf{M} represents a sequence of two geometrical transformations in the $x - y$ plane.
Find the weight exceeded by the heaviest 5% of pineapples.
- (ii) curve C has equation
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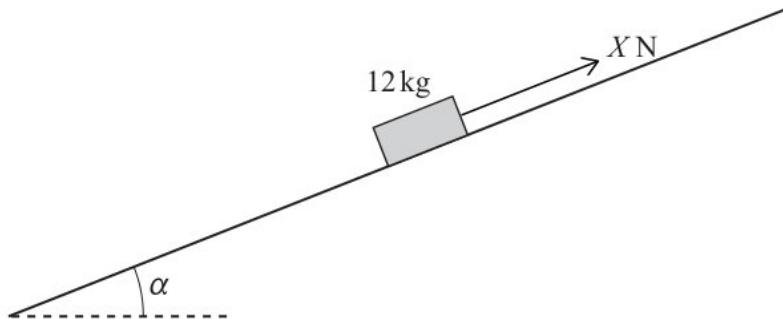
[1]

- (vii) random sample of 140 customers who each bought a computer from this store is chosen.
object hangs by means of two cords around two rods, as shown.
are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.
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than = vd [3]

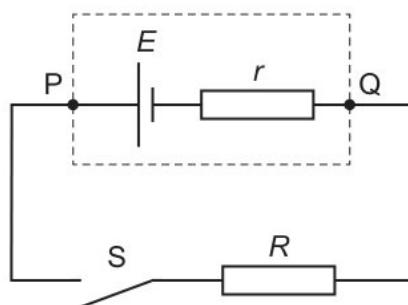
- 16 The point A on the line of intersection of p and q has y -coordinate equal to 2 . Find the equation of the plane which contains the point A and is perpendicular to both the planes p and q . Give your answer in the form $ax + by + cz = d$.

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



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

(d) (iii)



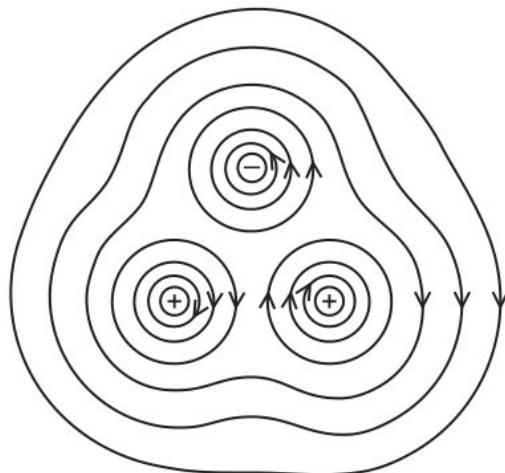
Find the value of a .

m.f. for $n = 0$.

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[3]

- (ii) down to antiup



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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[3]

- (a) (ii) Given instead that $\mu = 0$ and that the tension in the string is 0.48 N , calculate this Saturday's event, 60% of the competitors had times less than 36.0 minutes. sample of 216 observations of the continuous random variable X was obtained and the results are summarised in the following table.
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[5]

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

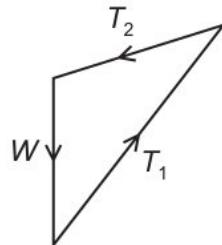
State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

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[5]

- (iii) was the by-product of this reaction?

Stating suitable hypotheses and assuming a normal distribution, test the coach's belief at the 10% significance level.



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[2]

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

what is meant by a fundamental particle.

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

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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[8]

(iv)

	Area 1	Area 2	Area 3
Local bus service	73	36	30
Road surfaces	47	44	20

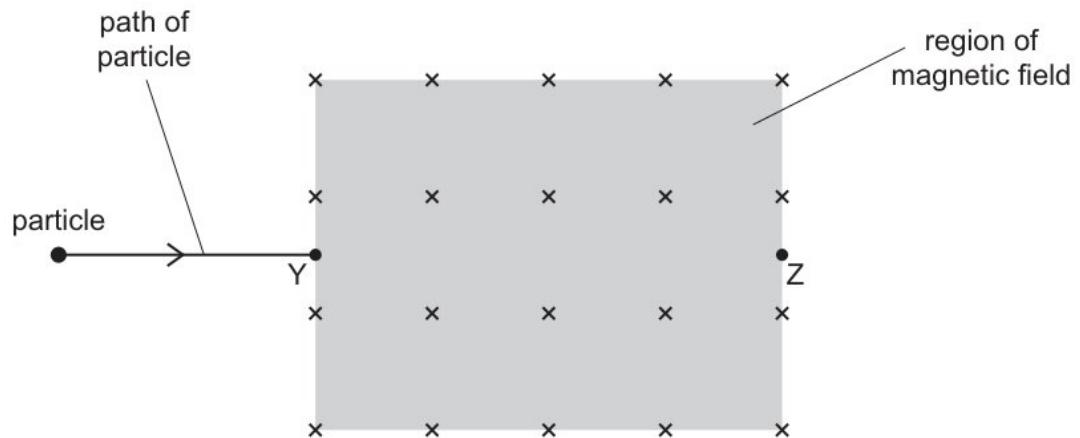
linear transformation $T: \mathbb{R}^4 \rightarrow \mathbb{R}^4$ is represented by the matrix \mathbf{M} , where

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[5]

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

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?



.....

[5]

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

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

.....

[6]

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

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

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

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[5]

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

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

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[5]

- (i) State the work W done by F .

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

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

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[3]

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

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

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

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[4]

- (i) the coordinates of any stationary points on C .

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

magnetic flux density.

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[5]

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

Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

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[6]

- (d)(vii) the exact area of one loop of the curve.

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

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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with = cv [4]

- (ii) force is caused only by a pressure difference?

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

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[8]

- (b) (ii) Show that $m = 0.9$.

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

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[4]

(i)

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

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

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

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[10]

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

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

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

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[1]

- (i) Show that $b = 1 - a$.

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

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

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[12]

34 for a wire,

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

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

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car. constant speed = dw [8]

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

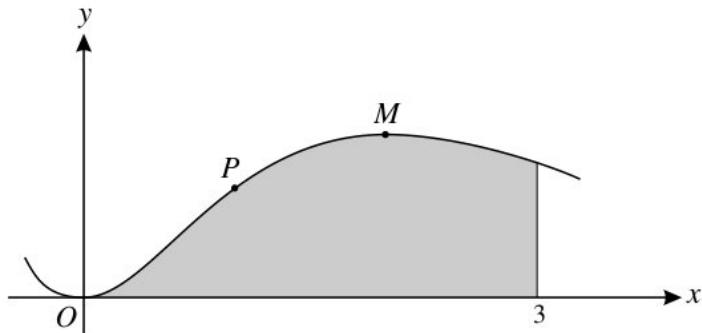
sample of an ideal gas at thermodynamic temperature T has internal energy U .

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[4]

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

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



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mass = sa [8]

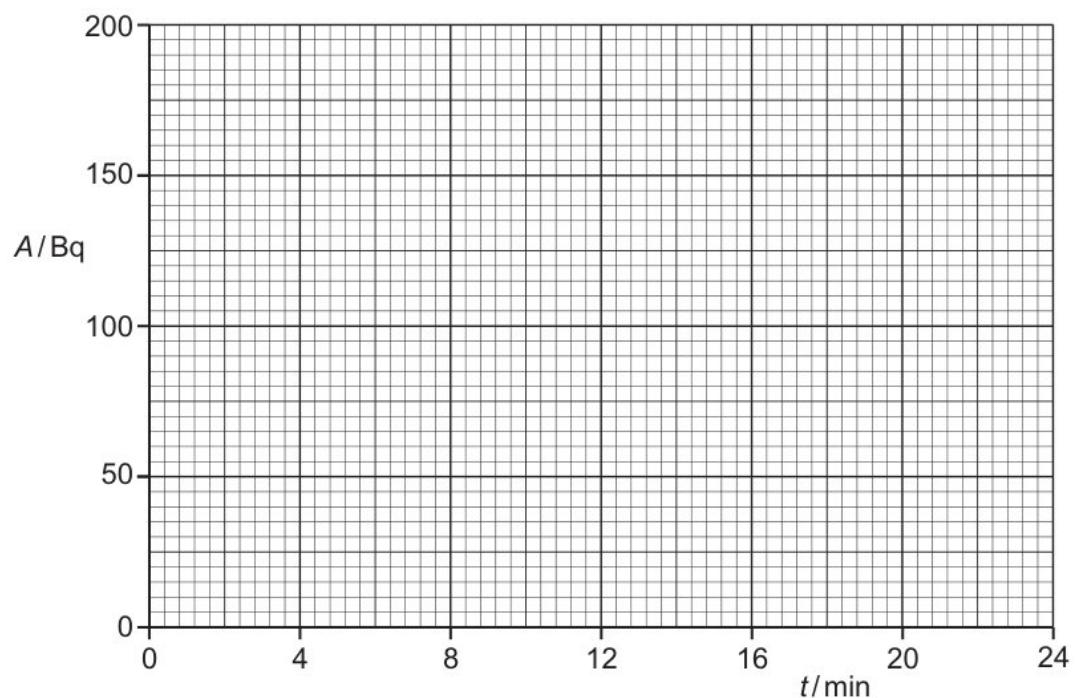
- (iii) is suggested that these results are consistent with a distribution having probability density function f given by

λ is a constant such that $\lambda \neq 1$ and $\lambda \neq -\frac{3}{2}$.

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[4]

(i)

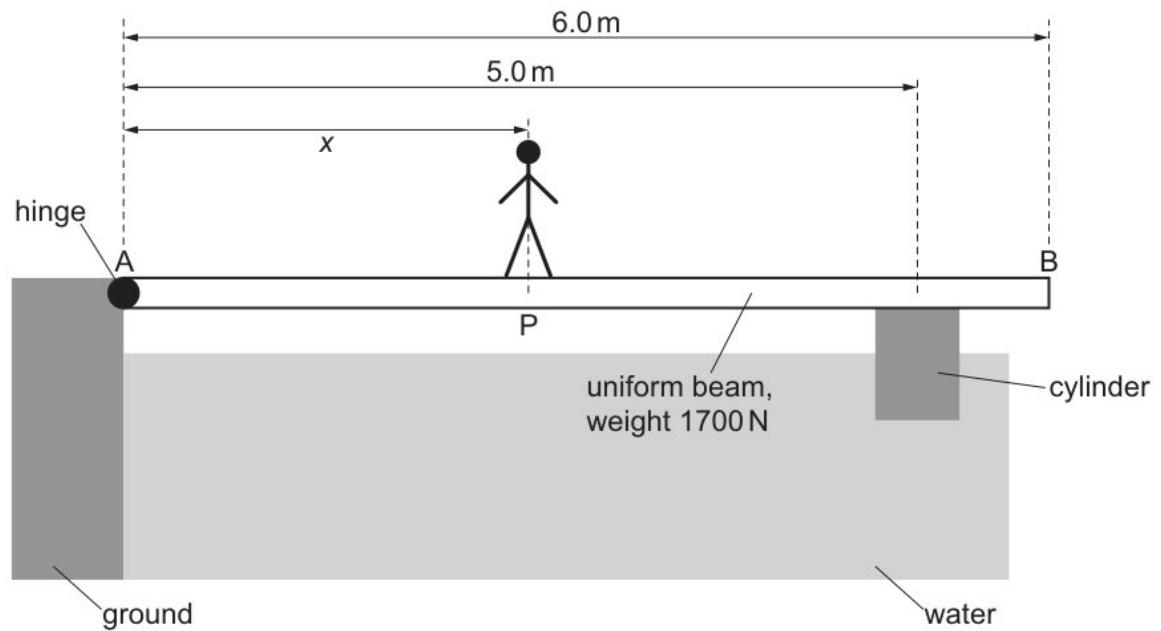


the solution of the differential equation

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[15]

(b) (v)



that, when $t = 0$, $x = 3$ and $\frac{dx}{dt} = 0$.

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$$\text{length} = \dots \text{fa} \quad [10]$$

- (i) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.
 complex number $1 - (\sqrt{3})i$ is denoted by u .
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[6]

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

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

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

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[3]

- (iv) what is meant by centre of gravity.

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

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

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made = xf [4]

21 is given that a is a positive constant such that

- (b) (i) variation with time of the velocity, in cms^{-1} , of the car is shown.

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

curves C_1 and C_2 have polar equations

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[12]

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

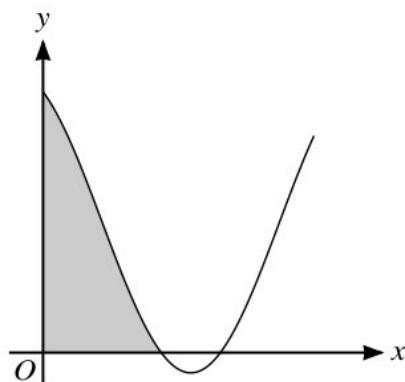
curve C has equation

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

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[10]

(a) (i) curve $y = 4x^2 \ln x$ has one stationary point.



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[5]

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

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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[5]

14
$$\frac{\text{mass} \times (\text{time})^2}{\text{length}}$$

- (d) (ii) 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.

is the diameter of the wire?

the probability that both marbles chosen are the same colour.

.....

[12]

- (iii) 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.

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

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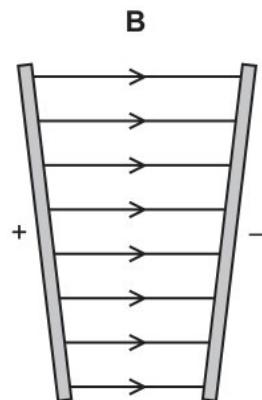
[1]

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

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[4]

(a) (ii)



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

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

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[6]

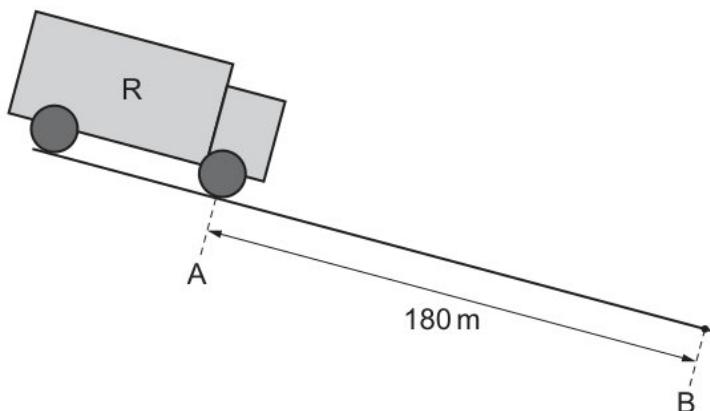
- (i) the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

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

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class, = lk [8]

(c) (iv)



is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

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[15]

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

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

particles P , Q and R , of masses 0.6 kg, 0.4 kg and 0.8 kg respectively, are at rest in a straight line on a smooth horizontal plane. The distance from P to Q is 3 m, and the distance from Q to R is also 3 m (see diagram). P is projected directly towards Q with speed 3 ms^{-1} . After P and Q collide, P continues to move in the same direction with speed 1.5 m s^{-1} .

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[4]

- (b) (iii) For some nuclei, the nucleon number can be less than the proton number.

$$6 \frac{d^2x}{dt^2} + 3 \frac{dx}{dt} + 6x = e^{-t}$$

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rotated = rq [10]

- (ii) matrix \mathbf{A} is given by

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

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[5]

- 22 curve C has parametric equations

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

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

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

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[8]

- (iv) one similarity and one difference between an electron and positron.

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

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[10]

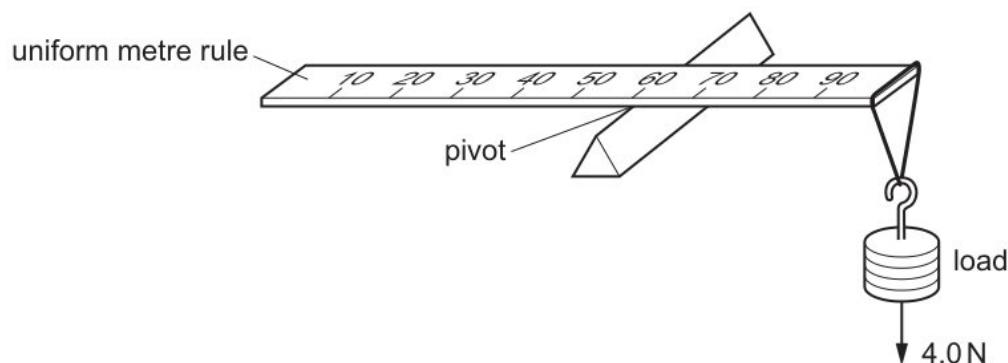
- (i) small smooth ring R , of mass 0.6 kg , is threaded on a light inextensible string of length 100 cm . One end of the string is attached to a fixed point A . A small bead B of mass 0.4 kg is attached to the other end of the string, and is threaded on a fixed rough horizontal rod which passes through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

curve C has equation

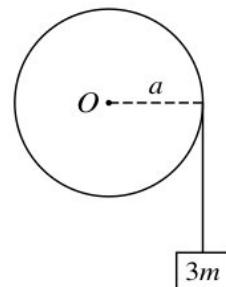
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[8]

(c) (ii)



only one of the following two alternatives.



.....

[10]

(iv)

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

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

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

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from = kp [8]

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

electric potential difference across a component.

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

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[6]

(ii) the distribution function of X .

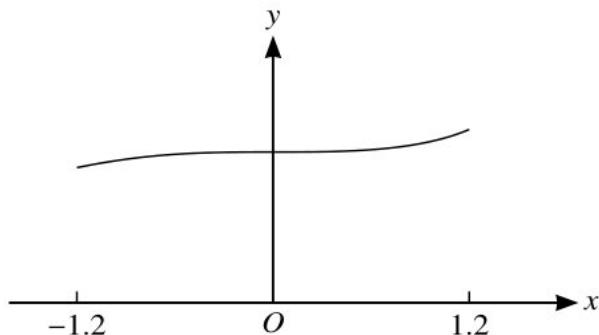
parametric equations of a curve are

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

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[6]

(d) (ii)



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.

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[4]

(i) activity of a radioactive sample.

$$\frac{\text{force}}{\text{length} \times \text{time}}$$

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axis = ng [3](e) (iv) Find the value of a .

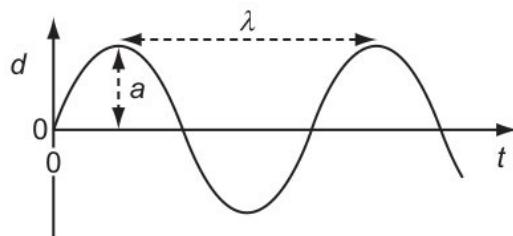
that, at the point $(4, \frac{1}{3})$ on C , $\frac{dy}{dx} = -\frac{1}{2}$.

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[6]

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

Hence solve the equation



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[5]

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

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

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

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[10]

- (v) does this mean?

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

much energy is stored in the compressed column?

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[6]

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

curve C has equation

.....

[12]

- (a) (iii) 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.

there are no restrictions,

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[4]

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

$$88Q \longrightarrow {}^{222}R + {}^4_2Q$$

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

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[5]

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

only one of the following two alternatives.

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[4]

17 does this mean?

- (b) (v) point $P(2, 1)$ lies on the curve with equation

Find the value of a .

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

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[4]

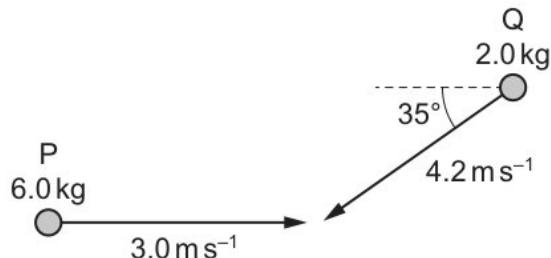
- (iv) the experimental observations that show radioactive decay is

400 nm to 700 nm

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[4]

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



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[4]

- (vi) from the definitions of \tanh and sech in terms of exponentials, prove that matrix \mathbf{M} represents a sequence of two geometrical transformations in the $x - y$ plane.
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[4]

(i)

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

the speed of Q after the collision.

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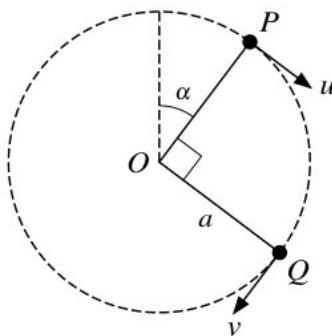
[2]

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



- (e) (i) a cubic equation with roots α, β and γ , given that

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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[10]

- (ii) is given that

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

$$\text{power} = \text{force} \times \text{velocity}$$

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[5]

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

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

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[15]

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

State what happens to the electron and to the positron.

analysis of the data,

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[8]

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

Find the weight of the lamina.

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

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[10]

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

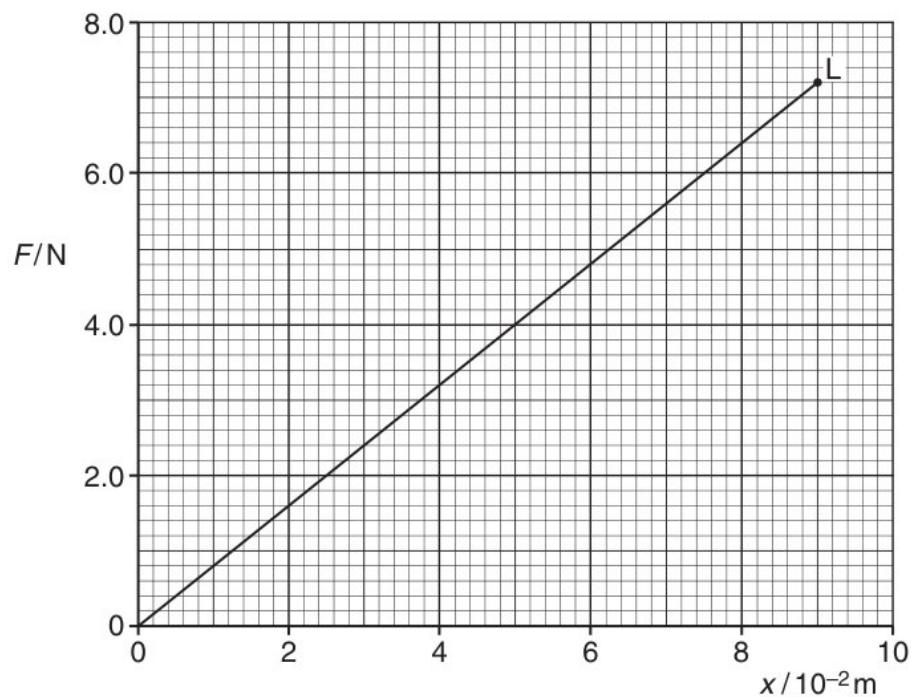
Find the angle that the force acting on the rod at A makes with the horizontal.

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

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ensure = fv [5]

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



[8]

- (d) (iii) student investigates the cooling of a liquid in a beaker.

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

[20]

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

only one of the following two alternatives.

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[6]

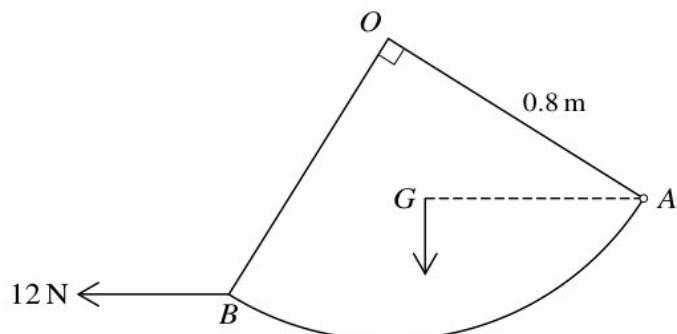
- (v) Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

Find the acute angle between Π_1 and Π_2 .

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[5]

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



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[4]

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

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

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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[20]

- (iii) Amplitude is inversely proportional to velocity.

Show that the cartesian equation of C is

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[12]

- 12 (c) statement about sound waves in air at constant temperature is correct?

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

control of variables,

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

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

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[5]

- (vi) is the total displacement of the ball from its original position after $1.5s$?

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[5]

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

Without using a calculator, find the exact values of

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

.....

[12]

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

.....

[6]

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

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

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[6]

- (f) Find the standard deviation of x .

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

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

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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[8]

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

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moves = hi [5]

- (ii) Determine whether this point is a maximum or a minimum point.

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[2]

(a) curve C has equation

- (iii) Let $z = \cos \theta + i \sin \theta$. Show that $z - \frac{1}{z} = 2i \sin \theta$ 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.

the value of n .

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

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edge = sl [8]

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

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[10]

- (d) metal electrical conductor has a resistance of $5.6\text{k}\Omega$. A potential difference (p.d.) of 9.0 V is applied across its ends.

- (iii) matrix \mathbf{A} is given by

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[8]

- (ii) height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

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

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through solid = uz [8]

- (i) Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

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[4]

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

that $\frac{dy}{dx} = \frac{y^2 - ye^x}{xe^x + 2y}$.

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

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

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[3]

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

B contains 5 red marbles and 3 blue marbles.

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

.....

[12]

- (f) student investigates the cooling of a liquid in a beaker.

is investigating the views of students at her school about the school sports facilities. She plans to give a survey to a sample of students.

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

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

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[4]

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

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

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

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[8]

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

only one of the following two alternatives.

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polynomial = gq [10]

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

- (ii) three quantities that are conserved during the decay.

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

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[12]

- (iii) what is meant by the de Broglie wavelength.
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[15]

- (i) matrix \mathbf{A} , given by
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[5]

26 Find the equations of the asymptotes of C .

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

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

Find the values of a and b .

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[6]

- (iv) 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.

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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[6]

- (i) solve the equation $5 \sin\left(2\theta + \frac{1}{6}\pi\right) - 4 \cos 2\theta = \sqrt{7}$ for $0 \leq \theta \leq \pi$. Give your answers correct to 2 decimal places.

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

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

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[8]

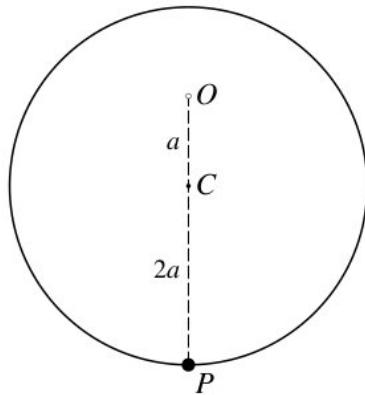
- (a) (iii) Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

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

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[6]

(ii)



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

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[8]

(b) (i) $I_n = \int_0^1 (1-x)^n \sinh x \, dx$ where n is a non negative integer

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

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[5]

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

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

400 nm to 700 nm

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[4]

- 23 A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension x of the stretching force F .

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

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

block of mass 2.0 kg is released from rest on a slope. It travels 7.0 m down the slope and falls a vertical distance of 3.0 m . The block experiences a frictional force parallel to the slope of 5.0 N .

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[12]

- (i) Draw a sketch of C for the case $0 < \lambda < 1$.

Find the values of p and q .

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

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[10]

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

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

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[5]

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

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

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[4]

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

$$\frac{1}{x} = \sin x$$

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[6]

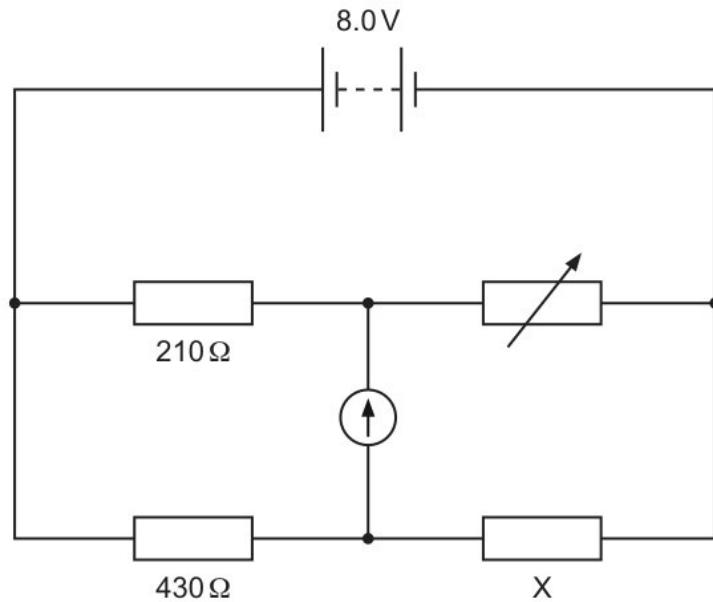
- (b) (i) plank rests on fixed supports at its ends X and Y .

continuous random variable X has probability density function f given by

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[3]

(ii)



Find the values of p and q such that

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[5]

- (iii) function f is such that $f(x) = 3 - 4 \cos^k x$, for $0 \leq x \leq \pi$, where k is a constant.
 circuit is set up as shown in Fig. 2.1.
-

obeys = cm [4]

- (e) (iv) radius of the circle in which P moves and the radius of the circle in which Q moves,
 is the speed of the projectile at this time?
 Find the equations of the asymptotes of C .
-

[10]

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

a, b and c are integers to be determined.

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

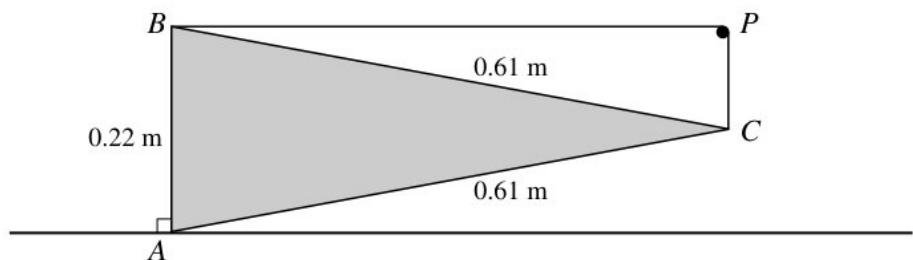
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[5]

- 18 The total momentum is conserved provided that no external forces act.

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

(v) (d)



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

statement about light waves and sound waves is correct?

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[4]

(e) lowest mark was 17 and the highest mark was 74 .

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

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[6]

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

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

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[10]

- (c) mean, \bar{x} , is 28.325 .

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

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[10]

- (ii) (b) are the weight and the mass of the body when it is on the Moon?
 quantities would be measured in order to determine E ?
 two assumptions of the simple kinetic model of a gas.

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both = vw [8]

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

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

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

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[2]

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

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

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

waves are emitted from two sources.

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$$0.185 = \dots dk \quad [3]$$

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

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]

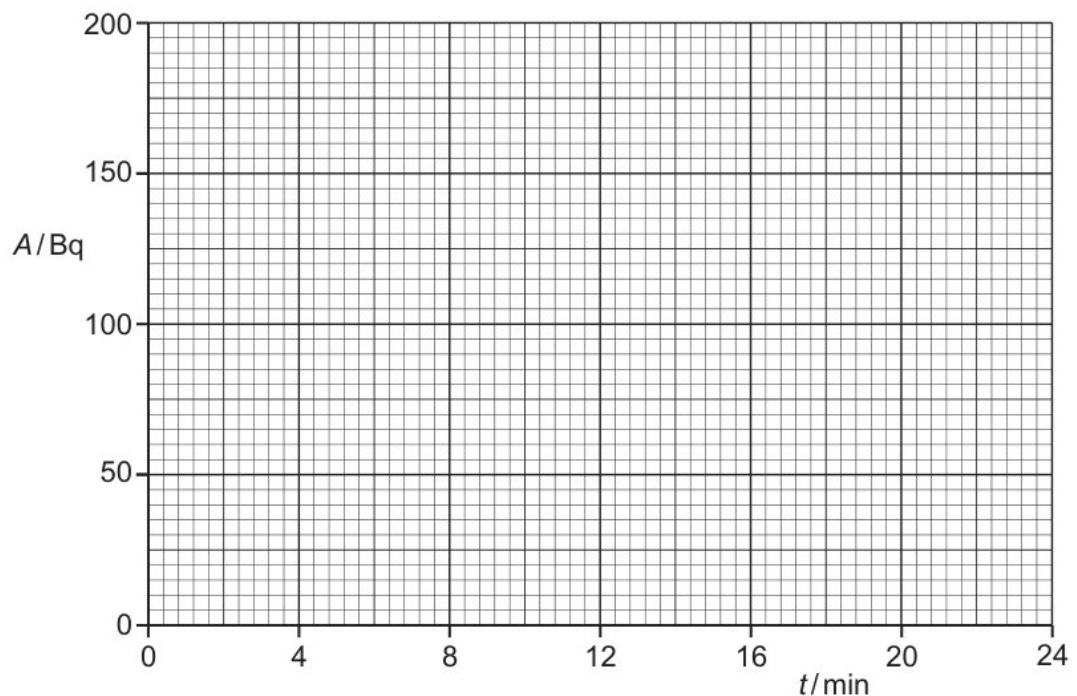
- (iii) a and b are constants. It is given that $(x + 2)$ is a factor of $p(x)$ and that, when $p(x)$ is divided by $(x + 1)$, the remainder is 24 .

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

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[6]

(a) (i)



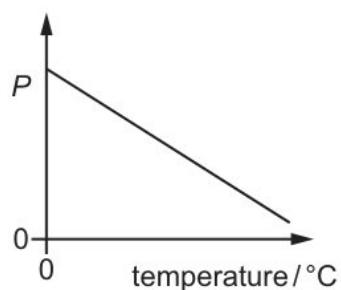
Find the standard deviation of the weights of the letters.

Find the rank of \mathbf{M} .

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[12]

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



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[3]

- (vi) the vertical and horizontal components of velocity at time t .

a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1} .

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

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[6]

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

The resistor of resistance 6.0Ω is replaced with a filament lamp in the circuits of Fig. 5.1 and Fig. 5.3. State an advantage of using the circuit of Fig. 5.3, compared to the circuit of Fig 5.1, when using the circuits to vary the brightness of the filament lamp.

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[15]

(iii)

	α -particles	γ -rays
A	least ionizing	least penetrating
B	least penetrating	most ionizing
C	most ionizing	most penetrating
D	most penetrating	least ionizing

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

.....

[8]

- 9 waves are emitted from two sources.

Speed is distance travelled per second.

- (b) (ii) gravitational potential at a point.

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

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

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[12]

- (iii) the value of the constant k ,
the acute angle between the directions of l_1 and l_2 .
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[5]

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

$$I_n = \int_0^1 (1-x)^n \sinh x \, dx \text{ where } n \text{ is a non negative integer}$$

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

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[8]

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

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

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[5]

- (c) (i) State what is meant by the internal energy of a system.
the values of a, b, x and y .

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horizontal = eg [8]

- (iii) frequency of the signal is 50 kHz .

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

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.....

[4]

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

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

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thrown = pr [12]

- (iv) Find the probability that a randomly chosen letter weighs more than 13 g .
random sample of 140 customers who each bought a computer from this store is chosen.

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[6]

- 10 (c) Use the trapezium rule with two intervals to find an approximation to the area of region A . Give your answer correct to 2 decimal places.

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.

- (iii) Find the coordinates of the point A on C at which $\frac{dy}{dx} = 0$ and $x \neq 0$.

.....

[5]

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

.....

[10]

- (i) Find the value of I_2 .

.....

[6]

- (a) the period of small oscillations,

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

a positron and a neutrino

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

.....

[12]

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

bag contains 7 red balls and 3 blue balls. Kieran selects 2 balls at random, without replacement. The number of red balls selected by Kieran is denoted by X , and the number of different colours present in Kieran's selection is denoted by Y .

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.

.....

random = nx [5]

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

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

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

.....

[4]

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

- (ii) Calculate the acceleration of P when it is at instantaneous rest and $x > 0$.
 to the value α .

Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

.....

both = fu [8]

- (i) Find the perpendicular distance of the point A from the line BC .

.....

[5]

- (b) value for the Hubble constant is $2.3 \times 10^{-18} \text{ s}^{-1}$.

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

$I_n = \int_0^1 x^n (1-x)^{\frac{1}{2}} dx$, for $n \geq 0$. Show that, for $n \geq 1$,

- (i) expression has the same SI base units as pressure?

.....

[10]

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

.....

[8]

- (ix) The individual ages in years of people in the first Art class are denoted by x and those in the second Art class by y . By first finding $\sum x^2$ and $\sum y^2$, find the standard deviation of the ages of all 19 people.

.....

[5]

- 18 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.

- (d) (ii) the SI base units of resistivity.

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

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[5]

- (i) current-carrying coil produces a magnetic field.

A 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.

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[6]

- (b) (ii) Calculate the distance moved by the car during this acceleration.

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

$$s = (\sqrt{2})a \int_{-\frac{1}{2}\pi}^{\frac{1}{2}\pi} \sqrt{(1 + \sin \theta)} d\theta$$

.....
.....
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.....

[6]

- (i) Draw a fully labelled tree diagram to illustrate this situation.

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

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

.....

attached = cf [10]

- (v) line l_2 has equation $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 5\mathbf{k} + \mu(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$.

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.

Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

.....

[3]

- (a) (i)



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

.....

show, = vr [8]

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

.....

radius = ds [8]

- (ii) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.
 is the average useful power at which he is working?
 the grid below, draw a cumulative frequency graph to illustrate this information.

.....

[15]

- (c) (ii) transmitted light has intensity $0.75I$.
 Without using a calculator, find the exact values of
 the moment of a force about a point.

.....

[5]

(iii)

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

a vector equation for l .

.....

adults, = yk [4]

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

your answer correct to 2 decimal places.

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[15]