20 velocity = acceleration × time

do each of the symbols represent for an electric current in a metal wire?

$$\sec 5\theta = \frac{\sec^5 \theta}{5\sec^4 \theta - 20\sec^2 \theta + 16}$$

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

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

[2]

exactly at point T

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

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

[12]

(b) the probability of a Type I error.

[4]

22 Find the distance OM.

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

$$\Sigma b = 92.0 \quad \Sigma b^2 = 216.5 \quad \Sigma g = 129.8 \quad \Sigma g^2 = 288.8$$

[5]

(b) up to down

[8]

(e) (vi) $\frac{1}{(2r+1)(2r+3)}$ in partial fractions and hence use the method of differences to find that the mean of these 40 values is 124.0 , find the value of k.

[10]

(ii) Pressure is force per unit area.

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

Express $\frac{5x-x^2}{(1+x)(2+x^2)}$ in partial fractions.

[15]

Given that $v = 2.5$, find x.

(i) transmitted light has intensity $0.75I$.

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

[4]

(d) particle moves in a straight line. The velocity v ms^{-1} of the particle t s after leaving a fixed point O is given by $v = k\left(20 + pt - 6t^2\right)$, where k and p are constants. The acceleration of the particle at $t = 1$ is 42 ms^{-2}, and the displacement of the particle from O at $t = 1$ is 93 m .

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

[12]

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

ensure = ... xo **[4]**

17 the differential equation, obtaining a relation between x and y.

[12]

21 (e) parametric equations of a curve are

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

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

[4]

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

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

[6]

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

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

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.

[4]

the instant when the rule is horizontal, what is the resultant moment about the pivot?

(iv) are speed v_1 and speed v_2 ?

[6]

how the pattern of interfering waves may be observed.

(ii) Draw a fully labelled tree diagram to illustrate this situation.

[2]

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

that l_1 and l_2 do not intersect.

(iv) Over 50 198 212 217 229 235 242

[5]

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

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

process does not require energy to be supplied?

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

[6]

(b) Wavelength is proportional to amplitude.

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

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

[6]

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.

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

Use de Moivre's theorem to show that

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

[5]

(a) 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.

It results in the measured value being different from the correct value.

(ii) procedure to be followed,

[5]

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

(i) Sound waves are transverse waves and light waves are longitudinal waves.

[6]

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

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

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

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

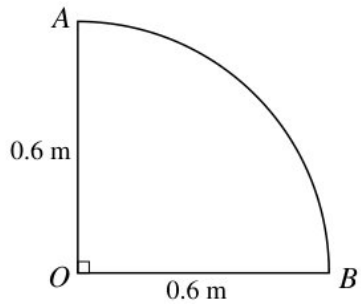
[8]

8 up the probability distribution table for X.

[4]

16 diagram shows the force-extension graph produced.

matrix **A**, given by



400 nm to 700 nm

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

matrix **A**, given by

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 .

[15]

this compression, work W is done on the gas.

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

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

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

[1]

the values of ωz_1 and ωz_2 Give your answers in the form $re^{i\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

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

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 .

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

[10]

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

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

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

[5]

(b) a positron and a neutrino

[4]

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

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

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

[6]

(a) body has a weight of 58.9 N when on the Earth. On the Moon, the acceleration of free fall is 1.64 m s^{-2}.

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

[5]

33 parametric equations of a curve are

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

object is fully submerged in a liquid.

parametric equations of a curve are

[4]

22 Show that x satisfies the equation

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

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

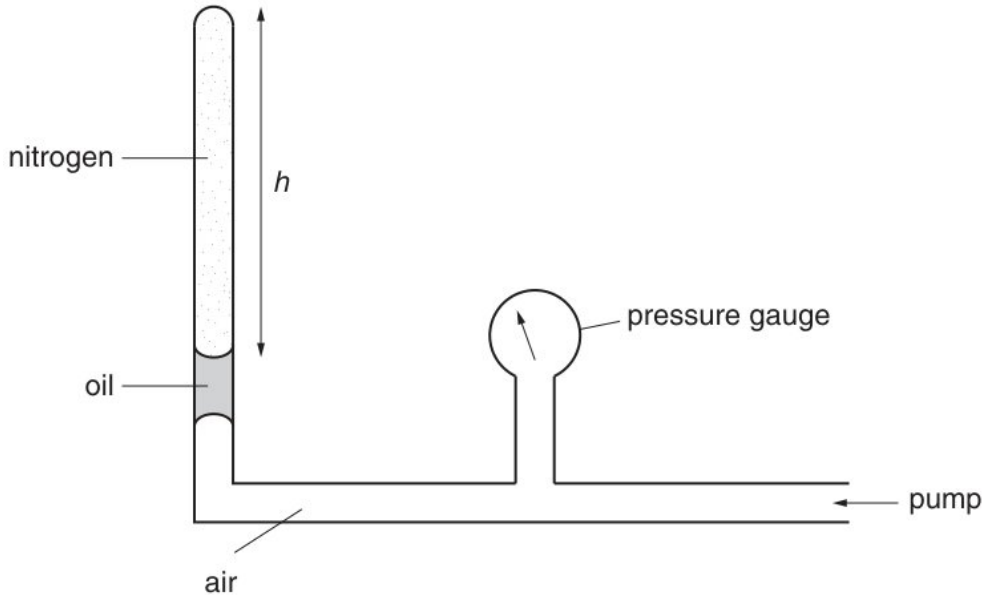
[8]

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

(b) only one of the following two alternatives.

[6]

(c) (ii)

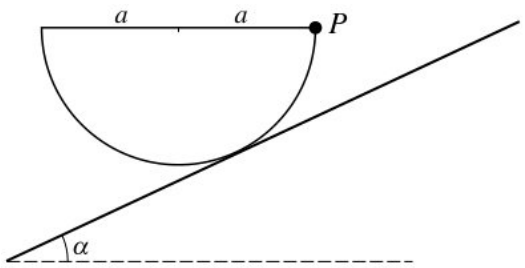


the time that it takes for the block to move 2 m down the plane from rest.

[10]

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

(i) 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



[6]

(a) Express u in the form $x + iy$, where x and y are real.

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.

specific latent heat.

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

[8]

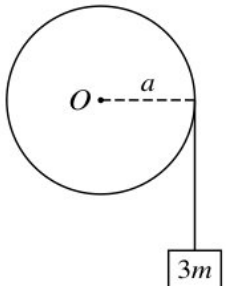
22 Show that the possible values of α are 3 and 5 .

[10]

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

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

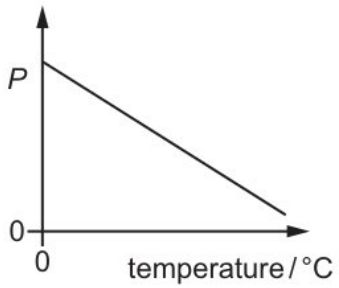
By sketching a suitable pair of graphs, show that the equation



[8]

the SI base units of resistivity.

(iii)



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

[12]

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

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

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

[15]

(iv) truck R of mass 9400 kg moves with constant acceleration in a straight line down a slope, as illustrated in Fig. 3.1.

Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

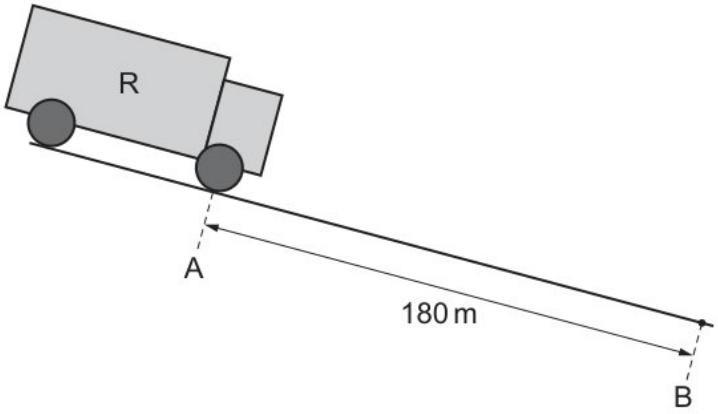
[5]

Find the equations of the asymptotes of C.

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

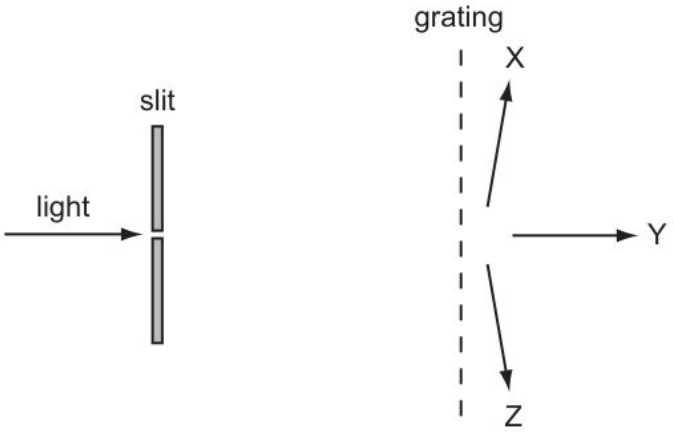
some of the oil evaporates, the droplet loses mass and starts to accelerate. Its charge remains constant.

(i) a suitable approximation to find the probability that more than 24 of these customers bought a computer made by company H.



[8]

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



[6]

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

the torque of a couple.

[10]

17 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).

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

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

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

[4]

solve the equation $5\sin\left(2\theta + \frac{1}{6}\pi\right) - 4\cos 2\theta = \sqrt{7}$ for $0 \leqslant \theta \leqslant \pi$. Give your answers correct to 2 decimal places.

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

Draw up a probability distribution table for X.

It results in the measured value being different from the correct value.

[10]

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

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

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

[5]

(d) (i)

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

student investigates the cooling of a liquid in a beaker.

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

[8]

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

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

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

[4]

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

(ii) is the grand-daughter product?

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.

[1]

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

(iv) is the reading on the ammeter?

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

[4]

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

gas, increase = ... xn **[6]**

13

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

up to down

[4]

17 roots of the equation

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

[5]

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

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

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

[12]

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

(iv)

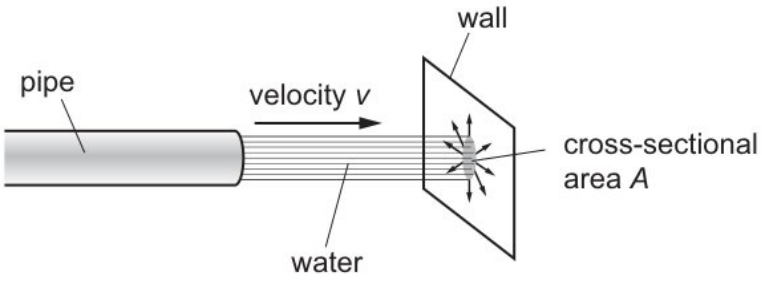
	α-particle	β-particle	γ-radiation
charge			0
mass	$4u$		
speed		up to $0.99c$	

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

[3]

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

(i)



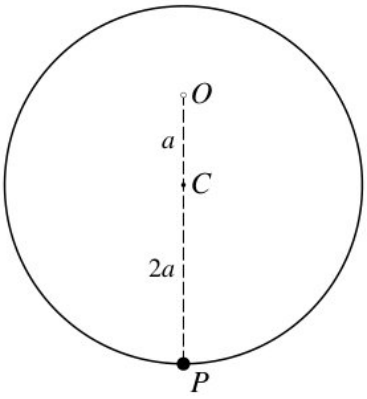
the time from release until OP makes an angle $\frac{1}{2}\alpha$ with the downward vertical for the first time.

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

[12]

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

Calculate the exact value of I_1 and deduce the exact value of I_3.



[3]

8 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.

[12]

20 parametric equations of a curve are

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

[10]

(b) up to down

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

[4]

23 analysis of the data,

diagram best represents the electric field surrounding the charges?

[2]

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

[6]

15 battery is marked 9.0 V .

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

[10]

14 The weight of the plank is causing a clockwise moment.

[5]

32 Find the equations of the asymptotes of C.

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.

[5]

22 then it converges to a.

(a) 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.

[4]

(c) (iii) temperature θ_{R} of the laboratory is measured using a thermometer.

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

Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

from = ... ms **[4]**

- coming to rest instantaneously on hitting the ground.

(i) that, at the point $\left(4, \frac{1}{3}\right)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -\frac{1}{2}$.

State the work W done by F.

[6]

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 .

(ii) exactly at point T

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

[5]

researcher wishes to test at the 1% significance level whether the mean concentration of the protein in the blood stream of patients taking the drug is less than 0.185 .

the tension in the string and the acceleration of the particles.

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

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

[5]

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

[5]

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

[5]

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

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

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

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

[8]

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

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

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

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

only one of the following two alternatives.

[5]

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

[12]

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

[6]

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

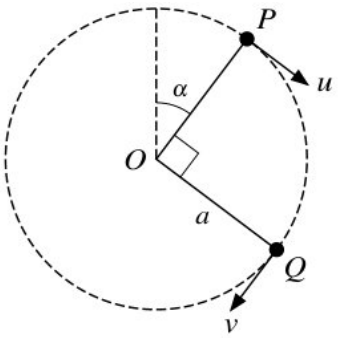
why the variation with time of the activity of a radioactive sample is exponential in nature.

the value of μ and the value of X for which the block is on the point of moving up the plane.

with = ... gp **[15]**

17 does this mean?

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



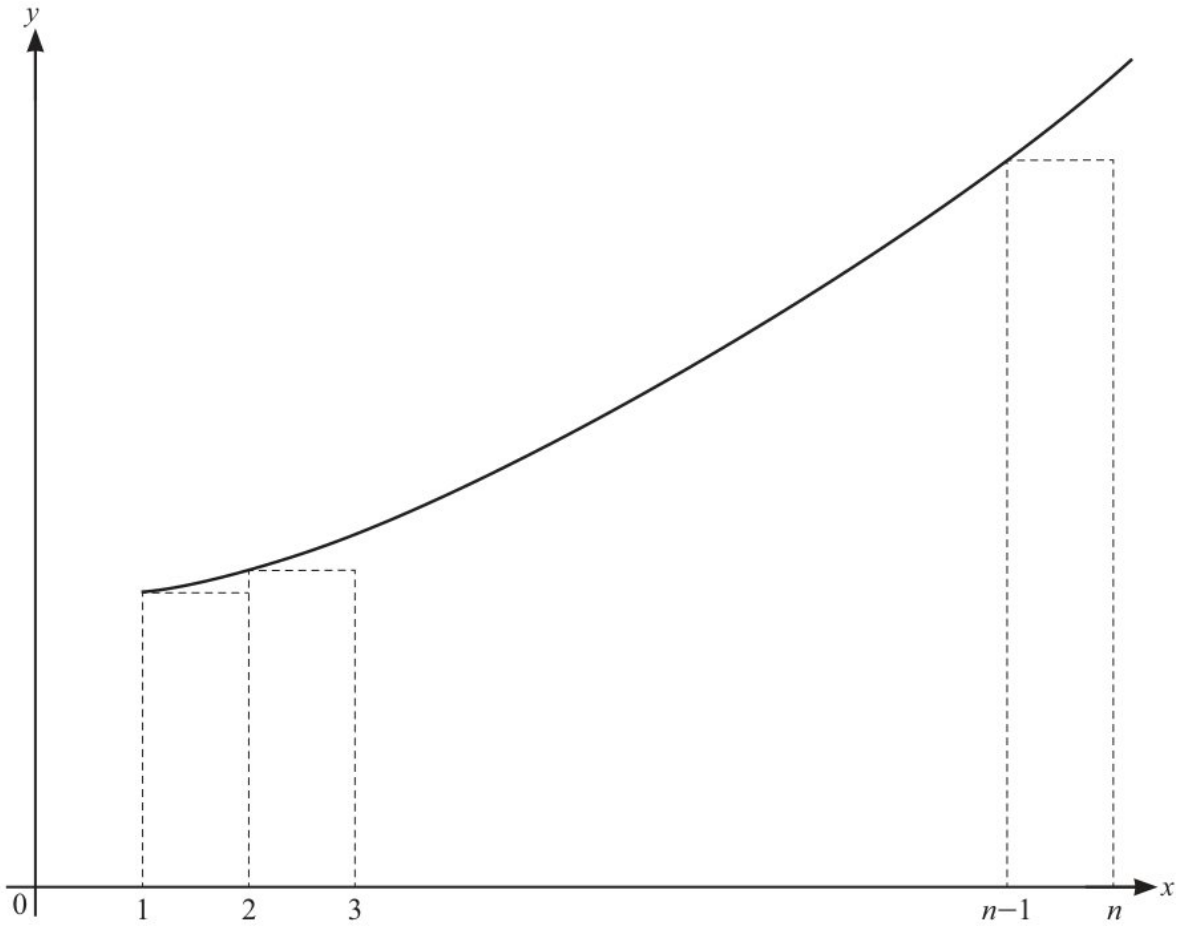
(a) State the equation of the other asymptote.

Estimate the probability of throwing a 4.

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

[6]

(c) (iii)



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

[10]

Find the equations of the asymptotes of C.

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

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

[3]

lowest mark was 17 and the highest mark was 74 .

(iv) It results in repeated measurements having different values from each other.

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

[10]

(b) is the total displacement of the ball from its original position after $1.5s$?

[6]

(f) and N are two electromagnetic waves.

[8]

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

(b) 800 nm to 1000μ m

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

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

stream whether = ... *or* **[8]**

(c) (ii) position vectors of points A, B, C, relative to the origin O, are $\mathbf{a}, \mathbf{b}, \mathbf{c}$, where the value of σ.

[4]

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

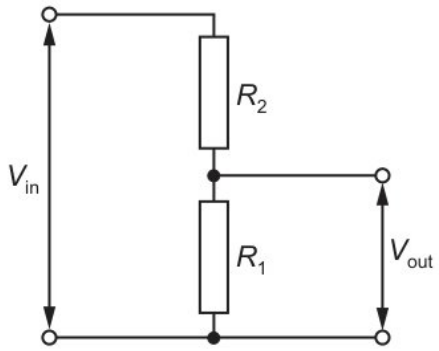
(v) Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

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

[8]

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

(iv)



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

[6]

(a) (iii) none of them

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?

are the amplitude and the period of wave S ?

[6]

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

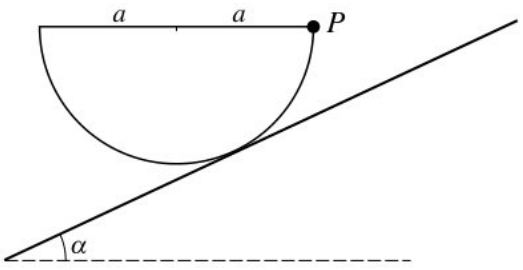
(i) Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

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

metre = ... *sl* **[2]**

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

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



[8]

20 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.

[5]

13 researcher records the time, T seconds, taken by adults to complete a questionnaire.

(iv) (a) the form $\sec(q\pi)$ where q is rational

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

[2]

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

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

[3]

(ii) (f) 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.

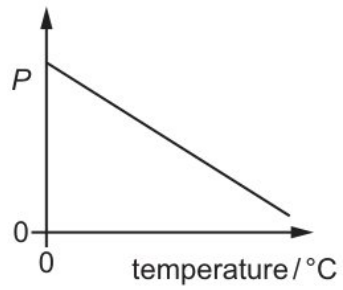
Deduce that the cartesian equation of C is

[10]

temperature θ_R of the laboratory is measured using a thermometer.

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

battery is marked 9.0 V .



[5]

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

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

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

[2]

8 wires X and Y are made of different metals. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

[4]

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

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 .

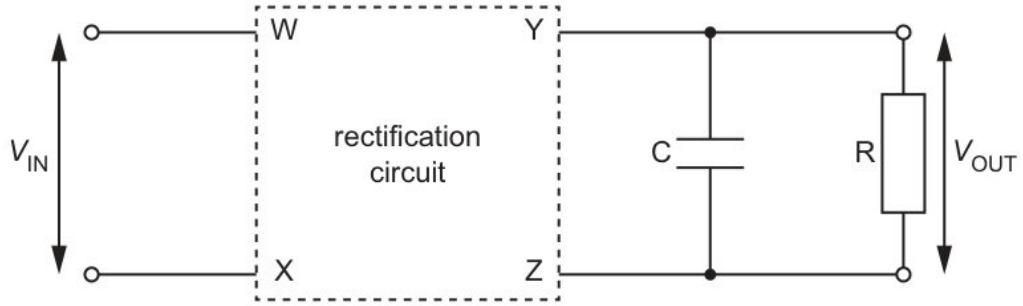
the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

[8]

25 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 .

[10]

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



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

[12]

19 finding a cubic equation whose roots are α, β and γ, solve the set of simultaneous equations

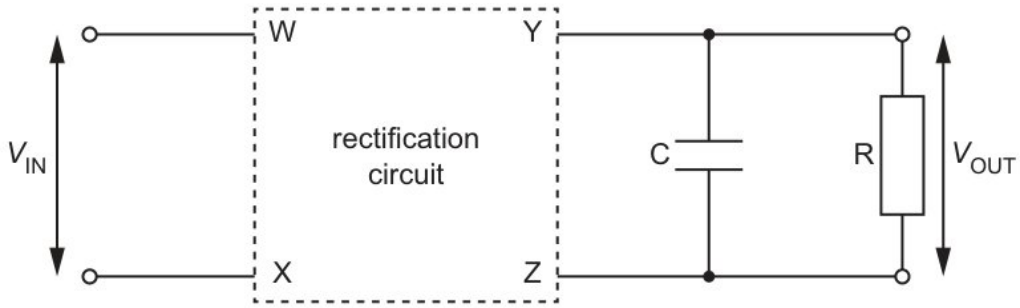
(a) (iii) that $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$ is an eigenvector of the matrix $\mathbf{D}$, where

the values of a, b, x and y.

[15]

It results in the measured value being different from the correct value.

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



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

[5]

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

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

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

[5]

(b) 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.

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

[15]

22 frequency of the signal is 50 kHz .

[10]

12 the vertical and horizontal components of velocity at time t.

[6]

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

points A, B, C have position vectors

curve C has equation

Find the probability density function of Y.

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

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

[5]

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

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

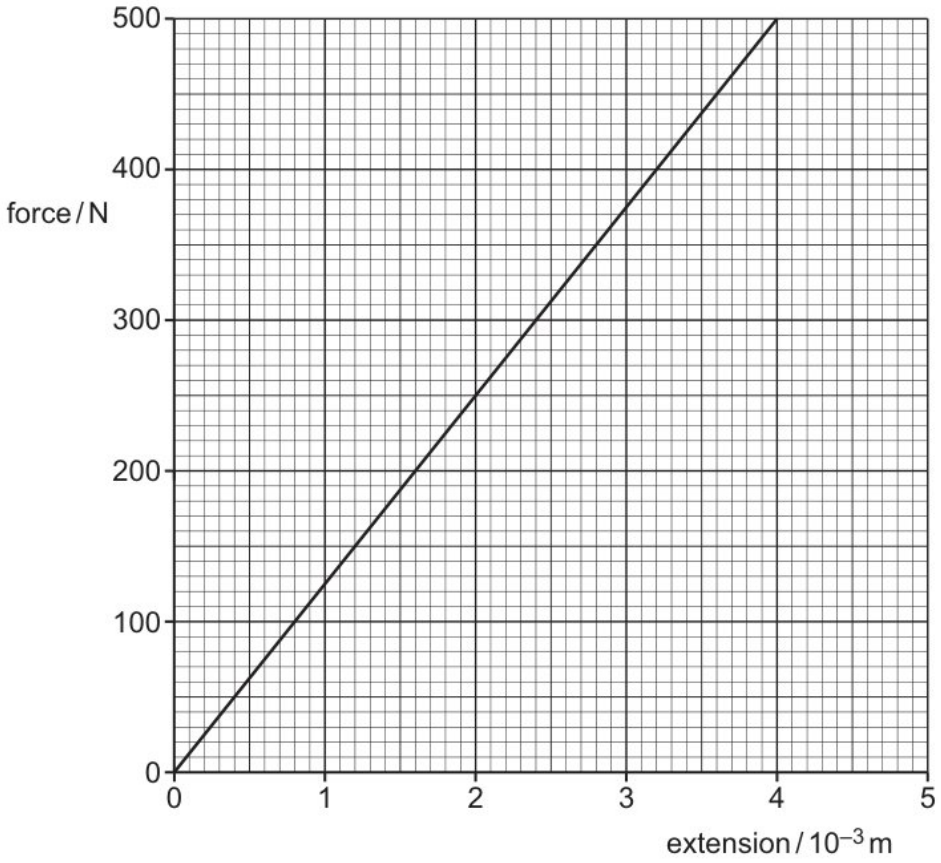
The total momentum and the total kinetic energy are always conserved.

Find the mean age of all 19 people.

[5]

Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

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



frequency of the signal is 50 kHz .

[10]

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

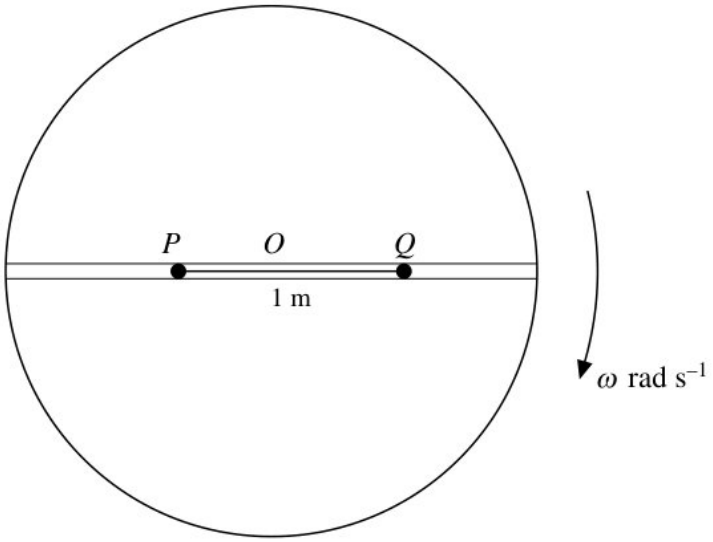
(v) Determine whether this point is a maximum or a minimum point.

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

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

when = ... xu **[2]**

(a) (iv)



this compression, work W is done on the gas.

is the mass of the car?

[5]

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

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

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.

[5]

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

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

[5]

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

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

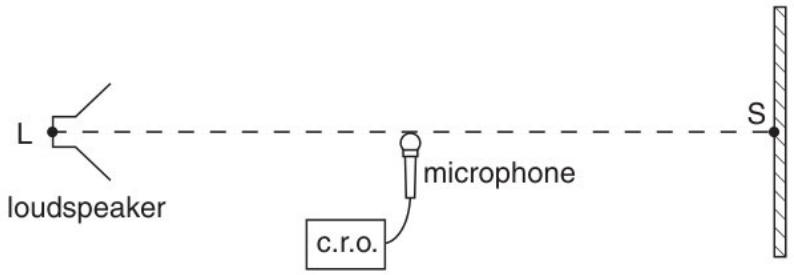
the value of the constant k,

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

[8]

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

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



[10]

Find the value of a.

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.

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

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

[2]

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

(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

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

[2]

(c) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{1}{\sin\theta\cos^3\theta}$.

[8]

(d) (i) Find the perpendicular distance of the point A from the line BC.

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

[1]

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

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

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

[8]

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

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

[15]

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

(ii) is the angle θ ?

the vertical and horizontal components of velocity at time t.

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

[6]

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

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

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

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

[8]

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

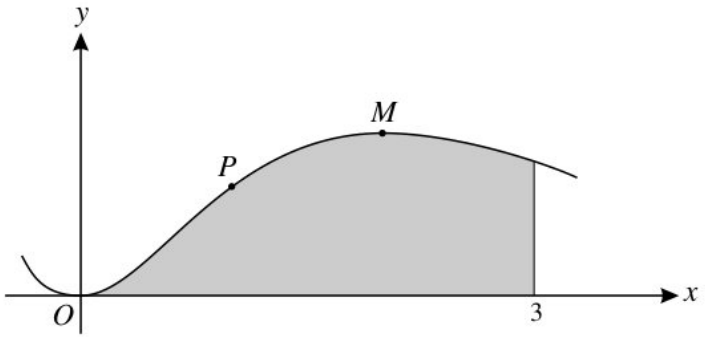
(iii) Find the area of the sector of C between $\theta = 0$ and $\theta = \frac{1}{3}\pi$.

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

[12]

Calculate the exact value of I_1 and deduce the exact value of I_3.

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



[10]

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

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

Calculate the distance moved by the car during this acceleration.

[5]

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

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

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]

relationship is used in the derivation of the equation shown?

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

Find the equations of the asymptotes of C.

[5]

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

$$^{235}_{92}\mathrm{U} + {}^{a}_{b}\mathrm{n} \rightarrow {}^{141}_{x}\mathrm{Ba} + {}^{y}_{36}\mathrm{Kr} + 3{}^{a}_{b}\mathrm{n}$$

[4]

is the mass of the car?

(ii)

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

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 $AC = a$.

[3]

9 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.

what is meant by the de Broglie wavelength.

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

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

[8]

(b) (iii) to the value α.

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

[5]

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

(v) Find the value of I_2.

Calculate the distance moved by the car during this acceleration.

[8]

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

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

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

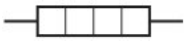
is given that λ is an eigenvalue of the non-singular square matrix $\mathbf{A}$, with corresponding eigenvector $\mathbf{e}$.

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

[5]

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

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



[10]

26 to the value α.

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

[5]

(d) the probability density function of Y,

[4]

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

[2]

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

are no resistive forces acting on the block.

(a) (iii) Find the work done by the tension.

equation of a curve is $x^3y - 3xy^3 = 2a^4$, where a is a non-zero constant.

[6]

Given that $\begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$ is an eigenvector of $\mathbf{A}$, find the corresponding eigenvalue.

(i) Show that x satisfies the equation

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

[8]

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

(ii) the gradient of the curve

the eigenvalues of the matrix $\mathbf{C}$, where

from centres = ... ea **[5]**

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

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

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.

[10]

Show that, for $n > 2$,

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

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

parametric equations of a curve are

[6]

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

[8]

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

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

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

[6]

Find the probability that a box is rejected.

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

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

[4]

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

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

[3]

(c) that the object is on the point of toppling in its vertical plane about the vertex D, find the value of k.

[5]

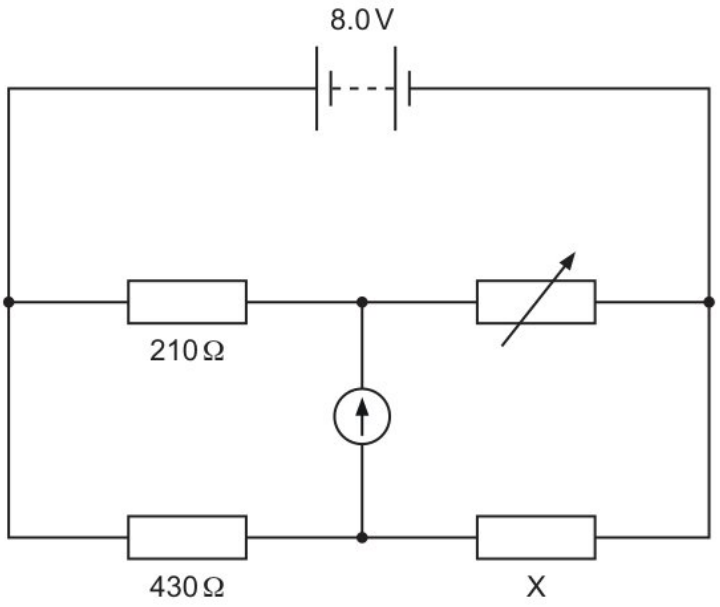
22 diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

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

curve C has equation

$$I_n = \int_0^{\frac{1}{4}\pi} \tan^n x \, \mathrm{d}x$$

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



[3]

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

[20]

20 Hence show that the differential equation

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

[6]

23 $\frac{\text{force}}{\text{length} \times \text{speed}}$

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

no unique solution.

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

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

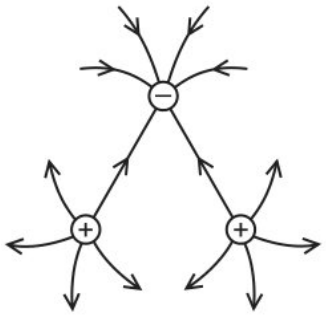
a laboratory experiment that uses a Hall probe to test the relationship between B and r. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

[5]

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

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

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



[6]

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

[4]

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

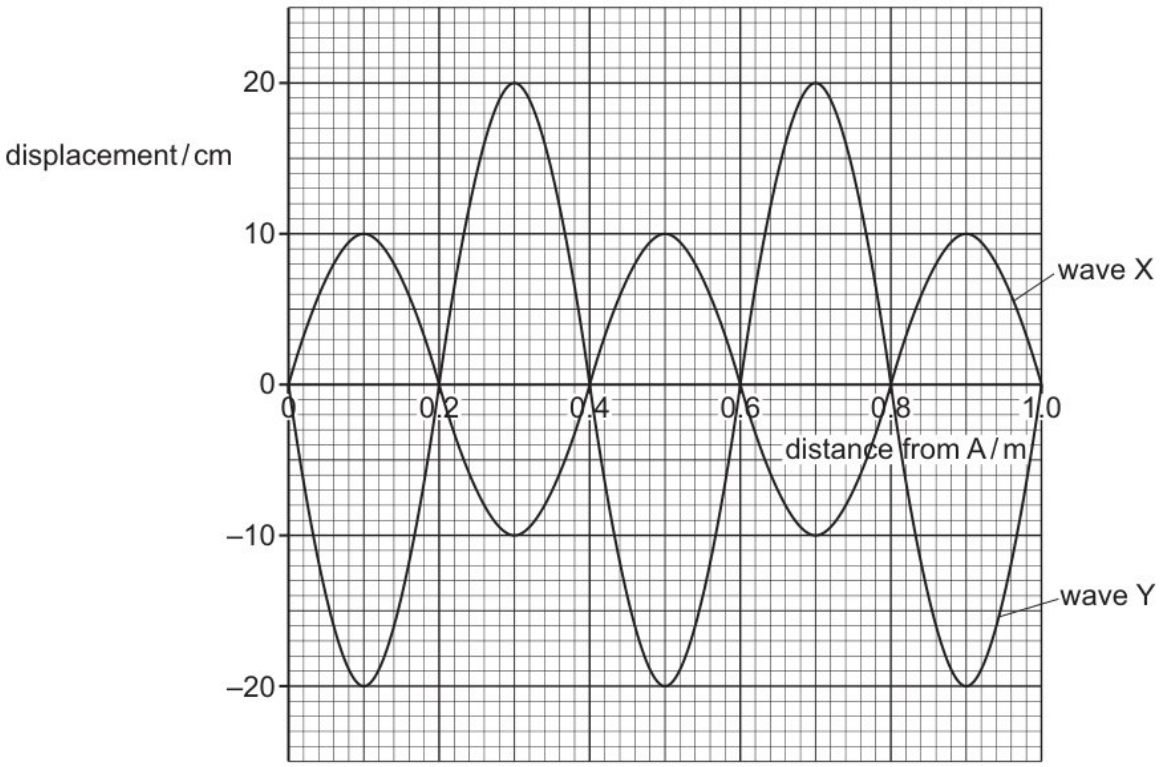
considering the binomial expansion of $\left(z - \frac{1}{z}\right)^5$, where $z = \cos\theta + \mathrm{i}\sin\theta$, use de Moivre's theorem to show that

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

[8]

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

(v)



Find the cartesian equation of Π_2.

[8]

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

[15]

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

[10]

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

(c) (ii) Express f(x) in partial fractions.

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

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

[10]

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

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

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

through = ... *bl* **[5]**

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

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

speeds of the particles.

junction = ... *jv* **[8]**

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

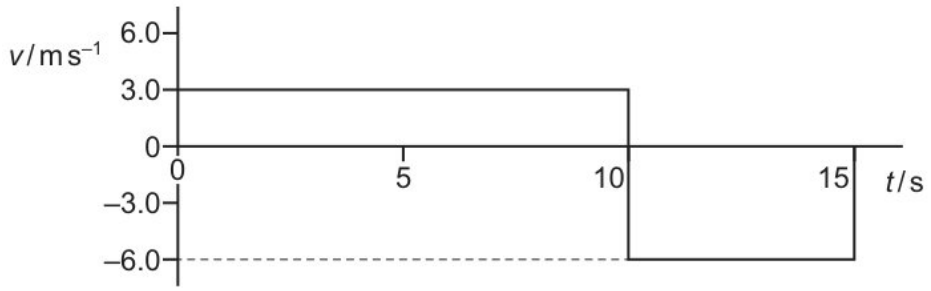
why the variation with time of the activity of a radioactive sample is exponential in nature.

[5]

beyond point S but before point T

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

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



[6]

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

(ii) the equation for this decay.

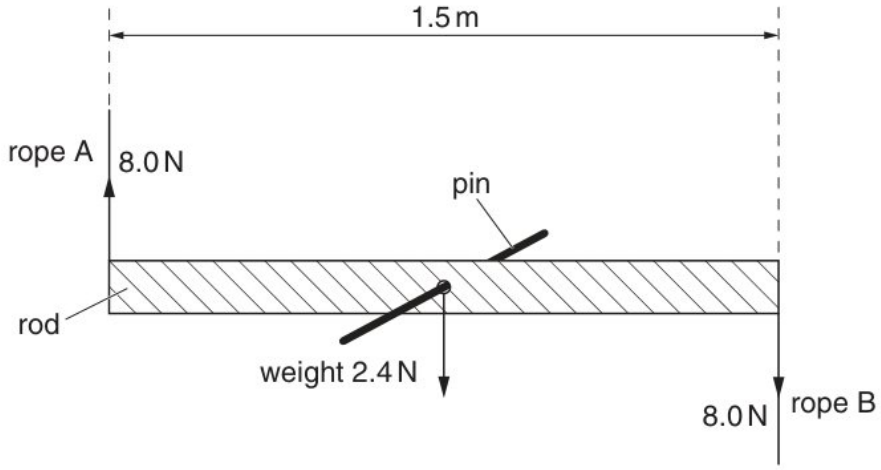
times taken to run 200 metres at the beginning of the year and at the end of the year are recorded for each member of a large athletics club. The time taken, in seconds, at the beginning of the year is denoted by x and the time taken, in seconds, at the end of the year is denoted by y. For a random sample of 8 members, the results are shown in the following table.

$$n = 150 \quad \Sigma x = 27.0 \quad \Sigma x^2 = 5.01$$

[4]

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

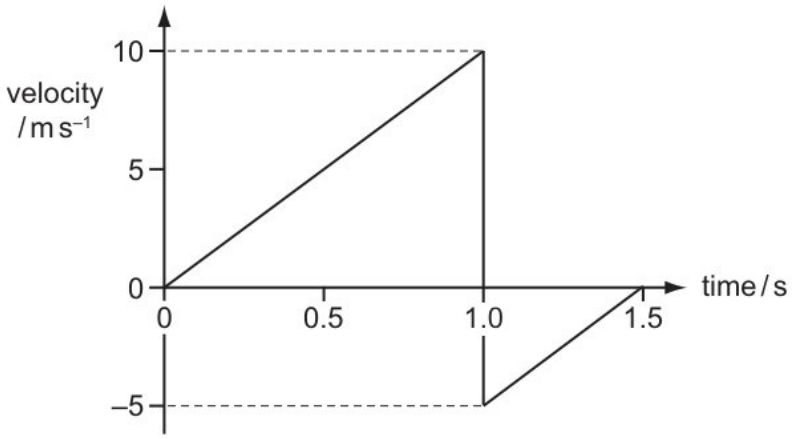
(i)



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

[5]

6 this compression, work W is done on the gas.



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

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

[10]

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

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

[5]

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

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

the principle of superposition.

[4]

quantities would be measured in order to determine E ?

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

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

[8]

16 random variable X is the number of heads obtained.

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

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

(b) row describes the resultant force and resultant torque on the object?

[6]

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

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

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

[6]

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

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

[8]

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

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.

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

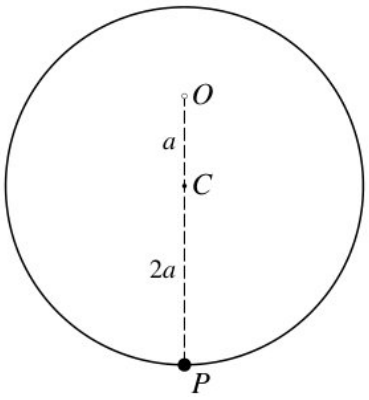
Find a set of corresponding eigenvectors.

[5]

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

[12]

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



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

[20]

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

Find a set of corresponding eigenvectors.

[8]

17 Find the x-coordinate of M.

diagram shows the electric field between the plates?

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

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

speed = ... ta **[10]**

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

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

Find the cartesian equation of Π_1.

[6]

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.

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

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

[6]

(c) (iii) 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.

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

[10]

Find the speed of P when it passes through L.

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

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

the median value of X.

particle is not involved in the decay process?

[6]

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

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

exactly at point T

[5]

(b) (ii) continuous random variable X has probability density function f given by

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

[5]

a 5% significance level, test whether there is an association between the area lived in and preference for improving the local bus service or improving the quality of road surfaces.

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

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

[10]

(f) (ii) - decelerating at a constant rate with the parachute open,

the number of different arrangements of the 7 men and 4 women in a line in which all the men stand together and all the women stand together.

[8]

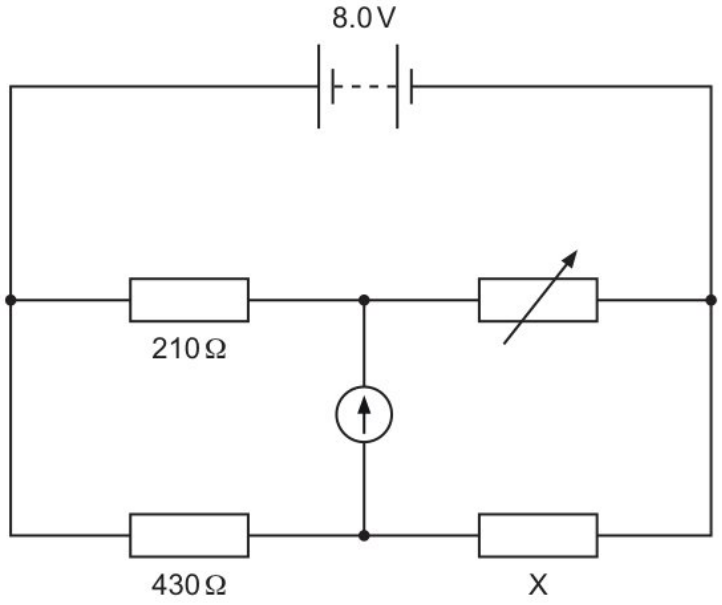
the equations of the asymptotes of C.

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

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

[4]

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



(i) that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{y^2 - y\mathrm{e}^x}{x\mathrm{e}^x + 2y}$.

curve C has equation

[6]

11 There will always be 9.0 V across the battery terminals.

(c) (iii) Calculate the distance moved by the car during this acceleration.

the term isotope.

[10]

marble is now chosen at random from bag B.

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

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

[10]

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

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

Find the weight of the lamina.

[10]

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

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

was the by-product of this reaction?

[8]

(d) the principle of superposition.

[4]

21 parametric equations of a curve are

(c) (i) the principle of superposition.

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

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.

[2]

is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

(iv) exactly at point T

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

[6]

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

[5]

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

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

[8]

(b) the general solution of the differential equation

[2]

31 only one of the following two alternatives.

[3]

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

chosen many = ... rj **[12]**

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

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

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

[15]

(e) (iii) only one of the following two alternatives.

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.

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

[10]

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

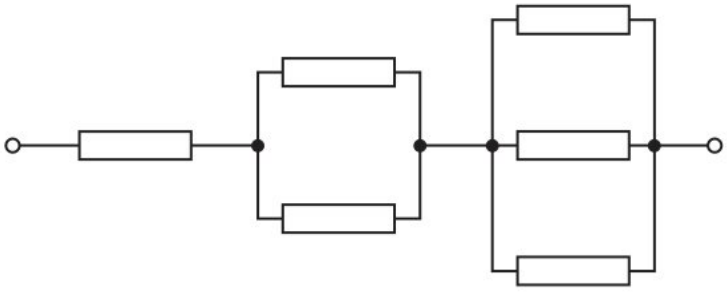
(iv) is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of $0.2g$?

Find the value of x.

[3]

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

(i) only one of the following two alternatives.



[6]

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

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

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

[6]

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

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

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

[12]

(e) points A, B, C have position vectors

$$\sin 5\theta = 5\sin\theta - 20\sin^3\theta + 16\sin^5\theta$$

[12]

17

Gulls	7.9	8.2	8.3	8.6	8.6	8.8	9.2	9.7	9.8	10.0	10.4
Herons	9.5	9.9	8.5	8.1	9.2	10.8	8.3	9.7	9.3	9.9	8.7

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

[10]

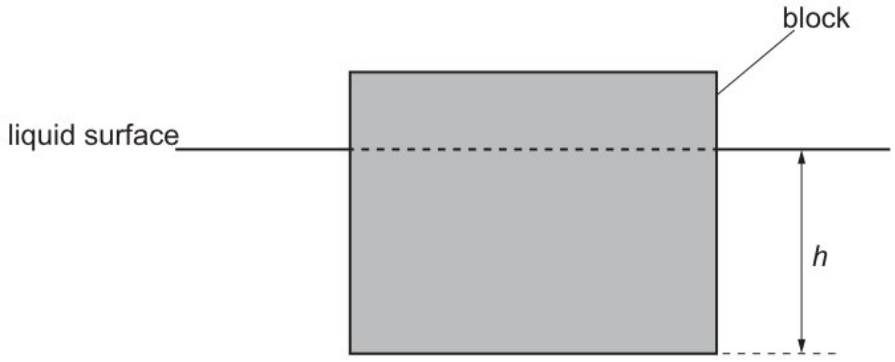
27 the polar coordinates of the points of intersection of C and l.

variables x and y are related by the differential equation

the graph of $y = |2x - 3|$.

[6]

20



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

[3]

28 the particular solution of the differential equation

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

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

C in the case $p = -1$. Your sketch should indicate the coordinates of any intersections with the axes, but need not show the coordinates of any turning points.

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

[6]

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

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

[1]

Find the values of p and q.

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

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

[8]

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

(iii) that $k = 3$ and $p = 26$.

exactly at point T

[3]

(a) Frequency is inversely proportional to wavelength.

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

[8]

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

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

[4]

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

[6]

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

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 .

(i) the length of C.

the value of V.

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

[5]

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

(iv) State the value of $E(X)$.

[3]

(a) 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.

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

[15]

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

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

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 $(x - 2)$.

[5]

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

[6]

14 why Kieran is incorrect.

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

the matrix **A**,

Show that the tension in the string is 10 N .

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

[6]

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

random variable X has the distribution Po(1.5).

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

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.

[6]

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

Find the area of the region enclosed by C.

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

Show that $v\frac{dv}{dx} = 5 - 0.5v^2$.

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

[2]

19 Hence find the solutions of the equation

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

[6]

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

[10]

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

[8]

9 The region R is bounded by C, the x-axis, the y-axis and the line $x = 4$. Find, in terms of e , the coordinates of the centroid of the region R.

[6]

23 the exact value of I_2

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.

[4]

19 Find the position vector of D.

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

[3]

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

(d) (iii) the equation for this decay.

matrix $\mathbf{A}$ is given by

plane = ... *lb* **[6]**

Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

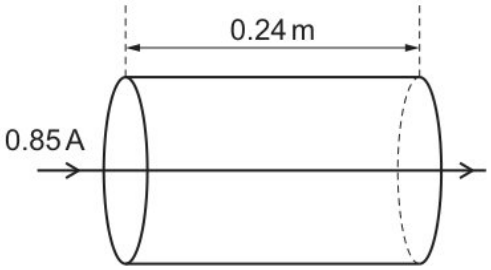


Table 4.1 to show, in terms of some or all of W, T and U, the work done on the gas, the thermal energy supplied to the gas and the increase in internal energy of the gas for each of the two processes.

(vi) the matrix $\mathbf{A}$,

to the value α.

through = ... *wi* **[6]**

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

[6]

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

continuous random variable X has probability density function f given by

[5]

the solution of the differential equation

(iv) and N are two electromagnetic waves.

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

[8]

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

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

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

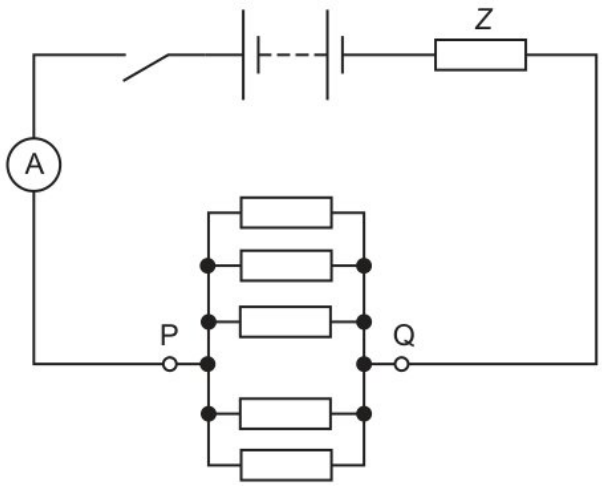
the vertical and horizontal components of velocity at time t.

[6]

Calculate the greatest deceleration of P.

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

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



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

[8]

safety precautions to be taken.

(v) activity of a radioactive sample.

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

[3]

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

[6]

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

charge of 4.0 C passes through the resistor.

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

[4]

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

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

[12]

(d) 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 $0 < \theta < 2\pi$.

[6]

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

[4]

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

(c) diagram illustrates successive wavefronts.

[5]

(d) (i) the exact value of I_2.

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

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

[5]

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

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

B bounces when it strikes the plane, and leaves the plane with speed 20 m s^{-1} but with its horizontal component of velocity unchanged.

[4]

(a) the particular solution of the differential equation

[5]

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

[4]

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

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

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

[8]

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

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

[8]

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

(ii) 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.

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

[6]

12 Calculate the acute angle between the planes.

[5]

21 curve C with equation

is the grand-daughter product?

if there are no restrictions,

(e) (iv) the differential equation, obtaining a relation between x and y.

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

[15]

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

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

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

[3]

(b) the general solution of the differential equation

[12]

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

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

[10]

this question the use of a calculator is not permitted.

(iii) diagram shows part of the curve

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

Find the power output of the tractor's engine.

battery = ... *ob* **[6]**

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

(d) 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.

what is meant by a fundamental particle.

[8]

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

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

[15]

anywhere between point R and point S

(ii) the instant when the rule is horizontal, what is the resultant moment about the pivot?

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

[6]

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

(i) aeroplane is flying at a constant speed.

$$x + 3y + kz = 4$$
$$4x - 2y - 10z = -5$$
$$x + y + 2z = 1$$

[8]

(c) (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.

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

Show that the cartesian equation of C is

[6]

that $v = y^3$, show that

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.

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

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

[4]

(b) (iv) Express $\mathrm{f}(x)$ in partial fractions.

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

[3]

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

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

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.

[4]

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

(ii) 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.

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

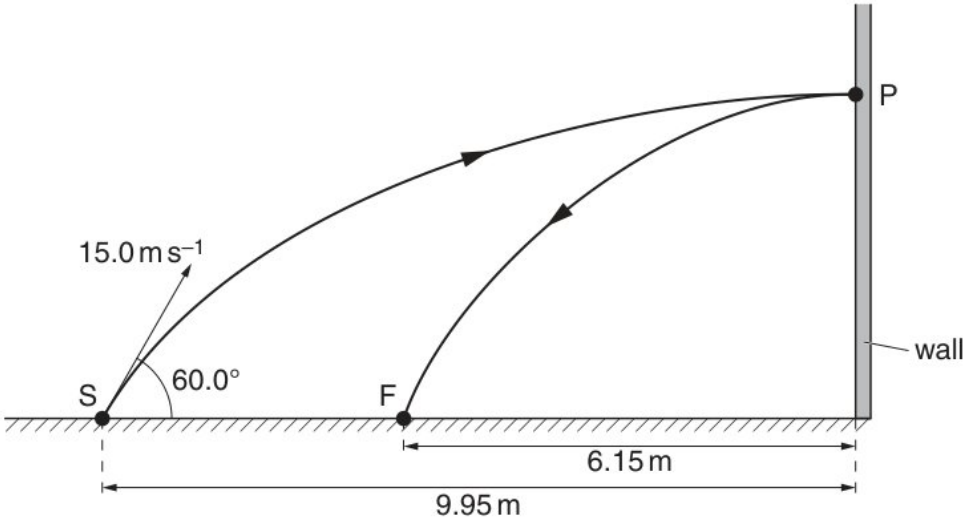
the graph of $y = \mathrm{f}(x)$,

[5]

curve C has equation

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

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 .



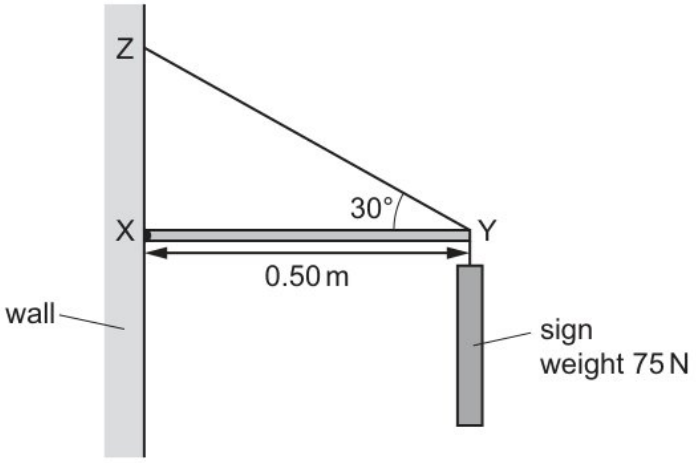
[6]

24 results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

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

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

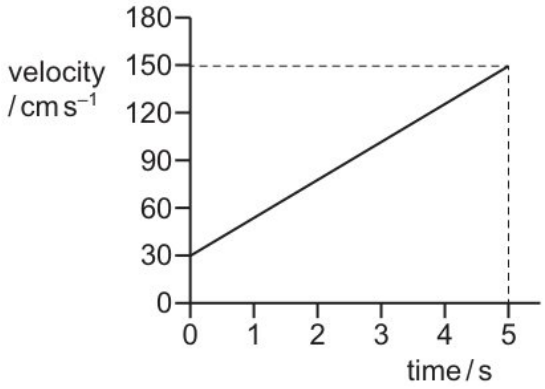
(b) (v) Find the value of I_2.



[15]

line l passes through B and C.

(ii) Find the value of a.



speed = ... *pr* **[4]**

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

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

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

Prove that $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) \equiv 4\cos 2\theta$.

circle = ... *ag* **[12]**

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

no unique solution.

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

[12]

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

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

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

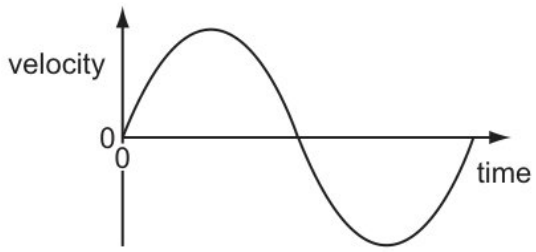
Find the angle that the force acting on the rod at A makes with the horizontal.

parametric equations of a curve are

[6]

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

(iii)



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

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

[10]

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

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

light elastic string has natural length 2 m and modulus of elasticity 39 N . The ends of the string are attached to fixed points A and B which are at the same horizontal level and 2.4 m apart. A particle P of mass m kg is attached to the mid-point of the string and hangs in equilibrium at a point 0.5 m below AB (see diagram).

[1]

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

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

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

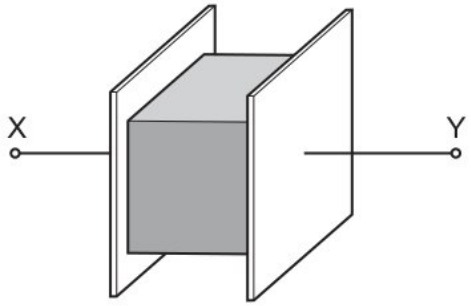
6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

[12]

Show by calculation that a lies between 2 and 4 .

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

expression calculates the fractional uncertainty in the value of this speed?



[5]

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

(v) 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.

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

Express $\frac{\mathrm{d}y}{\mathrm{d}x}$ in terms of t.

have deviation deviation = ... sm **[12]**

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

(iii) matrix $\mathbf{A}$ is given by

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.

find corresponding eigenvectors.

[2]

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

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

[3]

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

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

State what happens to the electron and to the positron.

[20]

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.

(iv) a vector equation for l.

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

an estimate for the mean length of these 250 leaves.

[10]

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

(v)

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

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.

[6]

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

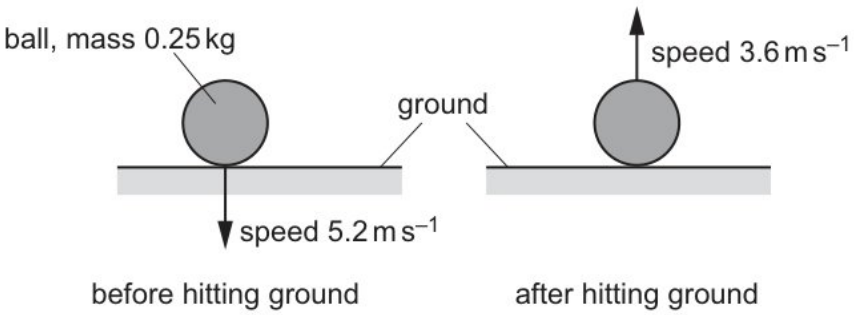
the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at P.

[4]

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

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

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



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

Calculate the distance moved by the car during this acceleration.

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

[12]

wires X and Y are made of different metals. The Young modulus of wire X is twice that of wire Y. The diameter of wire X is half that of wire Y.

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

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

[2]

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.

(iv) Find the value of k such that $\mathrm{P}(k < X < 610) = 0.3$.

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

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

[5]

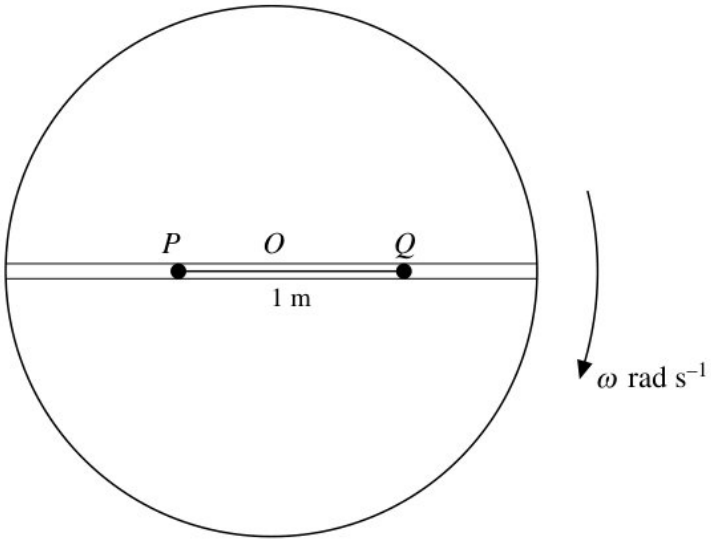
uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of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

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

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

[10]

(b) (ii)



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

[6]

Express v in terms of x.

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

should pay particular attention to

[4]

do each of the symbols represent for an electric current in a metal wire?

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

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

[5]

(e) 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).

[2]