

- 11 Each coulomb of charge from the battery supplies 9.0 J of electrical energy to the whole circuit.

Find angle ABC .

Find the coordinates of the turning points of C .

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

(a) (iii) the probability density function of Y ,

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

[12]

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

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

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

[3]

long, thin metal wire is suspended from a fixed support and hangs vertically. Masses are suspended from its lower end.

(e) Use de Moivre's theorem to show that

[5]

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

- (b) student takes measurements to calculate the density of a liquid in a beaker.

that = eu [5]

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

Find the area of the triangle ABC .

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 .

- (d) (vi) filter is rotated about the normal axis through an angle θ .

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

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.

[10]

- (v) weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.
the equation for this decay.

[10]

- (iii) polarised beam of light with intensity I is incident normally on a polarising filter.
Calculate the length AG .

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

[4]

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

control of variables,

angle = ve [6]

(ii) safety precautions to be taken.

Wavelength is proportional to amplitude.

that the distance travelled by the ball when it is moving upwards is $x =$

$$\frac{1}{2k} \ln \left(\frac{g+kU^2}{g+kv^2} \right).$$

[10]

(iv) Hence show that the differential equation



times = ki [6]

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

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

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

the period of small oscillations,

[10]

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

- (c) $n \geq 0$. Show that, for all $n \geq 2$,

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

[6]

- 11 curve C has equation

[6]

- 26 ball is released from rest at time zero. After 1.0 s it bounces inelastically from a horizontal surface and rebounds, reaching the top of its first bounce after 1.5 s .

area. = mw [3]

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

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

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

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

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

[8]

only one of the following two alternatives.

- (d) Find the acute angle between Π_1 and Π_2 .

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

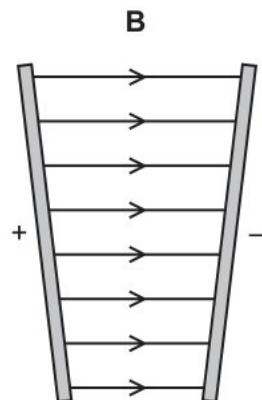
[8]

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

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 $te^{-v} \text{ N}$ directed away from O acts on P , where $v \text{ m s}^{-1}$ is the velocity of P at time $t \text{ s}$ after release. Find the velocity of P when $t = 2$.

[5]

- (ii)



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

[8]

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

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

[5]

up the probability distribution table for X .

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

[4]

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

[8]

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

resistors = hq [4]

the particular solution of the differential equation

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

[5]

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

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

[10]

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

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

Find the equations of the asymptotes of C .

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

[4]

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

object is fully submerged in a liquid.

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

neutron decays to form a proton.

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 .

[5]

- (i) if there are no restrictions,

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

[12]

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

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

[3]

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

$$\text{half horizontal} = \dots \quad qh \quad [6]$$

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.

- (b) Find a set of corresponding eigenvectors.

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

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

$$\text{particle} = \dots \quad vk \quad [4]$$

- (f) (iii) find corresponding eigenvectors.

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

$$\text{light beams} = \dots \quad zt \quad [12]$$

- (iv) if the 4 vowels A, E, E, I must all be together.

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & 0 & 2 \\ 3 & -1 & 4 & 0 \\ 5 & -8 & -6 & 19 \\ -2 & 3 & 2 & -7 \end{pmatrix},$$

For a different value of θ , the plane on which B rests is rough with coefficient of friction between the plane and B of 0.8 . The system is in limiting equilibrium with B on the point of moving in the direction of the 2.5 N force. Find the value of θ .

$$\text{curve} = \dots \quad rj \quad [12]$$

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

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

the position vector of the foot of the perpendicular from the point with position vector $\mathbf{i} + 10\mathbf{j} + 3\mathbf{k}$ to Π .

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

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

doctor = ex [4]

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

[4]

(ii) current-carrying coil produces a magnetic field.

[6]

(a) up to antidown

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

[12]

- (iv) plane Π_2 contains the lines

[1]

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

[15]

- (ii) aeroplane is flying at a constant speed.

The waves must not be polarised.

[8]

- (c) the distance AC .

- (v) Find the distance of B from the wall when it collides with A for the second time.

than = oe [5]

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

drug = ft [6]

- (i) diagram shows the electric field between the plates?

motion. = ng [3]

22 Use the iterative formula

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

curve C has equation

$$f(x) = \begin{cases} 0 & x < 0 \\ ae^{-x \ln 2} & x \geq 0 \end{cases}$$

band = dg [5]

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

spring = uc [6]

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

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

distance between = sl [15]

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

- (c) the equations of the asymptotes of C

[1]

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

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

[3]

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

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

length = en [6]

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

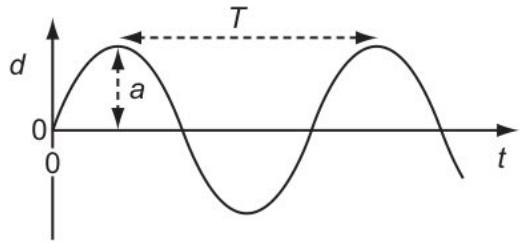
is the useful power output of the power station?

[6]

- (iii) up to antidown
the value of σ .

[15]

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



variables x and y satisfy the differential equation

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

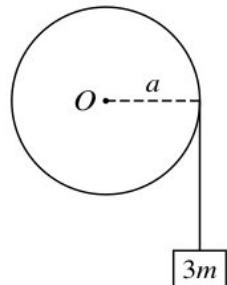
A sample of nitrogen gas is trapped in a vertical tube of uniform cross-sectional area by a

company = ov [3]

- (i) manufacturer claims that the machine produces rods with mean length 300 mm . Its speed decreases to a value greater than zero, then increases to a value greater than 20 ms^{-1} .

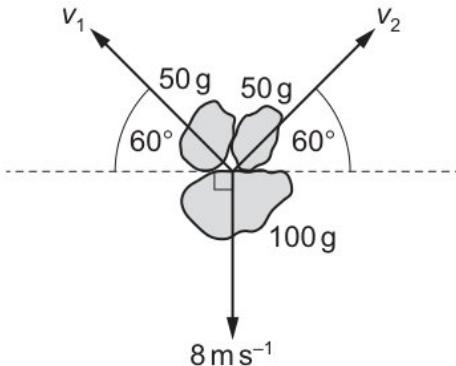
table. = ux [15]

- (v) at the 2.5% significance level whether this evidence supports Mr Lee's assertion.
Find the distance of B from the wall when it collides with A for the second time.



whether = ue [8]

(d) (i)



paving slab has a mass of 68 kg and dimensions $50\text{ mm} \times 600\text{ mm} \times 900\text{ mm}$.

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

[4]

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

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

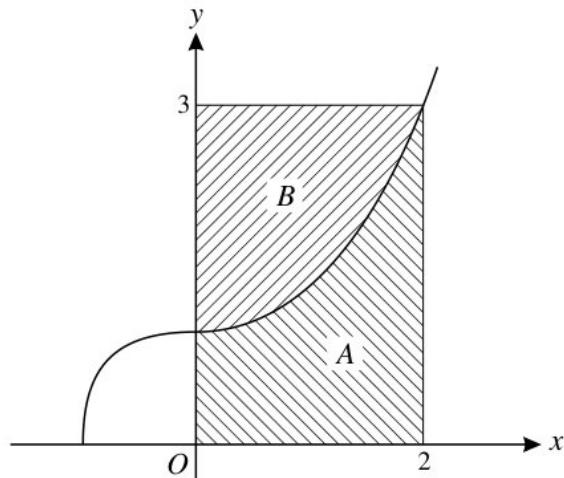
[15]

- (iii) Express $f(x)$ in partial fractions.

many different colour arrangements are there of the 10 books?

forward = iw [4]

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



Express v in terms of x .

[3]

- (c) (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 ?

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

junction = bj [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.

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

[12]

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

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

[4]

23 activity of a radioactive sample.

contains = bd [5]

14 exactly at point S

Show that the kinetic energy of the electron before the collision is $1.1 \times 10^{-15} \text{ J}$.

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

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

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

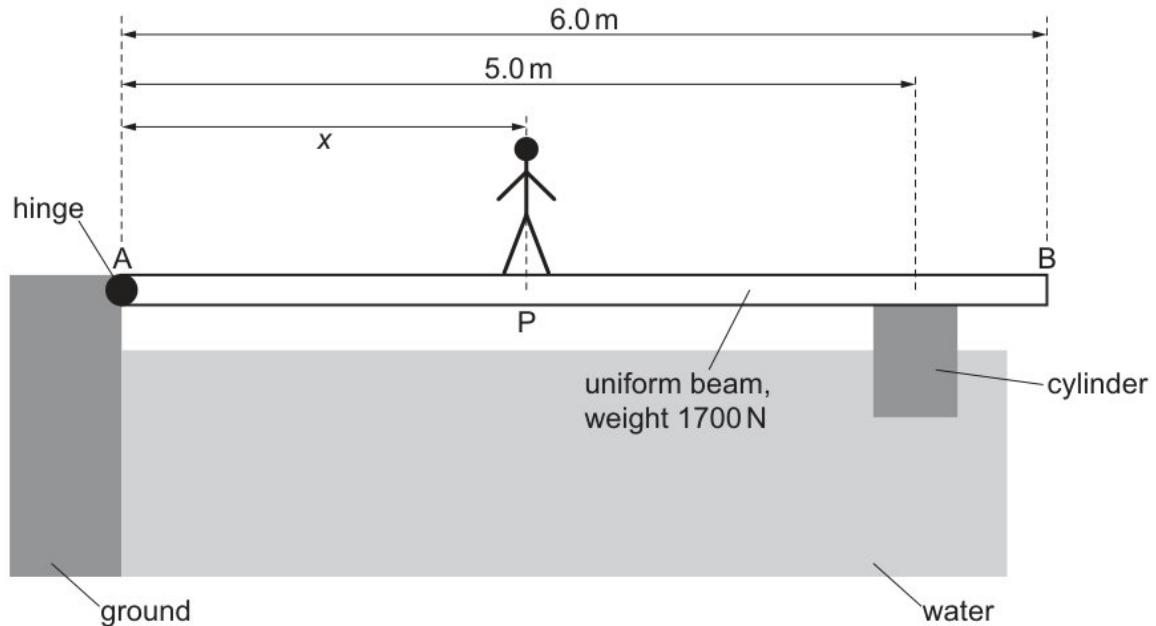
[4]

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

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

[6]

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



[5]

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

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

	M	N
A	microwaves	visible light
B	microwaves	γ -rays
C	γ -rays	microwaves
D	visible light	microwaves

[4]

- (d) (i) 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 .

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

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

[2]

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

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

[8]

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

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

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

[4]

- (d) (ii) is the force exerted on the wall by the water?

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

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

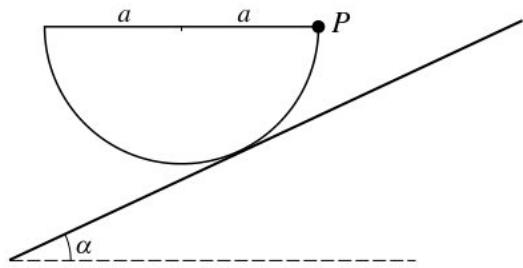
mass = kf [12]

- (v) is the diameter of the wire?

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

[2]

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



[6]

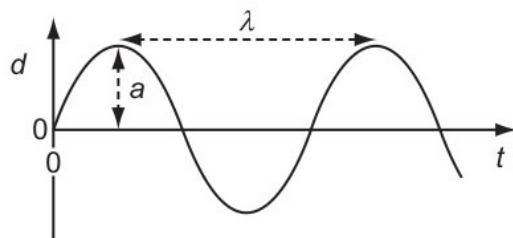
(iii) diagram correctly represents the forces acting at point P ?

Show that x satisfies the equation

mass of the liquid is $0.36 \text{ kg} \pm 10\%$.

[4]

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



(c) lowest mark was 17 and the highest mark was 74 .

[5]

p and q are given real numbers, then

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

particle = qi [6]

- 18 (a) the term elastic limit.

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

B contains 5 red marbles and 3 blue marbles.

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

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

[6]

- (i) the speed of the combined particle after this collision.

[10]

- (iii) to the origin O , the position vectors of the points A , B and C are given by

It limits the range of values obtained in repeated measurements.

neglected, = qr [8]

- (b) Calculate the length AG .

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

[6]

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

[8]

- (i) only one of the following two alternatives.

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

[3]

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

one similarity and one difference between an electron and positron.

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

- (iii) 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.

the distribution function of X .

Show by calculation that a lies between 2 and 4 .

[10]

- (i) cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

[2]

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

- (c) competitors who took part in this Saturday's event are selected at random.

[5]

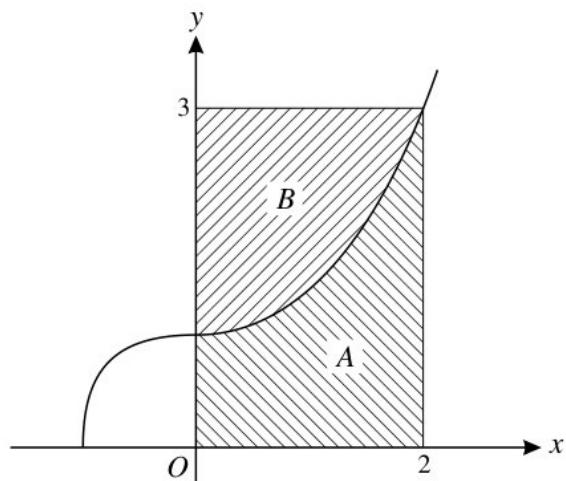
- (a) (iii) certain curve is such that its gradient at a point (x, y) is proportional to xy . At the point $(1, 2)$ the gradient is 4 .

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

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

$$\text{mass} = \dots\dots\dots yv \quad [2]$$

(vi)



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

[5]

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

statement about sound waves in air at constant temperature is correct?

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

[8]

cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

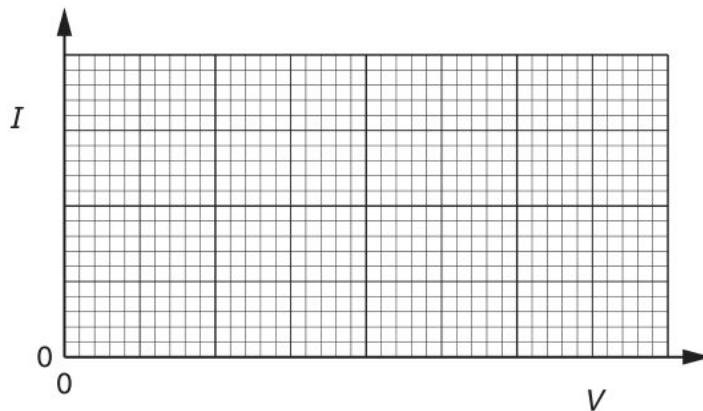
- (b) frame consists of a horizontal rod XY and a rod YZ that is at an angle of 30° to the horizontal. Rod XY is attached to the wall by a hinge at X and has length 0.50 m . Assume that the weights of the rods are negligible.

[8]

- 16 are the weight and the mass of the body when it is on the Moon?

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

- (b) (i) curve C has equation $y = x^{\frac{3}{2}}$. Find the coordinates of the centroid of the region bounded by C , the lines $x = 1, x = 4$ and the x -axis.



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

eigenvalue = ks [6]

- (iii) one similarity and one difference between an electron and positron.

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

slits beams = oq [6]

- (g) (i) gas is then cooled at constant volume so that its temperature decreases to $2T$.
is the density of the mixture with volume 2.0 m^3 ?

[6]

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

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

[4]

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

are two marks on the tube. The top mark is positioned at $115 \pm 1 \text{ mm}$ on the adjacent rule and the lower mark at $385 \pm 1 \text{ mm}$. The ball passes the top mark at $1.50 \pm 0.02 \text{ s}$ and passes the lower mark at $3.50 \pm 0.02 \text{ s}$.

[6]

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

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.

[12]

- (i) 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 .

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

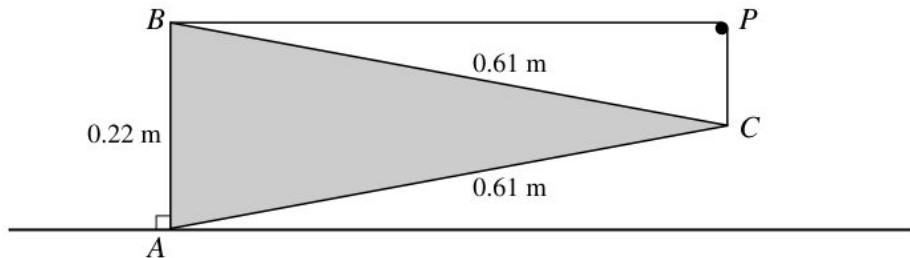
days, = we [12]

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

Find Σx^2 .

[4]

(c) (i)



procedure to be followed,

[10]

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

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 $\cos 2\theta = \frac{7}{25}$.

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

coin showing when = ac [5]

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

(c) row correctly identifies the properties of all electromagnetic waves?

[8]

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

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

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

[10]

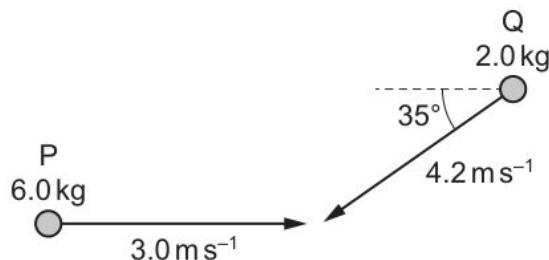
- 10 a similar method to find a lower bound for $\sum_{r=1}^n \frac{n}{n^2+r^2}$. Give your answer in terms of n and π .

[6]

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

Velocity is proportional to wavelength.

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



time = ld [5]

- (b) (iii) Prove by mathematical induction that, for all positive integers n ,

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.

[6]

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

the probability density function of Y ,

[8]

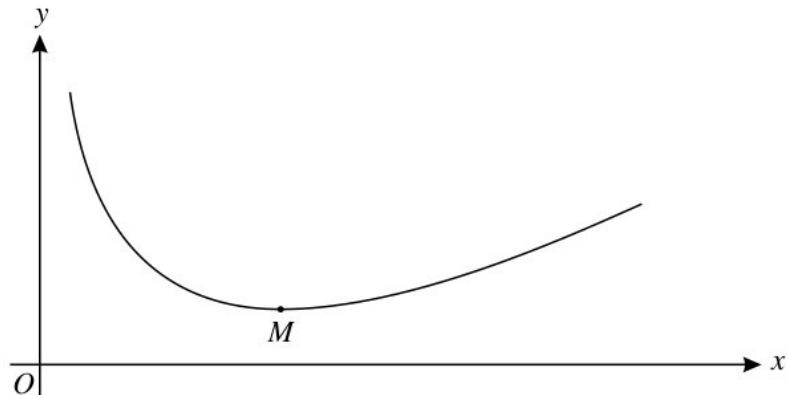
- (i) $\omega = \cos \frac{1}{5}\pi + i \sin \frac{1}{5}\pi$. Show that $\omega^5 + 1 = 0$ and deduce that many electrons pass through a given cross-section of the wire in one second?

[12]

- (e) (iii) in terms of m and g , the magnitude of the frictional force in this position. that $x^2y = z$, show that

[5]

(ii)



Without using a calculator, find the exact values of

[6]

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

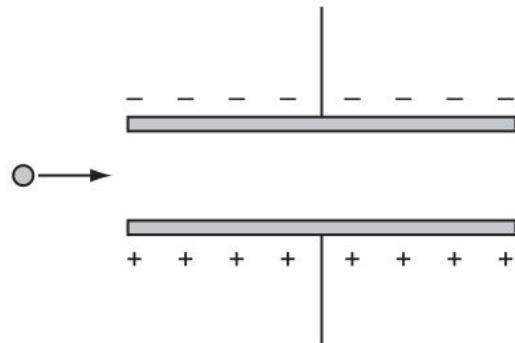


diagram best represents the electric field surrounding the charges?

$$\text{tension} = \dots \text{ } yu \quad [6]$$

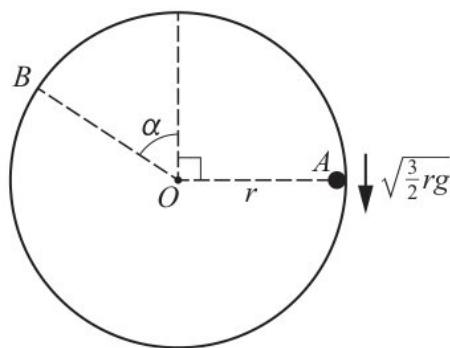
- (d) (ii) Find the cartesian equation of Π_2 .

Pressure is force per unit area.

$$\text{moving} = \dots \text{ } ff \quad [15]$$

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

shaded region is bounded by the curve and the two axes.



[10]

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

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

reduces = eo [3]

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

[6]

- 18 Calculate the acute angle between the planes p and q .

then = zr [4]

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

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

lengths, in millimetres, of rods produced by a machine are normally distributed with mean μ and standard deviation 0.9. A random sample of 75 rods produced by the machine has mean length 300.1 mm .

other teams of runners, the Eagles and the Swifts, also took part in the event. The recorded times in seconds for 20 runners from the Eagles and 30 runners from the Swifts are denoted by x and y respectively.

[4]

Calculate the modulus of elasticity of the string.

- (d) 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 $v \text{ m s}^{-1}$ is the velocity of P at time t s after release. Find the velocity of P when $t = 2$.

[2]

$$I_n = \int_0^1 (1-x)^n \sinh x \, dx \text{ where } n \text{ is a non negative integer}$$

- (a) mean, \bar{x} , is 28.325 .

[6]

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

- (c) 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 $\text{Po}(0.7)$.
 3×3 matrix \mathbf{A} has eigenvalues $-1, 1, 2$, with corresponding eigenvectors
is the ratio $\frac{\text{tension in wire } X}{\text{tension in wire } Y}$?

shown, = vy [8]

- 12 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, $H_1 : p < 0.2$.

[5]

- 10 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.

[4]

23

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

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.

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

[8]

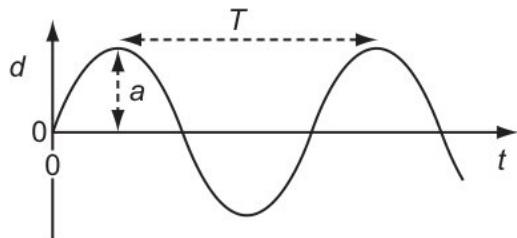
8 the graph of $y = |2x - 3|$.

(c) (ii) the value of θ .

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

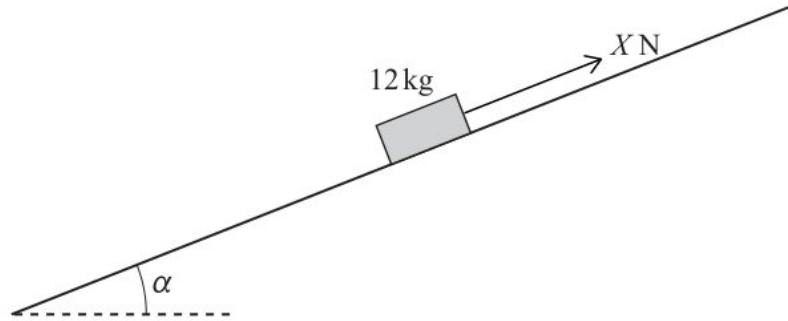
horizontal speed = vx [15]

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



[6]

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



[5]

- (v) activity of a radioactive sample.

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

[6]

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.

- (e) is the force exerted on the wall by the water?

[12]

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

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

[10]

- 16 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 .

proportion voted = me [8]

- 14 Velocity is proportional to wavelength.

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

- (c) Find the value of k for which the set of linear equations

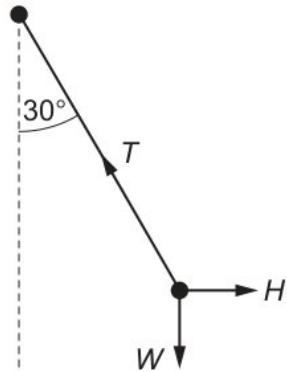
exactly study = xt [2]

- (a) (iii) Estimate the probability of throwing a 4.

$800 \text{ nm to } 1000 \mu \text{ m}$

[3]

- (iv) Find the acute angle between Π_1 and Π_2 .



$$5.1. = \dots \quad rh \quad [8]$$

X and Y are connected in series to a cell.

- (b) the term interference.

$$\text{show} = \dots \quad ty \quad [10]$$

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

- (d) cable car of weight W hangs in equilibrium from its cable at point P .

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

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

$$[12]$$

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

- (f) 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.

[8]

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

[4]

- 19 Density is mass per cubic metre.

a sketch of an Argand diagram with origin O show the points A, B, C and D representing the complex numbers $z_1, z_2, \omega z_1$ and ωz_2 respectively

angle smooth = $z l$ [5]

- 13 frequency of the signal is 50 kHz .

- (c) (i) the period of small oscillations,

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

[10]

- (iii) 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.

there are no restrictions,

speed = ze [8]

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 $v \text{ m s}^{-1}$ when its displacement from O is $x \text{ m}$. A retarding force of magnitude $0.2v^2 \text{ N}$ acts on P in the direction PO .

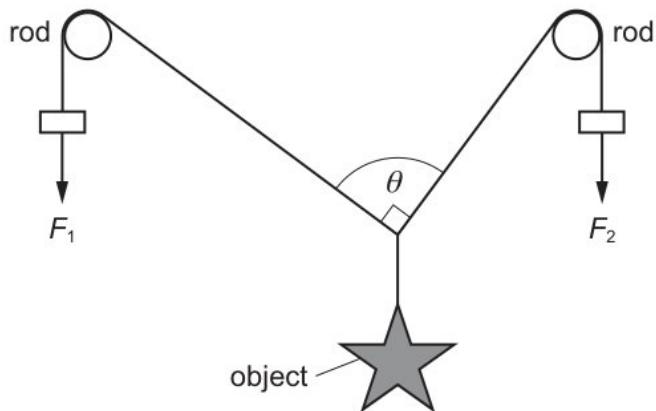
- (d) diagram shows the velocity-time graph of a particle which moves in a straight line. The graph consists of 5 straight line segments. The particle starts from rest at a point A at time $t = 0$, and initially travels towards point B on the line.

[10]

- 15 student investigates the cooling of a liquid in a beaker.

[4]

13



State the work W done by F .

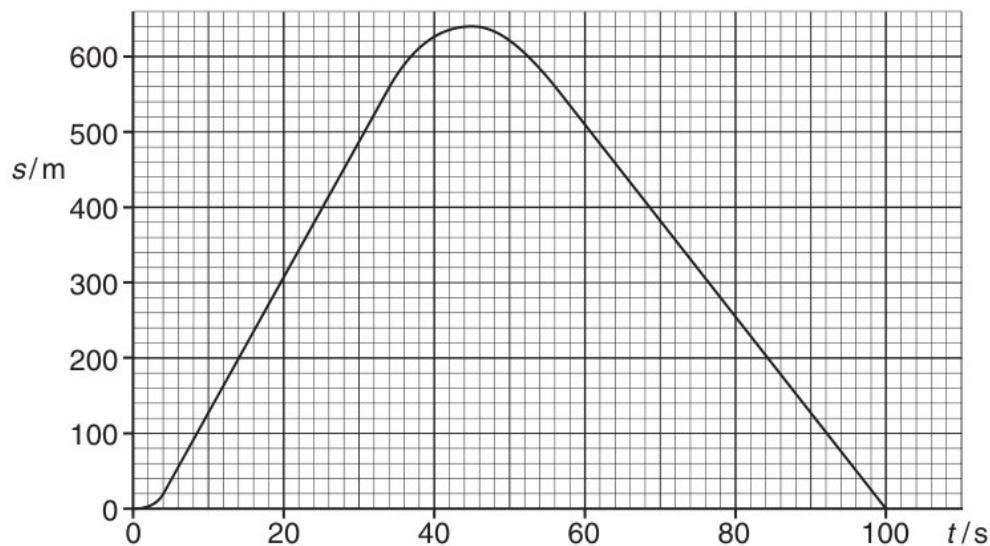
[12]

- 11 a cubic equation whose roots are $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$.
marble is chosen at random from bag A and placed in bag B .

[6]

- 13 linear transformation $T: \mathbb{R}^4 \rightarrow \mathbb{R}^4$ is represented by the matrix \mathbf{M} , where
 Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2} .

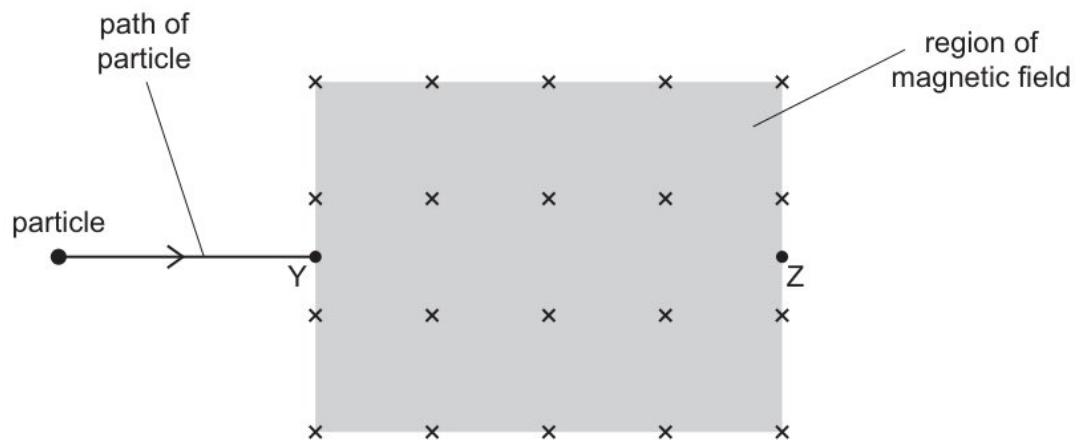
(d) (i)



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.

[20]

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



[4]

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

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

[20]

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

(a) Find the work done by the tension.

[6]

31 (a) width of the 99% confidence interval is double the width of the $x\%$ confidence interval.

[8]

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

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

[8]

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

[5]

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

[12]

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

State what happens to the electron and to the positron.

Show that $m = 0.9$.

- (i) 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.

[2]

- (iv) $n \geq 0$. Use the fact that $\tan^2 x = \sec^2 x - 1$ to show that, for $n \geq 2$,

[3]

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

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

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

[6]

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

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

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

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

1 and 2 only

about = rz [5]

State the work W done by F .

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 $x = a$.

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

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

[15]

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

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

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

[12]

- 9 the exact volume of the solid generated

[12]

- 15 only one of the following two alternatives.

into = mg [6]

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

[8]

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

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

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

[20]

(ii) Show that $m = 0.9$.

Draw up a probability distribution table for X .

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

[6]

(a) (i) 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 resistors of equal value are connected as shown.

force = nd [8]

(ii) object is fully submerged in a liquid.

weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.

collides = ol [6]

- 14 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.

	F_1/N	F_2/N
A	4.0	6.0
B	6.0	4.0
C	6.0	8.0
D	8.0	6.0

[5]

- 23 projectile is thrown at an angle to the ground.

[4]

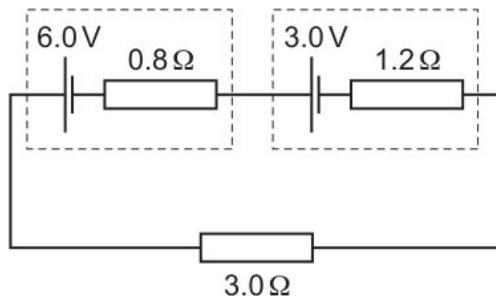
- 15 Express $f(x)$ in partial fractions.

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

random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.

[5]

(iii)



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

State the equation of the other asymptote.

[6]

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

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

bounded = vr [8]

- (d) (iii) sample contains a single radioactive isotope that decays to form a stable isotope.
the probability of a Type II error.

normally = sr [12]

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

The waves must be polarised.

mass = da [10]

- (ii) three coplanar forces shown in the diagram act at a point P and are in equilibrium.
the distribution function of X .

values, x , in a particular set of data are summarised by

confidence = ak [8]

none of them

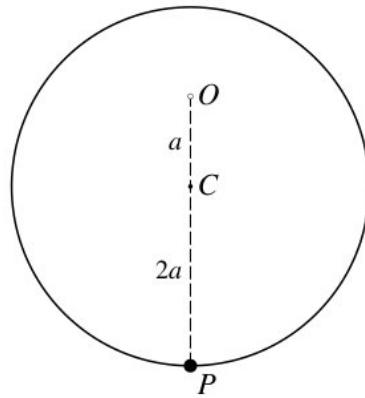
- (a) By setting up and solving a differential equation, show that the equation of the curve is $y = 2e^{x^2-1}$.

[5]

10 student investigates the cooling of a liquid in a beaker.

[20]

16 the position vector of P .



- (c) (iv) The extension of the wire is proportional to the tensile force.

eigenvectors $\begin{pmatrix} 1 \\ -1 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$ and $\begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}$. Find the eigenvalues of the matrix

\mathbf{AB} , and state corresponding eigenvectors.

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

mean = vk [8]

- (i) the values of a for which the system of equations

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

this people = bq [3]

Find the power output of the tractor's engine.

- (a) graph shows the variation with temperature of power, P , dissipated in the thermistor?

[6]

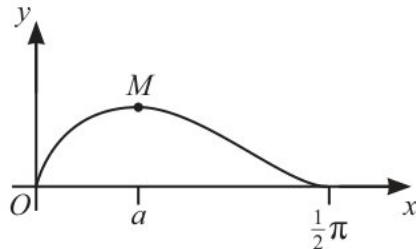
- 16 Explain the features of the graphs in (d) that show the characteristics of ductile and brittle materials.

[6]

- 39 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.

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

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



[8]

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

[6]

- (b) (v) A contains 6 red marbles, 5 blue marbles and 1 green marble.

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

[4]

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

Use the iterative formula

is the grand-daughter product?

[8]

- (i) Hence factorise $p(x)$ completely.

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.

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 .

[5]

- 26 only one of the following two alternatives.

obtained = or [4]

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

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.

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

(e) (vi) Calculate the greatest deceleration of P .

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

[5]

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

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

forests = pl [4]

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 $AC = a$.

- (b) obtain the roots of the equation

curve C has equation

[6]

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

Calculate the distance moved by the car during this acceleration.

[12]

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

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]

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

Find the coordinates of A and M .

other teams of runners, the Eagles and the Swifts, also took part in the event. The recorded times in seconds for 20 runners from the Eagles and 30 runners from the Swifts are denoted by x and y respectively.

[2]

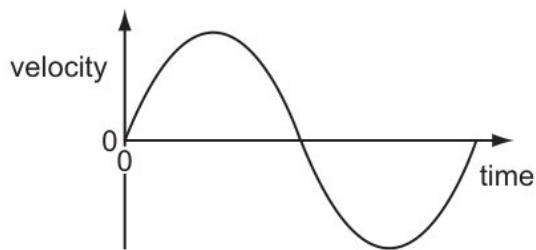
- (i) Find the equations of the asymptotes of C .

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

[4]

Show that $\frac{ds}{dx} = \frac{1}{2}(e^x + e^{-x})$, where s denotes the arc length of C , and find the surface area generated when C is rotated through 2π radians about the x -axis.

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



[3]

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

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.

- (d) 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} .

[3]

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

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

cylinder loses with = gb [20]

- (b) (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 .

$$\frac{d^2x}{dt^2} + 6 \frac{dx}{dt} + 9x = 18t^2 + 6t + 1$$

[4]

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

the particular solution of the differential equation

rest = fd [8]

18 your answer correct to 2 decimal places.

- (a) Use the confidence interval found in part (i) to comment on this claim.
logarithms to solve the equation $3^x = 2^{x+2}$, giving your answer correct to 3 significant figures.

[4]

(b) (i)

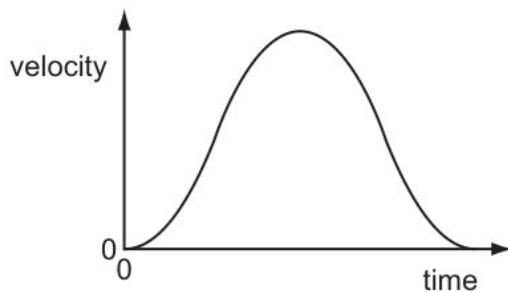


diagram best represents the electric field surrounding the charges?

[12]

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

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

[5]

- (iv) 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.

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

524 526 520 523 530

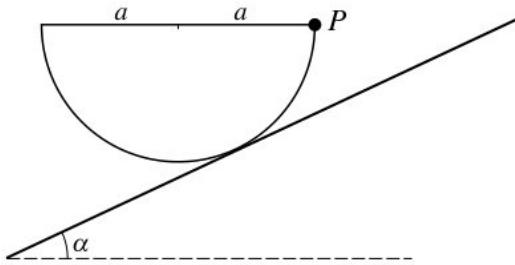
'exactly = ho [3]

20 curve C has equation

is the diameter of the wire?

[5]

14



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

calculated used moved = qu [3]

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

[6]

- (c) 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.
- (v) 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.

[12]

- (iii) measurements to be taken,

[5]

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

[8]

- 12 A block of mass 3 kg is initially at rest on a smooth horizontal floor. A force of 12 N , acting at an angle of 25° above the horizontal, is applied to the block. Find the distance travelled by the block in the first 5 seconds of its motion.

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

number = or [8]

(a) (vi) one similarity and one difference between an electron and positron.

Find the speed of P when it passes through L .

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

string = yi [8]

(v) activity of a radioactive sample.

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

[12]