9 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.

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

[4]

15 random variable X has the distribution Po(1.5).

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

[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.

(e) is given that $k = 0.025$ and that $U = 20$

[3]

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

[8]

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

$$\overset{14}{\ldots\ldots}X \rightarrow \overset{\ldots\ldots}{\ldots\ldots}Z + \ldots\ldots\cdots .$$

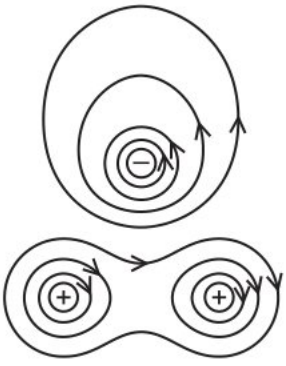
diagram shows a sketch of the curve $y = \frac{3}{\sqrt{(9-x^3)}}$ for values of x from -1.2 to 1.2 .

(b) (iii) Calculate the exact value of I_1 and deduce the exact value of I_3.

is given that

[2]

(ii)

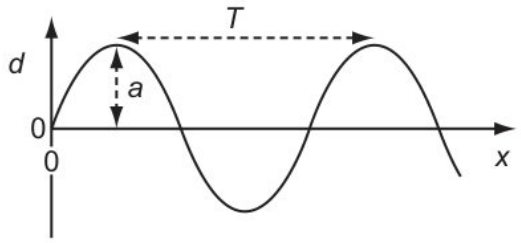


Young modulus E can be determined from measurements made when a wire is stretched.

$$_{88}Q \longrightarrow \overset{222}{\ldots}R + {}^4_2Q$$

[8]

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



[4]

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

(c) Hence find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $\left(1, \frac{1}{4}\pi\right)$ on C.

[6]

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

[15]

20 1.1 shows the measurements for cube A.

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.

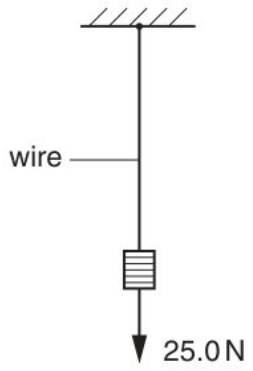
The waves must not be polarised.

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

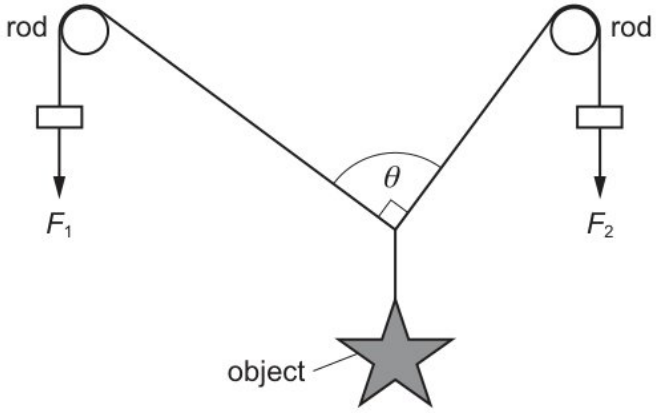
[10]

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

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



(b)



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

cable car of weight W hangs in equilibrium from its cable at point P.

[3]

all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

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

object is held in equilibrium by the forces F_1 and F_2. The object weighs 10 N . There is negligible friction between the rods and cords. Angle θ is 90°.

[5]

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

(a) P and Q form an isolated system.

[8]

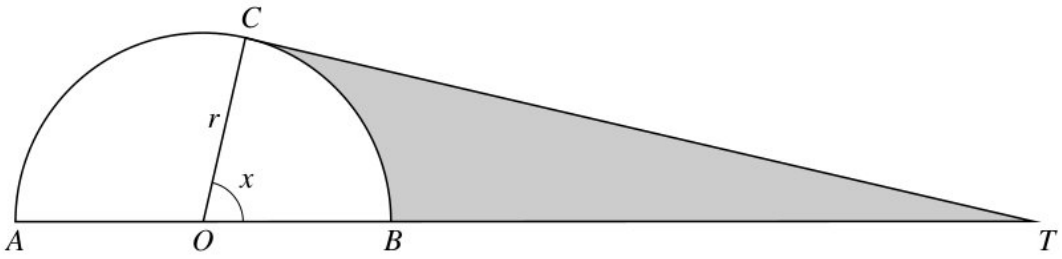
15 is the speed of the projectile at this time?

(e) (i) the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is before the fifth day of the week.

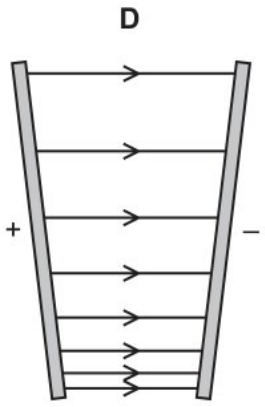
decides to choose 35 students at random. If 3 or fewer of these students are left-handed, Amir will reject his belief.

[4]

(iii)



the value of the constant k,



[15]

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

eigenvalues $1, -1$ and -2 .

[15]

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

Use de Moivre's theorem to show that

[2]

(v)

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

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

[5]

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

(c) 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.

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

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

[3]

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

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

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

[5]

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

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

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

[6]

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

(d) object consists of a uniform lamina with a particle attached. The uniform lamina $ABCEFD$ of mass m is formed from a rectangle $ABCD$ and an isosceles triangle CEF, where F is the midpoint of CD. The rectangle has sides $AB = 2a$ and $AD = a$. The triangle CEF has base a and height $2a$. The particle of mass km is attached to the lamina at E. The object rests in a vertical plane with its edge AD on horizontal ground (see diagram).

[4]

wavelength of light is 550 nm .

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

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

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

[10]

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

[10]

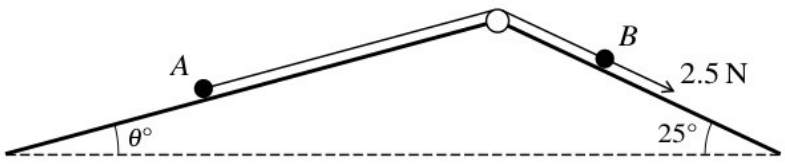
13 The vector $\mathbf{e}$ is an eigenvector of the matrix $\mathbf{A}$, with corresponding eigenvalue λ, and is also an eigenvector of the matrix $\mathbf{B}$, with corresponding eigenvalue μ. Show that $\mathbf{e}$ is an eigenvector of the matrix $\mathbf{AB}$ with corresponding eigenvalue $\lambda\mu$.

[4]

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

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

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 $\theta°$ 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).



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

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

[6]

is a necessary condition for observable interference fringes to be produced?

(a) analysis of the data,

then it converges to a.

electric potential difference across a component.

[4]

18 lines l_1 and l_2 have equations

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

[8]

13 $\frac{\text{mass} \times (\text{ time })^2}{\text{length}}$

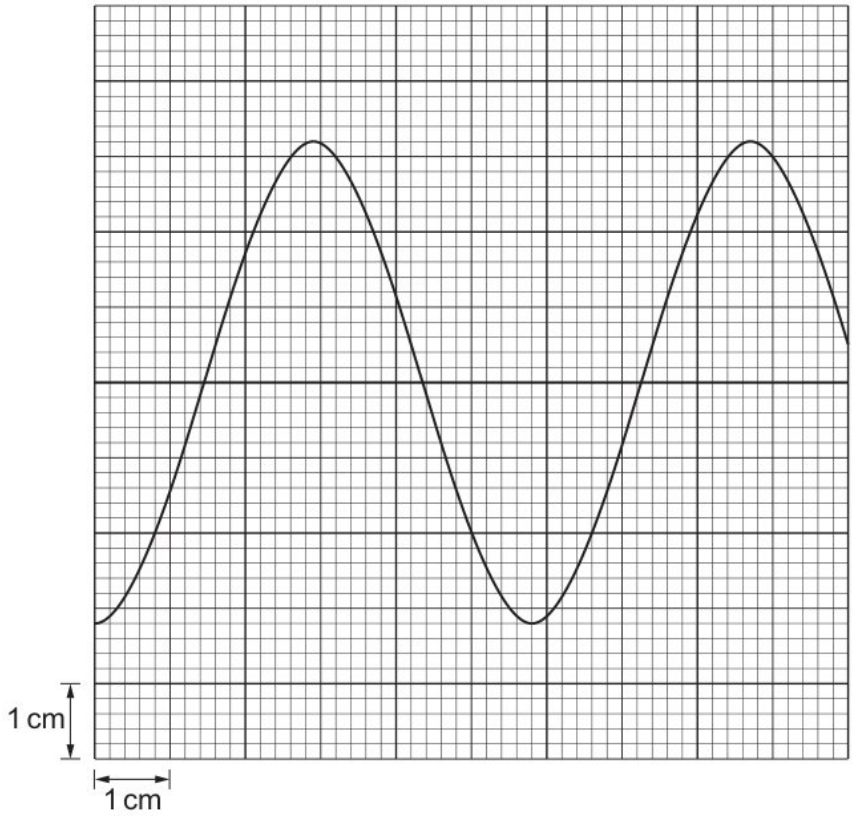
$$y = 2\cos 2x \cos\left(2x + \frac{1}{6}\pi\right)$$

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

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

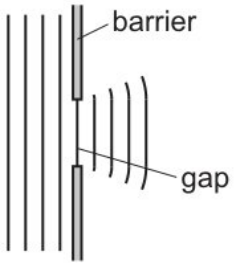
[6]

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



[10]

(ii) Calculate the distance of the centre of mass of the lamina from A.



[3]

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.

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

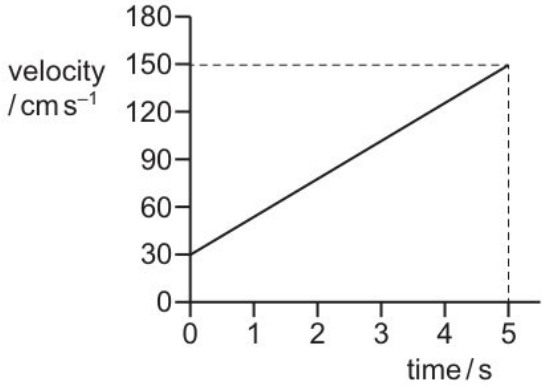
[4]

(e) (iv) $I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$ where n is a non negative integer

that $\mathbf{e}$ is an eigenvector of $\mathbf{A}^3$ with corresponding eigenvalue λ^3.

[5]

(ii) many images of the slit does he see?



[6]

(iii) control of variables,

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

[10]

17 3×3 matrix $\mathbf{A}$ has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

1.26 1.24 1.17 1.23 1.18 1.25 1.19 1.20 1.21 1.18

(a) 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 .

[10]

is the speed of the block after falling this distance?

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

[6]

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

Calculate the acute angle between the planes.

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

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

electric potential difference across a component.

[8]

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

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

[12]

(iii) the exact value of I_2.

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

[12]

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

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

[2]

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

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

[6]

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

one similarity and one difference between an electron and positron.

[5]

23 equation gives v in terms of A and u ?

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

[6]

the expected value and variance of Y.

matrix **A** is given by

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

[20]

14 random variable X has the distribution Po(1.5).

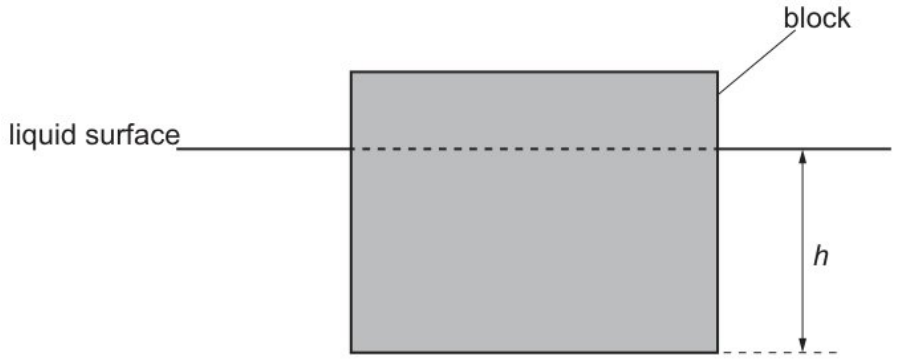
a basis for the null space of T .

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

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

[10]

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



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

[2]

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

Find the distance OM.

[4]

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

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

[6]

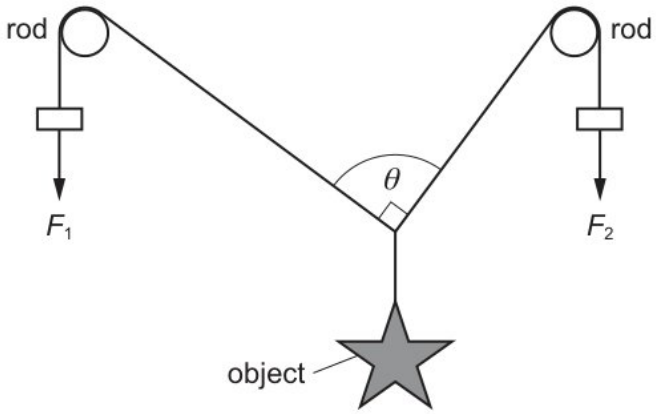
the speed of the combined particle after this collision.

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

[5]

9 the total time for which she is in motion from the instant that she passes O.

(c)



spherical object falls through water at constant speed. Three forces act on the object.

[2]

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

variables x and y satisfy the differential equation

[5]

(iii) 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 .

is given that

[4]

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

is the current in the load resistor?

[10]

(a) (i) the solution of the differential equation

are the amplitude and period of the wave?

[3]

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

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.

[12]

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

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

[5]

12 the number of different arrangements of the 7 men in a line in which Ali and Ben do not stand next to each other.

variables x and y are related by the differential equation

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

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

[5]

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

State what happens to the electron and to the positron.

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

[1]

(ii) only one of the following two alternatives.

plane Π_2 contains the lines

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

[2]

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

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

[5]

much energy is stored in the compressed column?

(d) the general solution of the differential equation

each numbered = ... mj **[8]**

(c) (i) smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.

Find the exact value of the arc length of C.

[3]

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

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Number of nights	4	9	18	26	20	16	7	0

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

[4]

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

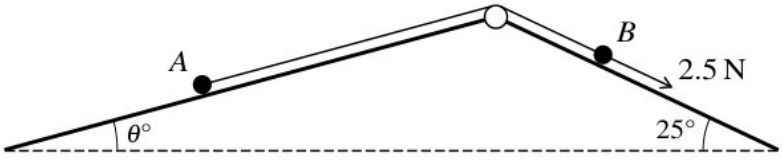
(b) gas is then cooled at constant volume so that its temperature decreases to $2T$.

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

expression potential = ... qa **[5]**

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

(ii)



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

[12]

(v) (c) amplitude $\propto$ (intensity)^2

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

[12]

(a) is the value of R ?

marks of the pupils in a Physics examination are summarised as follows.

[2]

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

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

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

[6]

(d) 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.

the general solution of the differential equation

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

[4]

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.

(iii) the graph of $y = |3x - 2a|$, where a is a positive constant.

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

[8]

11 400 nm to 700 nm

(b) curve C has parametric equations $x = \text{e}^t \cos t, y = \text{e}^t \sin t$, for $0 \leqslant t \leqslant \pi$. Find the arc length of C.

[10]

(h) (vi) Find the tension in the string in terms of W.

the term interference.

using = ... vt **[3]**

(iii) 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 $\frac{84}{5}Ma^2$.

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

[2]

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

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

the standard deviation of these 40 values of x.

(e) (ii) the principle of moments.

one similarity and one difference between an electron and positron.

[3]

(iii) Show that $u^3 + 8 = 0$.

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

[6]

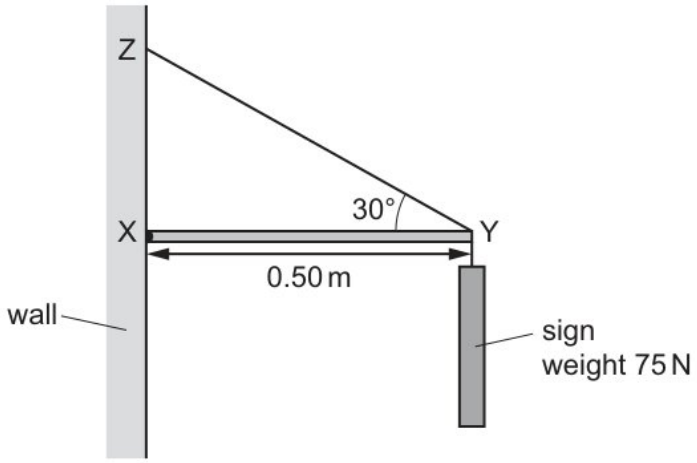
(i) the speed of the aeroplane.

Use de Moivre's theorem to show that

[8]

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

(c)



only one of the following two alternatives.

activity of a radioactive sample.

[4]

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

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

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.

[3]

(ii) only one of the following two alternatives.

Find the weight of the lamina.

[12]

(v) 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 .

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.

[6]

8 parametric equations of a curve are

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

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

[8]

(vii) Show that the total distance fallen is 1048 m .

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

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

[12]

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

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

[4]

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

flows out of a pipe and hits a wall.

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}.

the position vector of D.

[6]

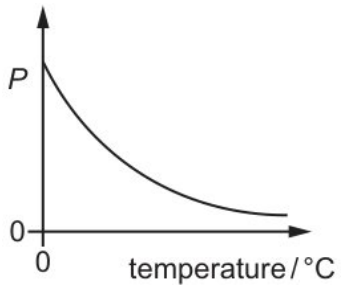
find the probability that in 15 throws the number of 4 s obtained is 2 or more.

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

the particular solution of the differential equation

[6]

(d) (iv) diagram shows two waves R and S.



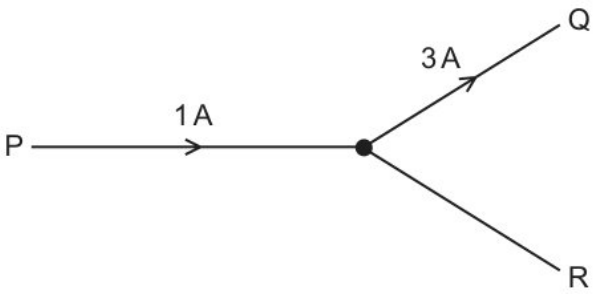
[4]

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

$$6\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 3\frac{\mathrm{d}x}{\mathrm{d}t} + 6x = \mathrm{e}^{-t}$$

[1]

14

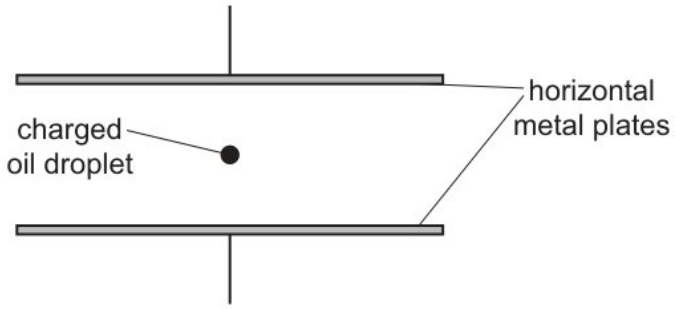


is the efficiency of the process?

[8]

18 Show that $m = 0.9$.

uniform small smooth spheres A and B have equal radii and each has mass m. Sphere A is moving with speed u on a smooth horizontal surface when it collides directly with sphere B which is at rest. The coefficient of restitution between the spheres is $\frac{2}{3}$. Sphere B is initially at a distance d from a fixed smooth vertical wall which is perpendicular to the direction of motion of A. The coefficient of restitution between B and the wall is $\frac{1}{3}$.



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

$$8nI_{n+1} = (2n-1)I_n + 2 \times 8^{-n}$$

[6]

(iii) On a sketch of an Argand diagram, shade the region whose points represent complex numbers z satisfying both the inequalities $|z - u| \leqslant 2$ and $\mathrm{Re}\, z \geqslant 2$, where $\mathrm{Re}\, z$ denotes the real part of z.

$$\sum_{r=1}^{n} \frac{1}{\sqrt{r}} \mathrm{e}^{\sqrt{r}} < \left(2 + \frac{1}{\sqrt{n}}\right) \mathrm{e}^{\sqrt{n}} - 2\mathrm{e}.$$

[6]

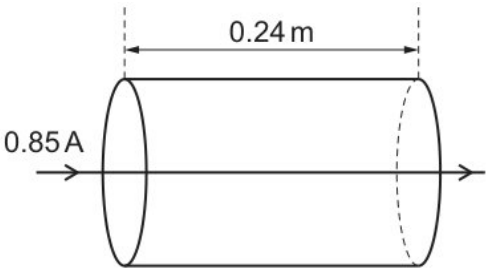
(i) State the equation of the other asymptote.

$$\mathbf{A} = \begin{pmatrix} 1 & -1 & -1 & 1 \\ 2 & -1 & -4 & 3 \\ 3 & -3 & -2 & 2 \\ 5 & -4 & -6 & 5 \end{pmatrix}.$$

the distribution function of X.

[5]

(ii)



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.

[8]

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

the distribution function of X.

the solution of the differential equation

[5]

(ii) Hence solve the equation

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

$$x = 1 + 2\sin^2\theta, \quad y = 4\tan\theta$$

[4]

only one of the following two alternatives.

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

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

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

[3]

12 the speed of the combined particle after this collision.

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

(c) (ii) nucleus X has 14 nucleons and p protons. The ratio of charge to mass for nucleus X is $4.1 \times 10^7 \text{Ckg}^{-1}$.

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

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 .

[4]

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

flows out of a pipe and hits a wall.

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

[10]

(iv) 400 nm to 700 nm

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

parametric equations of a curve are

[8]

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

(a) expression gives the electrical resistance of the metal cube between X and Y ?

[6]

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

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

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

[10]

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

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

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

[6]

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

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

[8]

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

[4]

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

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

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

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

[5]

(i) an estimate for the mean length of these 250 leaves.

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

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

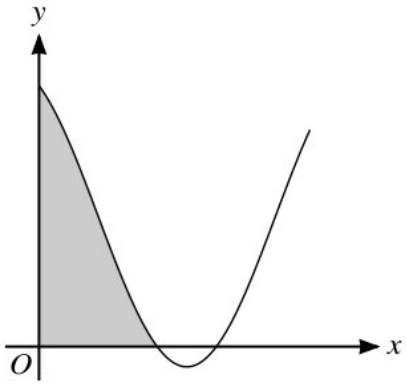
[8]

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

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.

[4]

(b) (iii)



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

[12]

(ii) up to down

to the value α.

[4]

22 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.

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

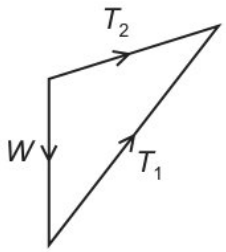
that the eigenvalues of $\mathbf{A}$ are $-1, 1$ and 5 .

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

[5]

32 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 .

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



[6]

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

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

definition is correct and uses only quantities rather than units?

[6]

(vii) Given that the total number of cars sold during the 5 days is 5 , carry out the test.

Hence solve the equation

[6]

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

the moment of a force about a point.

[12]

Use the equation of a suitable regression line to estimate the number of hours of sunshine on a day when the mid-day temperature is 2°C.

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

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

[15]

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

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

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

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

[15]

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

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

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

[4]

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

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

[1]

(i) how the pattern of interfering waves may be observed.

statement is correct when S is changed from open to closed?

[15]

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

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

Show that $m = 0.9$.

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

[12]

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

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

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

$$C_1: \quad r = a$$
$$C_2: \quad r = 2a\cos 2\theta, \text{ for } 0 \leqslant \theta \leqslant \tfrac{1}{4}\pi$$

team of 5 is chosen from 6 boys and 4 girls. Find the number of ways the team can be chosen if

[5]

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

labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.

[8]

(i) Event X is 'exactly two of the selected balls have the same number'. Event Y is 'the ball selected from bag A has number 2'. Showing your working, determine whether events X and Y are independent or not.

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.

[8]

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

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

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

[8]

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

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

State the work W done by F.

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

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.

(c) (iii) 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 $(x - 2)$.

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

[6]

(ii) the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

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

[12]

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

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

$$\mathbf{C} = \begin{pmatrix} -1 & -1 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 2 \end{pmatrix},$$

[10]

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

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

[12]

(i) Calculate the speed of projection of P.

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

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.

[3]

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

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

[3]

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

the term isotope.

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.

[8]

(iii) the expected value and variance of Y.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n \ln x\right) = n!\left(\ln x + 1 + \frac{1}{2} + \ldots + \frac{1}{n}\right).$$

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

[10]

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

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

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

[4]

8 $n \geqslant 0$. Show that, for all $n \geqslant 2$,

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

the solution of the differential equation

[6]

(i) rigid body is made from uniform wire of negligible thickness and is in the form of a square $ABCD$ of mass M enclosed within a circular ring of radius a and mass $2M$. The centres of the square and the circle coincide at O and the corners of the square are joined to the circle (see diagram). Show that the moment of inertia of the body about an axis through O, perpendicular to the plane of the body, is $\frac{8}{3}Ma^2$.

$$\frac{1}{x} = \sin x$$

[2]

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

activity of a radioactive sample.

Find the rank of **M**.

[8]

(ii) show that $PQ = 13$,

$$\int_2^5 (x - 2\ln x)\mathrm{d}x$$

state an eigenvector of the matrix **CD** and give the corresponding eigenvalue.

[8]

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

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

[3]

(a) (iv) 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.

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

[5]

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

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{2x+6}{x^2+6x+5}y = 4,$$

[1]

(i) marble is now chosen at random from bag B.

	v_1/ms^{-1}	v_2/ms^{-1}
A	4.0	4.0
B	9.2	9.2
C	14	14
D	16	16

[8]

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

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

[4]

(d) (i) the solution of the differential equation

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

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 $0 < \theta < 2\pi$

[4]

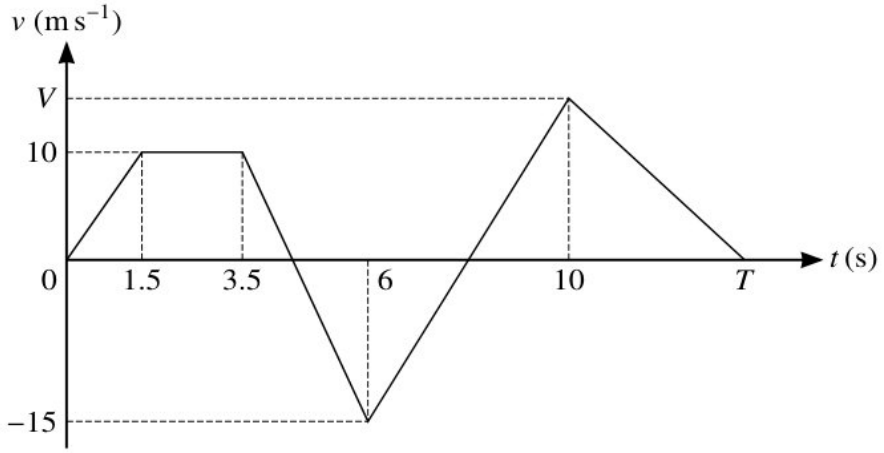
(iii) Find the modulus and argument of u.

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

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

[8]

(vi)



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.

[3]

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

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 .

[6]

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

[5]

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

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

[4]

up the probability distribution table for X.

(a) 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.

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

[5]

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

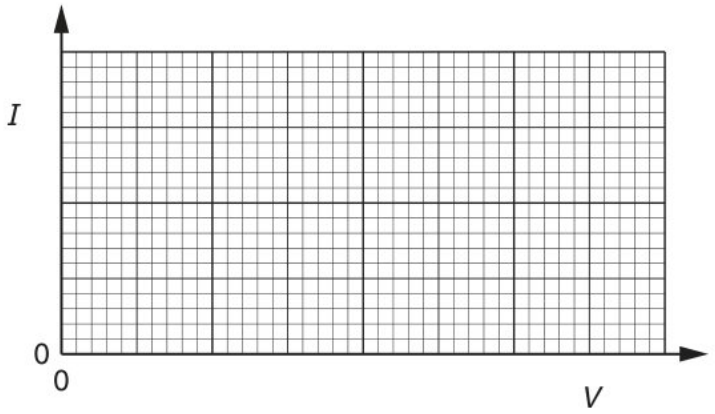
	direction of acceleration	separation of the plates
A	downwards	decrease
B	downwards	increase
C	upwards	decrease
D	upwards	increase

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

curve $y = 4x^2 \ln x$ has one stationary point.

[10]

(ii) is the minimum constant acceleration necessary for the aircraft?



[6]

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

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

[4]

(b) (vi)

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

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

curve C with equation

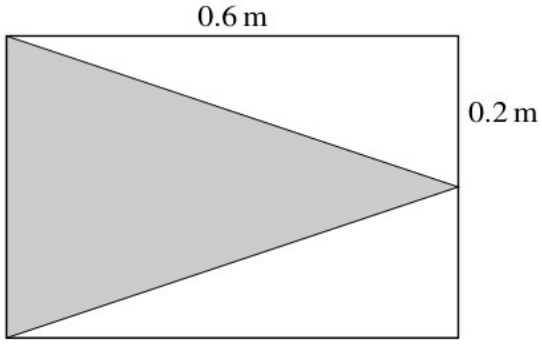
[3]

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

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{2x+6}{x^2+6x+5}y = 4,$$

[4]

(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.

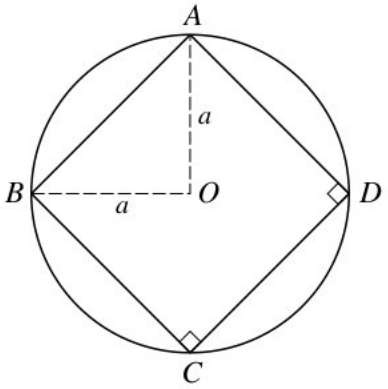
Show that $\mathrm{P}(X = 3) = \frac{1}{15}$.

[3]

19 (d) the point $\left(2, \frac{1}{2}\pi\right)$.

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

Draw up a probability distribution table for X.



(iv) continuous random variable X takes values in the interval $0 \leqslant x \leqslant 3$ only. For $0 \leqslant x \leqslant 3$ the graph of its probability density function f consists of two straight line segments meeting at the point $(1, k)$, as shown in the diagram. Find k and hence show that the distribution function F is given by

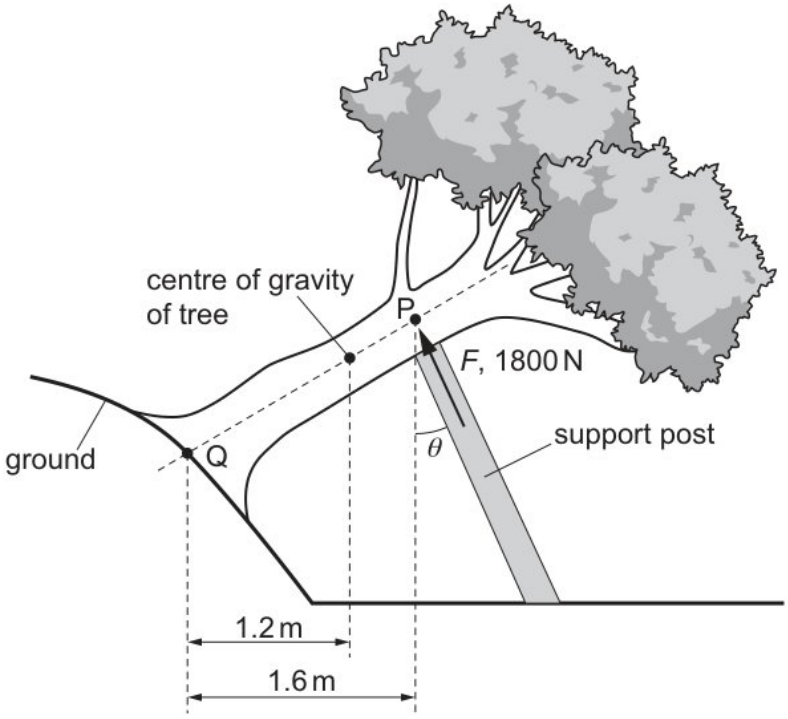
[6]

(ii) Find Σx^2.

[10]

(a) Given that $\mathrm{E}(X) = 1.2$, find the value of a.

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 .



(iii) the equations of the asymptotes of C

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

[6]

(ii) 100 nm to 400 nm

[5]

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

[10]

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

(iv) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$

$$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}.$$

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

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

[10]

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

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

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

[2]

(i) are no resistive forces acting on the block.

[12]

(c) Find the value of I_2.

(vi) places the books in a row on her shelf. She is only interested in the arrangement of the colours.

[8]

(ii) 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.

[5]

20 Hence find the solutions of the equation

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

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

Find the area of the triangle ABC.

[8]

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

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

[10]

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

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

[4]

(d) (iv) the subsequent collision between Q and R, these particles coalesce.

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

[6]

(iii) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{M} =$

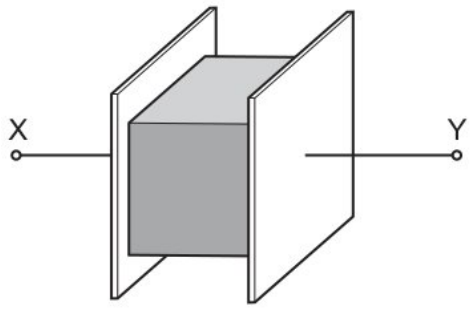
$$\begin{pmatrix} 1 & 3 & -2 & 4 \\ 5 & 15 & -9 & 19 \\ -2 & -6 & 3 & -7 \\ 3 & 9 & -5 & 11 \end{pmatrix}.$$

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

	amplitude /cm	period /ms
A	2	10
B	2	90
C	4	10
D	4	90

[8]

(i)



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

[3]

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.

(c) is the current in the load resistor?

[5]

(a) (iii) the point $\left(2, \frac{1}{2}\pi\right)$.

400 nm to 700 nm

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

[6]

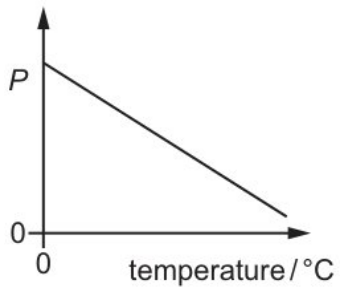
(ii) by calculation that $0.9 < a < 0.95$.

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

particle of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle is moving in complete vertical circles with the string taut. When the particle is at the point P, where OP makes an angle α with the upward vertical through O, its speed is u. When the particle is at the point Q, where angle $QOP = 90°$, its speed is v (see diagram). It is given that $\cos\alpha = \frac{4}{5}$.

[6]

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



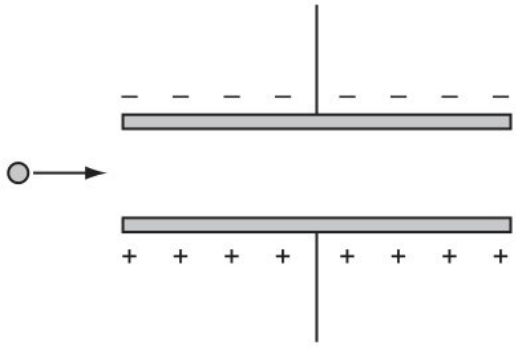
[8]

(vi) random sample of twelve pairs of values of x and y is taken from a bivariate distribution. The equations of the regression lines of y on x and of x on y are respectively

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

[4]

(ii)



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.

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

[5]

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

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

[10]

17 position vectors of the points A, B, C, D are

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

[4]

Find the equations of the asymptotes of C.

(b) wire is extended by a tensile force so that its deformation is elastic.

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

[6]

statement about nuclei is correct?

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

[6]

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

[8]

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

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

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

is the minimum constant acceleration necessary for the aircraft?

[4]

(iii) the term interference.

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

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

[6]

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

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

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

[5]

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

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

[10]

(iii) width of the 99% confidence interval is double the width of the x% confidence interval.

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

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 $X \sim \mathrm{N}\left(3.2, 0.4^2\right)$ and $Y \sim \mathrm{N}\left(4.3, 0.6^2\right)$. The income generated by the oil from the two fields is \$90 per barrel for A and \$95 per barrel for B.

cars = ... xz **[20]**

(e) (ii) positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

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

[1]

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

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

[6]

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

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

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

[8]

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

Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{3x^2y - 3y^3}{9xy^2 - x^3}$.

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

[5]

8 to the value α.

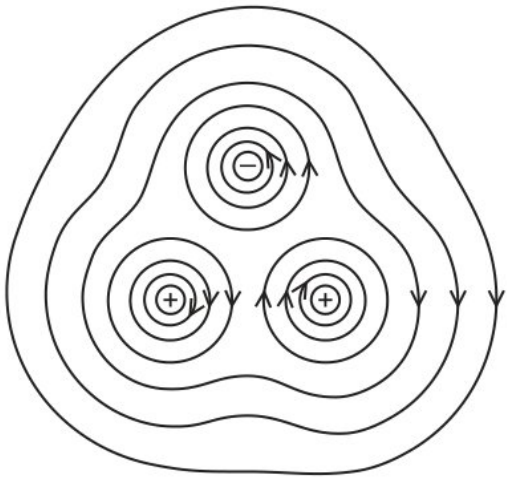
the sum to infinity of the progression.

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.

[12]

19 only one of the following two alternatives.

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



(a) (ii) State, with a reason, whether the trapezium rule gives an under-estimate or an over-estimate of the true value of the integral in part (ii).

tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

$$\begin{pmatrix} 0 \\ 1 \\ -1 \end{pmatrix}, \quad \begin{pmatrix} -1 \\ 0 \\ 1 \end{pmatrix}, \quad \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix},$$

[10]

(i) the coordinates of any stationary points on C

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

$$_{88}Q \longrightarrow {}^{222}_{\cdots}R + {}^{4}_{2}Q$$

[2]

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

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

[12]

(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.

then it converges to a.

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

[3]

much charge passes a given point in wire R in a time of $5s$?

(d) student investigates an electrical circuit.

[5]

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

(c) 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.

[5]

(b) (i) the subsequent collision between Q and R, these particles coalesce.

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.

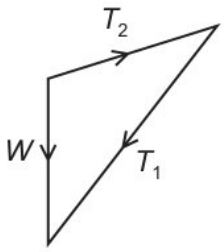
[12]

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

Find the median of X.

[10]

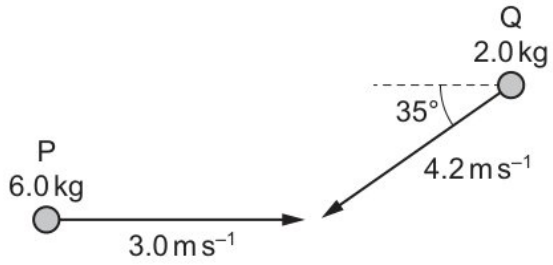
(iv)



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

[5]

11 parametric equations of a curve are



[4]

14 was the by-product of this reaction?

[5]

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

[8]

18 (c) 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 $\cos 2\theta = \frac{7}{25}$.

(iii) 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.

[3]

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

[5]

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

Calculate the distance of the centre of mass of the lamina from A.

[1]

matrix **A**, given by

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

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

[8]

many different colour arrangements are there of the 10 books?

statement about nuclei is correct?

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

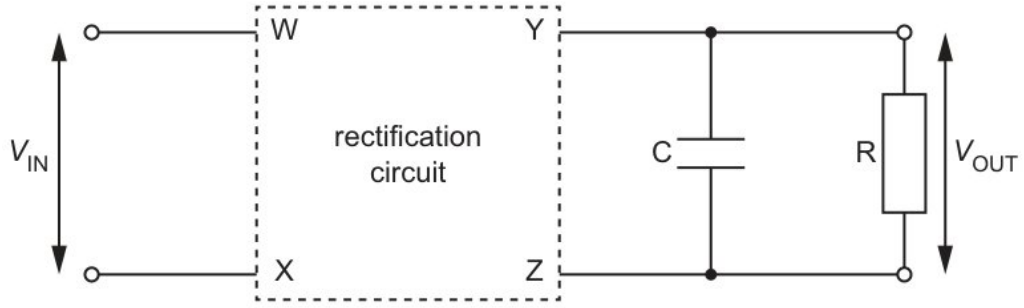
three coplanar forces shown in the diagram act at a point P and are in equilibrium.

[12]

13 The waves must be polarised.

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

(i) that $rp^3 = q^3$.



[12]

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

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

nucleus = ... sf **[8]**

20 Find the area of the region enclosed by C.

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

[3]

11 Prove by mathematical induction that, for all positive integers n,

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

[2]

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

(a) smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.

[4]

21 3×3 matrix $\mathbf{A}$ has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

only one of the following two alternatives.

(b) (v) measurements to be taken,

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

[10]

(vii) a basis for the null space of T .

the acute angle between the directions of l_1 and l_2.

[2]

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

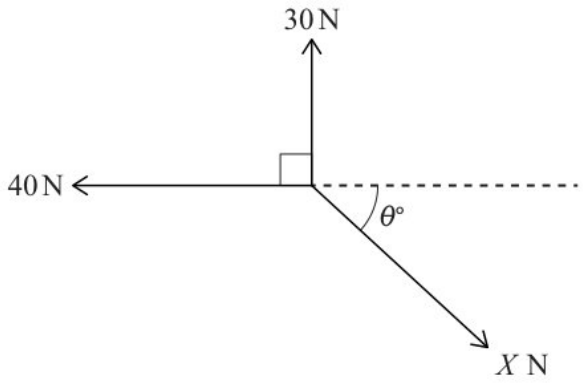
particle P of mass m is attached to one end of a light elastic string of natural length a and modulus of elasticity mg. The other end of the string is attached to a fixed point O on a rough plane inclined at an angle of 30° to the horizontal. The particle P is held at rest at point O before being released.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

Find the value of x.

[4]

farmer is investigating whether using a new fertiliser will increase the yield of tomato plants. The farmer selects 40 tomato plants at random and gives them the new fertiliser. The crop mass, x kg, of each of these 40 plants is recorded. The farmer selects a further 60 tomato plants at random and gives them a standard fertiliser. The crop mass, y kg, of each of these 60 plants is recorded. The results are summarised as follows.

(d)



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

[1]

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

(c) Use an iterative formula based on the equation in part (i) to find the value of a correct to 4 significant figures. Give the result of each iteration to 6 significant figures.

[5]

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

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

curve C has equation $\tan y = x$, for $x > 0$.

[4]

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

the sum to infinity of the progression.

different = ... qw **[3]**

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

(a) labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.

[5]

(e) (iv) Prove that, for $n \geqslant 2$,

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

[10]

(iii) between gravitational potential energy and electric potential energy.

spherical object falls through water at constant speed. Three forces act on the object.

[20]

Find the perpendicular distance of the point A from the line BC.

(h) the expected value and variance of Y.

[2]

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

[8]

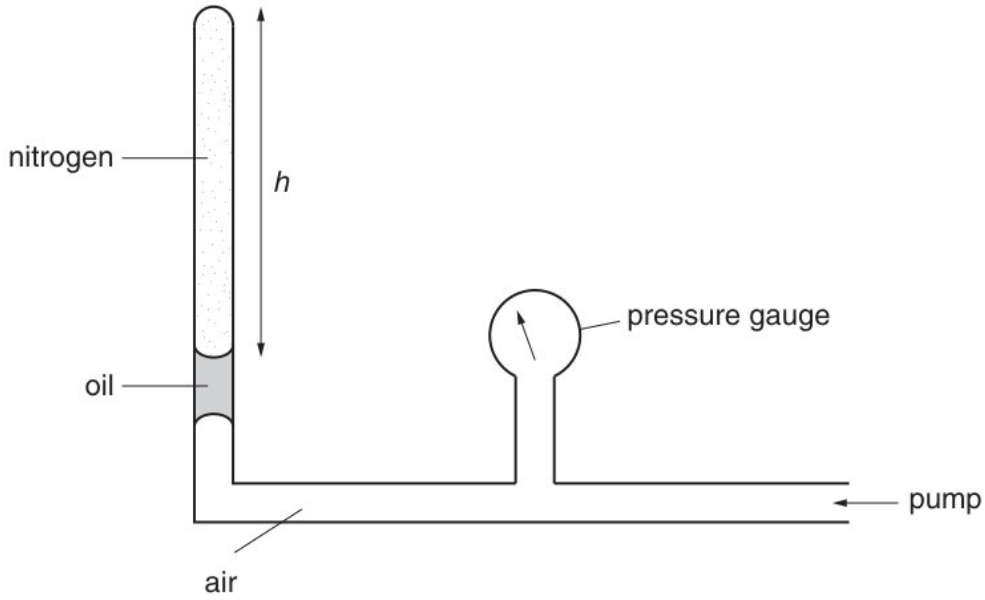
22 diagram shows a sketch of the curve $y = \frac{3}{\sqrt{(9-x^3)}}$ for values of x from -1.2 to 1.2 .

if there are no restrictions,

[5]

14 $\frac{\text{mass} \times (\text{ time })^2}{\text{length}}$

(ii) (a)



aeroplane is flying at a constant speed.

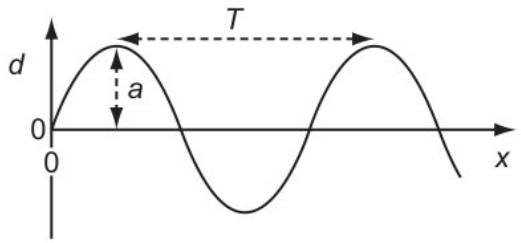
[5]

(b) the values of p and q

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.

[4]

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



[6]

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

Density is mass per cubic metre.

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.

[8]

(iii) (b) relationship is used in the derivation of the equation shown?

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

[10]

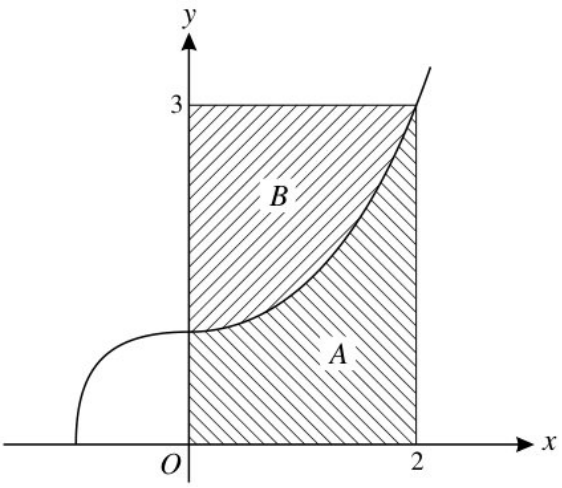
(d) random variable X is the number of heads obtained.

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

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

[6]

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



[4]

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

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

[5]

(a) is given that $y = 2$ when $x = 2$.

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

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

[3]

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

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

[6]

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

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

[2]

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

Show that x satisfies the equation

[20]

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

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.

[10]

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

is meant by elastic deformation?

[5]

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

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

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

Show by calculation that a lies between 2 and 4 .

[6]

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

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

[4]

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

(b) (iv) the probability that Ali, Ben and Charlie are all in the same group.

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

[8]

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

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.

[4]

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

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

[2]

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

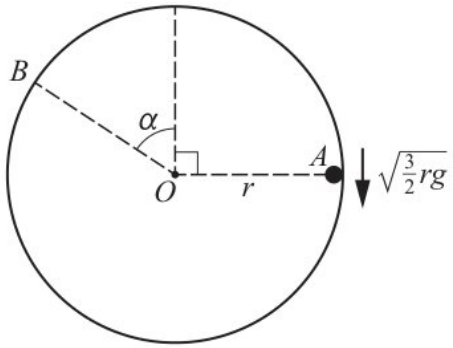
the period of small oscillations,

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.

[10]

statement is correct?

(a) 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 m s^{-1}. She maintains the speed of V 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 .



[6]

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

(ii) diagram shows a semicircle ACB with centre O and radius r. The tangent at C meets AB produced at T. The angle BOC is x radians. The area of the shaded region is equal to the area of the semicircle.

deviation = ... jy **[12]**

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

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

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

[4]

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

is given that $\sum x = 175.0$ and that the mean of y is 8.4 .

[4]

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

[6]

10 Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m , calculate the greatest possible value of ω and the corresponding tension in the string.

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

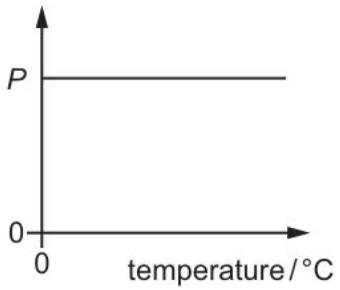
respect to the origin O, the points A, B and C have position vectors given by

(b) Obtain a basis for the null space of T .

[5]

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

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



[12]

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

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

[5]

25 100 nm to 400 nm

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

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

[8]

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

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

[6]

(iii) Estimate the probability of throwing a 4.

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

[6]

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

smooth spheres P and Q, of equal radius, have masses m and $3m$ respectively. They are moving in the same direction in the same straight line on a smooth horizontal table. Sphere P has speed u and collides directly with sphere Q which has speed ku, where $0 < k < 1$. Sphere P is brought to rest by the collision. Show that the coefficient of restitution between P and Q is $\frac{3k+1}{3(1-k)}$.

[4]

(iv) 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 m s^{-1}. She maintains the speed of V 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 .

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

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

[5]

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

the probability that the second A is obtained on the 6th roll of the dice.

[12]

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

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

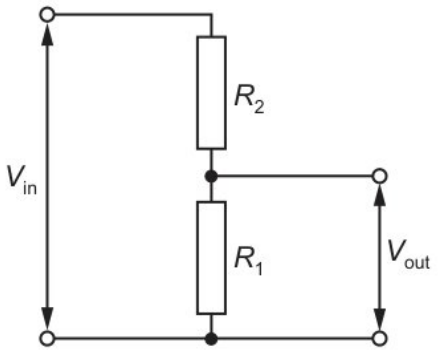
[5]

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

$$6\frac{\mathrm{d}^2x}{\mathrm{d}t^2} + 3\frac{\mathrm{d}x}{\mathrm{d}t} + 6x = \mathrm{e}^{-t}$$

[8]

16 curve C has equation



gravitational potential at a point.

[3]

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

Hence solve the equation

[3]

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

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

[8]

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

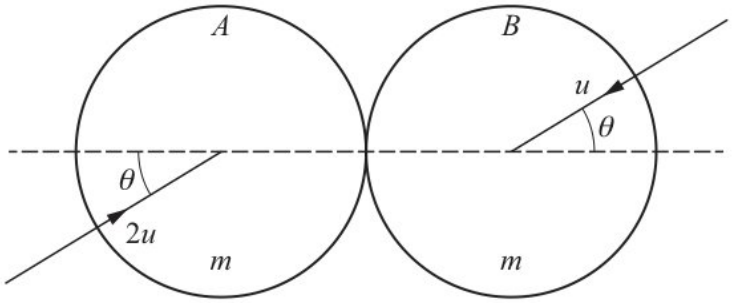
(b) the value of $\sum_{r=1}^{\infty} \frac{1}{(2-3r)(5-3r)}$.

[8]

diagram shows the force-extension graph produced.

expression has the same SI base units as pressure?

(d)



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

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

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

[8]

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

[12]

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

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.

Show that the tension in the string is 10 N .

(b) (i) Show that the total distance fallen is 1048 m .

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

[6]

(iii) wire is extended by a tensile force so that its deformation is elastic.

is the average useful power at which he is working?

the general solution of the differential equation

[5]

(ii) Both light waves and sound waves show the Doppler effect.

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

[5]

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

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

(a) velocity = acceleration × time

[4]

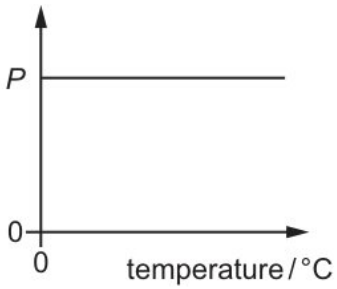
26 the equations of the asymptotes of C

(d) (ii) does this mean?

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.

[5]

(iv)

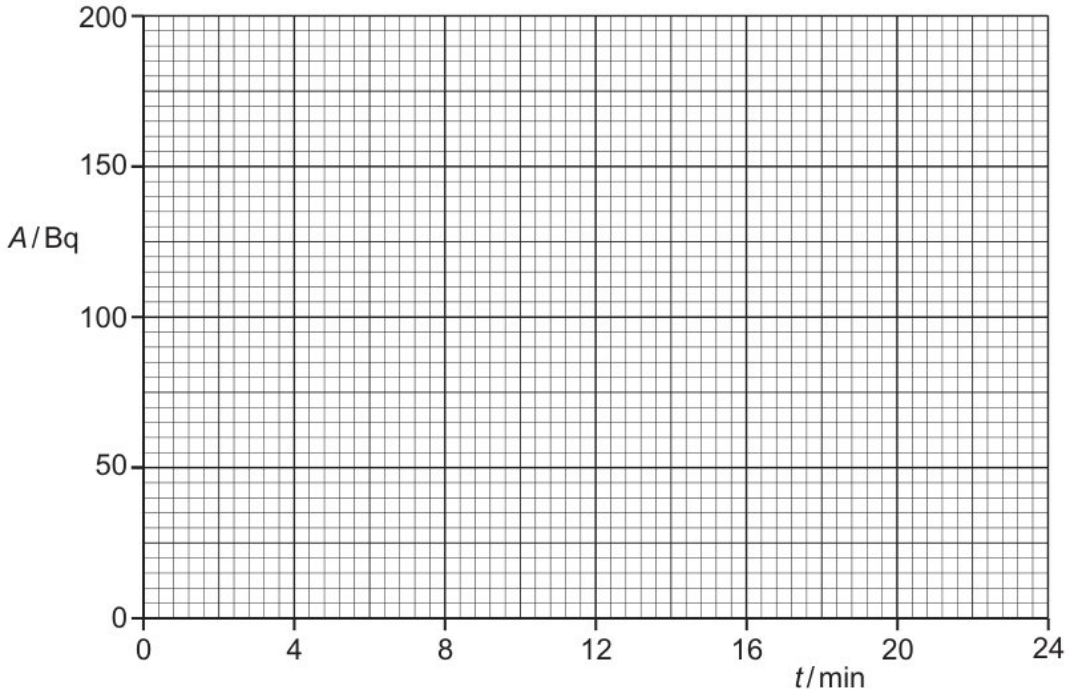


Given that, in fact, the mean concentration for patients taking the drug is 0.175 , find the probability of a Type II error occurring in the test.

[20]

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

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



[8]

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

[5]

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

a positron and an antineutrino

(b) (iii) wavelength of light is 550 nm .

Use implicit differentiation to show that

the number of different ways in which the 12 letters of the word STRAWBERRIES can be arranged

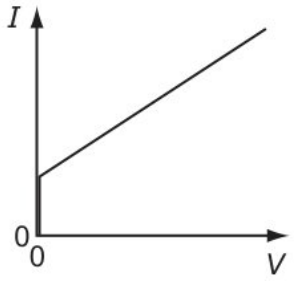
[6]

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

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

[6]

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



Use de Moivre's theorem to show that

second = ... aw **[10]**

particle P starts from rest at a point O and travels in a straight line. The acceleration of P is $(15 - 6x)\text{ms}^{-2}$, where x m is the displacement of P from O.

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

[5]

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

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

[4]

7 Given that, in fact, the mean concentration for patients taking the drug is 0.175 , find the probability of a Type II error occurring in the test.

force = mass × acceleration

[1]

8 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.

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

[8]

13

	α-particles	γ-rays
A	least ionizing	least penetrating
B	least penetrating	most ionizing
C	most ionizing	most penetrating
D	most penetrating	least ionizing

the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

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.

guests. night occupied = ... vc **[1]**

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

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

[8]

(ii) Find the area of the region enclosed by C.

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

[3]

Find the cartesian equation of Π_1.

(d) 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.

[5]

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

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

[5]

12 $\text{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

(d) (iv) Use the trapezium rule, with two intervals, to estimate the value of

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

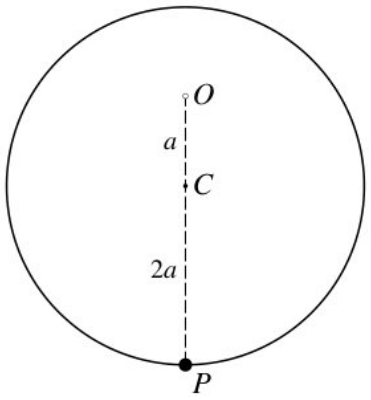
diagram = ... vf **[8]**

(ii) 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}.

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.

[6]

(iii)



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

[6]

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

(a) Calculate the exact value of I_1 and deduce the exact value of I_3.

t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

[4]

(b) (v) is the grand-daughter product?

labels on the graphs are intended to show the wavelength λ, the period T and the amplitude a of the wave, but only one graph is correctly labelled.

[6]

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

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

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 $\lambda\mu$.

[1]

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

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

[4]

(ii) circle is divided into 6 sectors in such a way that the angles of the sectors are in arithmetic progression. The angle of the largest sector is 4 times the angle of the smallest sector. Given that the radius of the circle is 5 cm , find the perimeter of the smallest sector.

Find the values of a and b.

[8]

26 would this object weigh on Pluto?

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

[4]

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

[5]

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

the equations of the asymptotes of C.

[10]

12 ripple tank is used to demonstrate interference between water waves.

[4]

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

the distribution function of X.

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

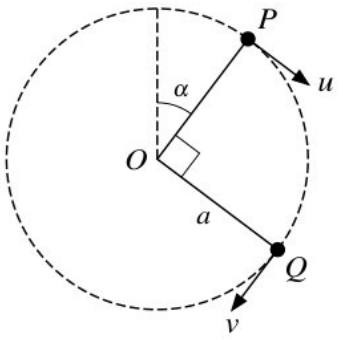
[10]

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

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

[3]

(a) the general solution of the differential equation



the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

[12]

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

Find the exact area of the shaded region.

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

the mean value of y with respect to x over the interval $0 \leqslant x \leqslant \ln 5$,

[3]

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

[3]

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

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

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

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.

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

[6]

18 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.

curve $y = 4x^2\ln x$ has one stationary point.

[1]

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

curve C has equation

[6]

15 the probability that Ali, Ben and Charlie are all in the same group.

[4]

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

[12]

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

1.1 shows the measurements for cube A.

[8]

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

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

State, with a reason, whether the trapezium rule gives an under-estimate or an over-estimate of the true value of the integral in part (ii).

[3]

14 object hangs by means of two cords around two rods, as shown.

[1]

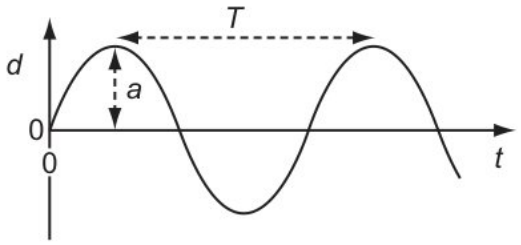
18 masses of the bags of rice made by a company are normally distributed with mean μkg and standard deviation 0.14 kg . The probability that the mass of a randomly chosen bag of this rice is less than 1.48 kg is 0.22 .

[4]

10 is given that

statement is correct when S is changed from open to closed?

(c) (iii)



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

[6]

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

the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

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

[6]

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

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

[8]

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

Find the tension in the string.

the value of $\sum y^2$, correct to 1 decimal place.

[12]

(vi) tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

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

[6]

(iii) object is held in equilibrium by the forces F_1 and F_2. The object weighs 10 N . There is negligible friction between the rods and cords. Angle θ is 90°.

$$\frac{1}{x} = \sin x$$

the distribution function of X.

[20]

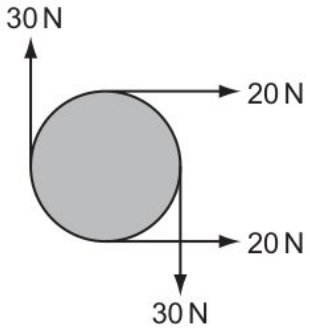
will the powers to the resistors change when resistor W is removed?

(d) 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.

[1]

variables x and y are related by the differential equation

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



[4]

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

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

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

[6]

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

the graph of $y = |3x - 2a|$, where a is a positive constant.

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.

[12]

(iv) 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.

$$\mathbf{A} = \begin{pmatrix} 6 & -8 & 7 \\ 7 & -9 & 7 \\ 6 & -6 & 5 \end{pmatrix}$$

[6]

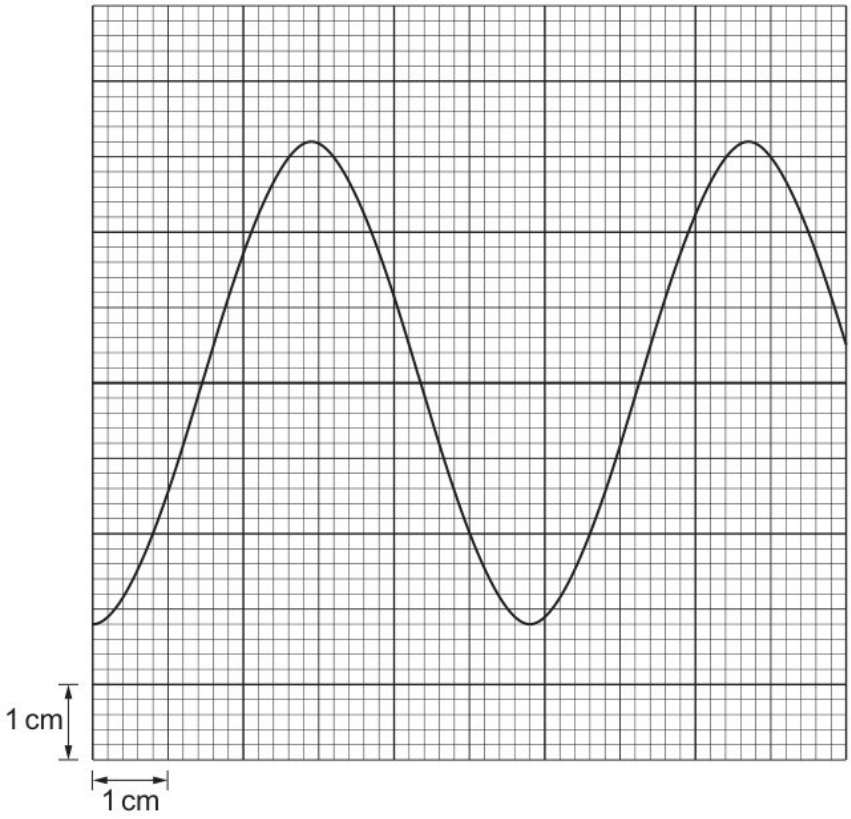
(c) (iii) is the efficiency of the process?

Use the trapezium rule, with two intervals, to estimate the value of

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

[12]

(ii)



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

[4]

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

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

[6]

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

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

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

[6]

19 Find the standard deviation of x.

Use the trapezium rule with two intervals to find an approximation to the area of region A. Give your answer correct to 2 decimal places.

[12]

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

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

(f) curve C has parametric equations

supermarket is open 7 days a week.

[5]

(b) (iii) the process by which α-particles lose energy when they pass through air.

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

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.

[8]

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

the equation representing this decay.

[12]

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

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

[4]

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

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

(c) Find the values of p and q.

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

[8]

20 equation gives v in terms of A and u ?

t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

(b) (iv) Use the equation of a suitable regression line to estimate the number of hours of sunshine on a day when the mid-day temperature is 2°C.

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.

bolt is subjected to a tensile force, as shown.

[5]

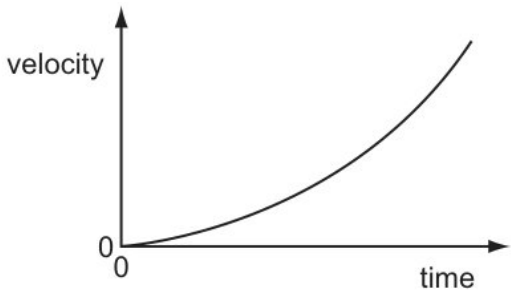
(ii) curve C has polar equation $r = 2a\cos\left(2\theta + \frac{1}{2}\pi\right)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

Calculate the greatest deceleration of P.

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 $\mathrm{G}_X(t) \times \mathrm{G}_Y(t)$.

[6]

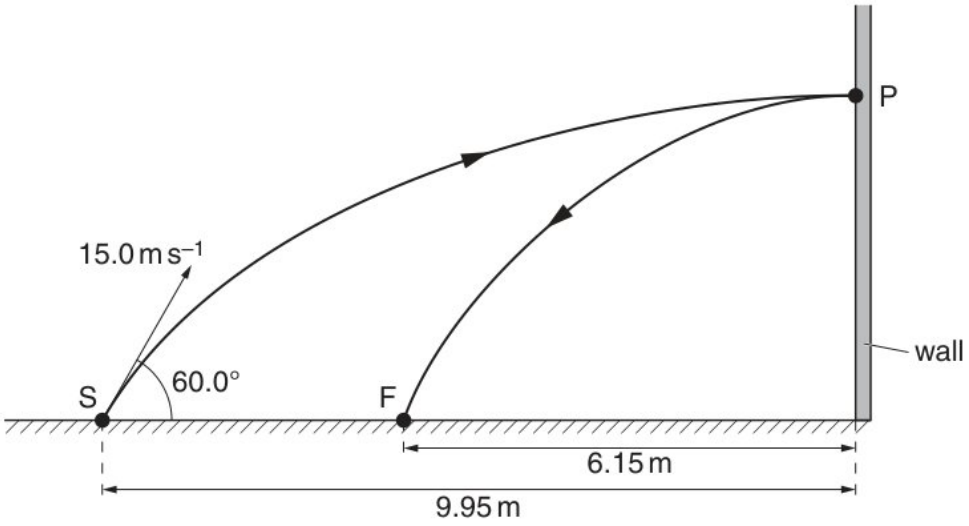
(i) student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).



spherical object falls through water at constant speed. Three forces act on the object.

[2]

(c) (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



[5]

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

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

[20]

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

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

[1]

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

(c) (iii) the Young modulus.

circuit is set up as shown in Fig. 2.1.

[2]

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

projectile is thrown at an angle to the ground.

[6]

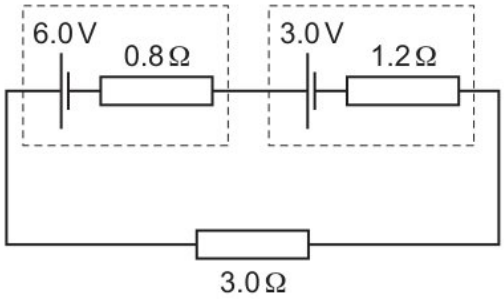
points A, B and C have position vectors $2\mathbf{i}-\mathbf{j}+\mathbf{k}, 3\mathbf{i}+4\mathbf{j}-\mathbf{k}$ and $-\mathbf{i}+2\mathbf{j}+4\mathbf{k}$ respectively.

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

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

[8]

18



safety precautions to be taken.

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

[5]