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

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

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

time-base setting on the oscilloscope should be used?

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 $\frac{8}{3}Ma^2$.

[6]

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

that $rp^3 = q^3$.

[4]

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

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

[8]

(i) ABC is a uniform triangular lamina of weight 19 N , with $AB = 0.22$ m and $AC = BC = 0.61$ m. The plane of the lamina is vertical. A rests on a rough horizontal surface, and AB is vertical. The equilibrium of the lamina is maintained by a light elastic string of natural length 0.7 m which passes over a small smooth peg P and is attached to B and C. The portion of the string attached to B is horizontal, and the portion of the string attached to C is vertical (see diagram).

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

speeds of the particles.

with = ... ht **[2]**

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

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

[5]

(ii) a transformation from $\mathbb{R}^4$ to $\mathbb{R}^4$.

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

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

semicircle. area = ... mq **[8]**

15 It limits the range of values obtained in repeated measurements.

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

Find the x-coordinate of M.

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

number experiment = ... eh **[8]**

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

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

[2]

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

aeroplane is flying at a constant speed.

[8]

(c) (i) Find the x-coordinate of M.

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

[3]

(ii) Light waves can be diffracted but sound waves cannot be diffracted.

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 .

[8]

(a) (ii) State one other feature of this orbit.

524 526 520 523 530

fixed = ... hl **[3]**

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

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

[8]

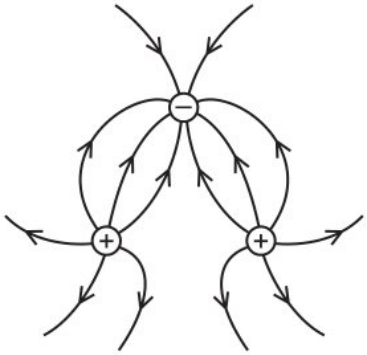
(iv) position vectors of the points A, B, C, D are

the probability of a Type I error.

projection, horizontal ground. = ... *lo* **[12]**

20 Draw a fully labelled tree diagram to illustrate this situation.

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



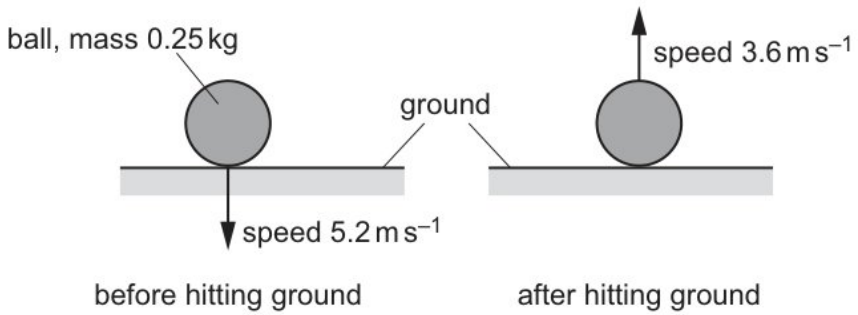
value = ... *ic* **[8]**

(i) cubic polynomial p(x) is defined by

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

[5]

(ii) 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



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]

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

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

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

[6]

(v) by mathematical induction, that 5^n+3 is divisible by 4 for all non-negative integers n.

Calculate the speed of projection of P.

[6]

(iv) what is meant by the de Broglie wavelength.

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

[6]

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

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

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

[6]

(iv) Calculate the density, in kgm^{-3}, of the material from which the paving slab is made.

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

7.65 ages = ... wj **[12]**

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

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

[5]

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

statement about nuclei is correct?

[8]

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

a and **b** are vectors and t is a scalar.

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

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

a tree diagram to represent this information, giving the probability on each branch.

[4]

(ii) Find the probability that a randomly chosen boy aged 16 years in Jimpuri weighs more than 65 kilograms.

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

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

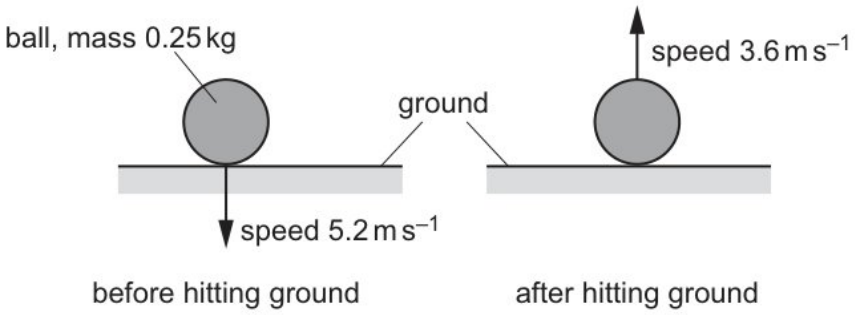
linesper = ... *ps* **[5]**

(v) that, at the point of C furthest from the initial line,

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

[8]

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



is the force exerted on the wall by the water?

[5]

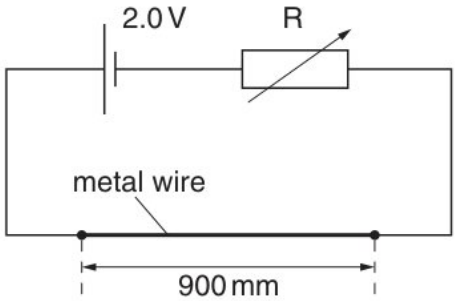
(h) (ii) Find the initial speed and the angle of projection of B.

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

[12]

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

stationary loudspeaker emits sound of constant frequency. A microphone is placed near to the loudspeaker and connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.



[8]

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

the term ultimate tensile stress.

screen = ... *dw* **[12]**

26 what is meant by the de Broglie wavelength.

aeroplane then ascends 300 m in 50 s , while maintaining the same speed. The resistance force is no longer constant, and the work done against the resistance force in ascending the 300 m is 270000 kJ . The mass of the aeroplane is 60000 kg .

if there are no restrictions,

cable has tensions T_1 and T_2 as shown.

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

(b) (vi)

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

Given that $v = 2.5$, find x.

apart. = ... *df* **[5]**

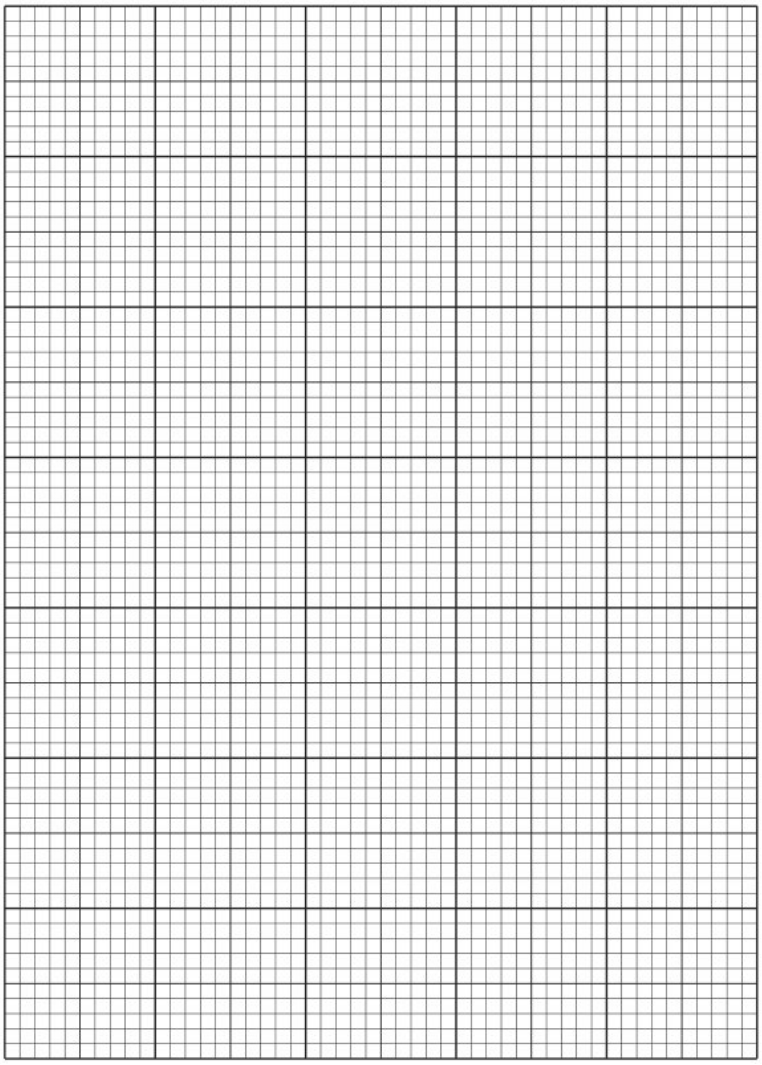
(i) Given that $F = 0, G = 75$ and $\alpha = 60°$, find the magnitude and direction of the resultant force.

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

bolt is subjected to a tensile force, as shown.

angles, = ... wz **[5]**

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



[8]

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

roots of the equation

[10]

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

believes that 20% of the students at his college are left-handed. His friend believes that the true proportion, p, is less than 20%. Amir plans to use the binomial distribution to test the null hypothesis, $\mathrm{H}_0 : p = 0.2$, against the alternative hypothesis, $\mathrm{H}_1 : p < 0.2$.

[10]

(vi) Find the acute angle between Π_1 and Π_2.

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

the speed of the aeroplane.

[5]

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

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

$$\Sigma x = 18.7 \quad \Sigma x^2 = 106.43 \quad \Sigma y = 34.7 \quad \Sigma y^2 = 133.43 \quad \Sigma xy = 92.01$$

[10]

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

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

The matrix **B**, where

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

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

on the graph would the elastic limit be found?

3876 = ... fn **[6]**

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

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 .

[6]

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

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

[3]

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

decimal = ... fd **[8]**

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

turbine at a hydroelectric power station is situated at a vertical distance of 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

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

[10]

(i)

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

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

different = ... jh **[8]**

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

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

why Kieran is incorrect.

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

[6]

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

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

[12]

(i) (c) statement about sound waves in air at constant temperature is correct?

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

[5]

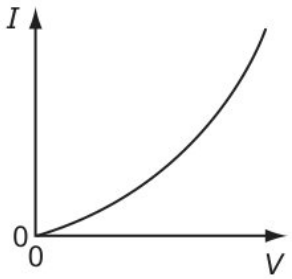
(a) what is meant by the accuracy of a measured value.

matrix **A** is given by

28 33 55 38 42 39 27 48 51 37 57 49 33

[10]

(b)



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.

line = ... *vn* **[8]**

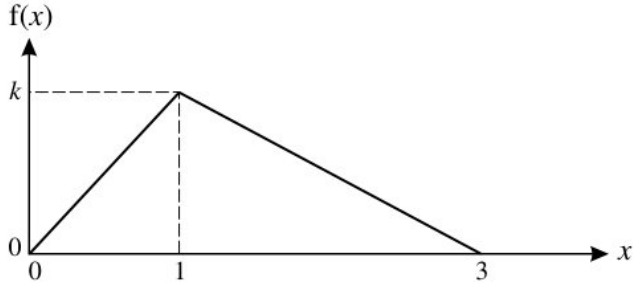
(ii) (g) the position vector of D.

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

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

[10]

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



[2]

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

The waves must not be polarised.

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

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

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 $\frac{1}{3}$.

variables x and y satisfy the differential equation

[15]

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

Calculate the greatest deceleration of P.

[4]

(iv) why Kieran is incorrect.

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.

[5]

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

only one of the following two alternatives.

three = ... *cm* **[4]**

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

Calculate the initial speed and the angle of projection of P.

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

[4]

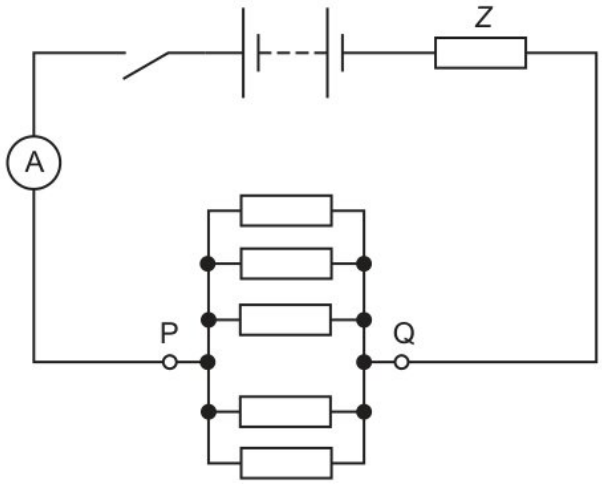
(iv) the subsequent motion find, in terms of r, the greatest height above O reached by the particle.

is the minimum constant acceleration necessary for the aircraft?

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

diameter coil = ... *ob* **[8]**

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



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

shown Fig. = ... xi **[3]**

(i) How many possible arrangements are there of seating Mary, Ahmad, Wayne, Elsie and John if Mary and Ahmad sit together in the front row and the other three sit together in one of the other rows?

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

[6]

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

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

[6]

26 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.

(b) (ii) the median and the interquartile range of the times of the runners from the Gulls.

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

Find the values of a and b.

[10]

(iii) skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

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

[8]

(v) de Moivre's theorem to show that

the probability density function of Y

[6]

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

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

note = ... *vn* **[3]**

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

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

[4]

(iii) shaded region is bounded by the curve and the two axes.

transmitted light has intensity $0.75I$.

[5]

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

is the average useful power at which he is working?

[4]

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

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

rebounds wall strikes = ... xs **[4]**

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

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

[15]

(ii) 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.

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

[10]

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

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

[5]

(i) the number of different arrangements of the 8 letters in the word KANGAROO in which the two As are together and the two Os are not together.

Find the values of p and q such that

[8]

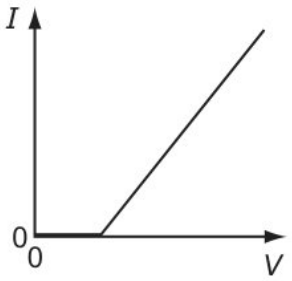
(c) (iv) R has an amplitude of 8 cm and a period of 30 ms .

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

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

Diameter wound = ... *sy* **[8]**

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



Prove that, for $n \geqslant 2$,

[2]

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

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

[20]

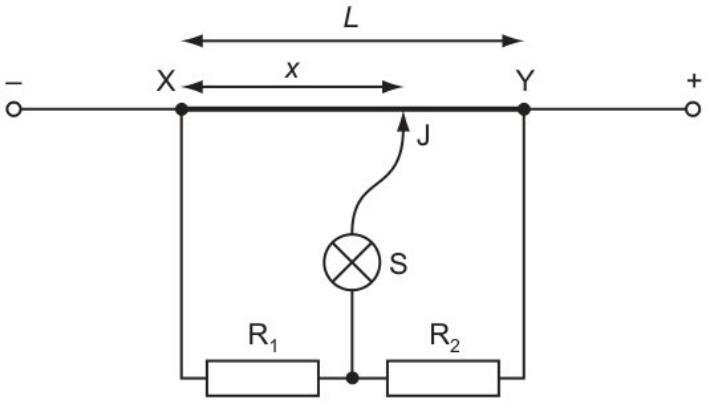
24 In some nuclear processes, mass-energy is not conserved.

(e) (i) 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.

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

string. = ... az **[3]**

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



brings = ... la **[6]**

(iv) Find Σx^2.

$$a_{n+1} = \left(\frac{7 + 2a_n^{\frac{3}{2}}}{3 \ln a_n} \right)^{\frac{2}{3}}$$

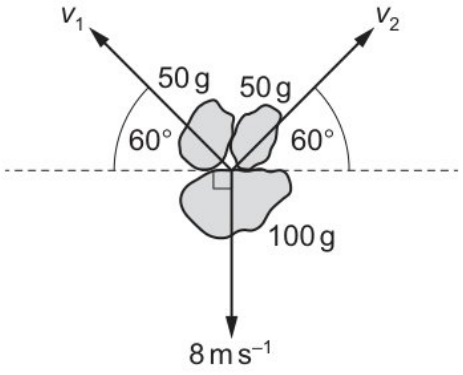
balls = ... mb **[6]**

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

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

[4]

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



[4]

(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.

a, b and c are integers to be determined.

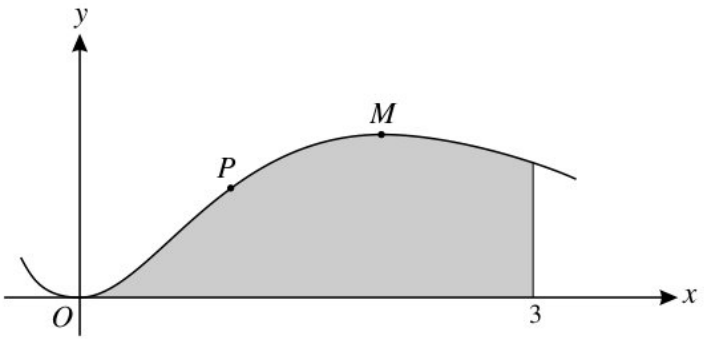
[6]

(d) (ii) values, x, in a particular set of data are summarised by

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

speed work = ... qn **[10]**

(iii) how the difference in the densities of solids, liquids and gases may be related to the spacing of their molecules.



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 .

Find = ... mv **[4]**

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

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

from = ... wn **[12]**

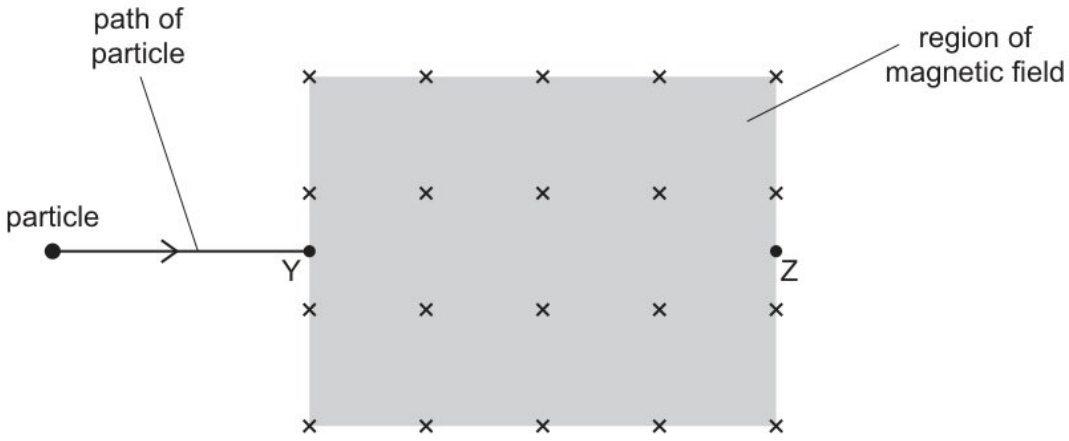
(vi) Explain the features of the graphs in (d) that show the characteristics of ductile and brittle materials.

$$\mathbf{Ax} = p\begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q\begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix}$$

[5]

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

(e) (iii) Find the values of p and q such that



speed = ... nt **[10]**

(ii) Find the power output of the tractor's engine.

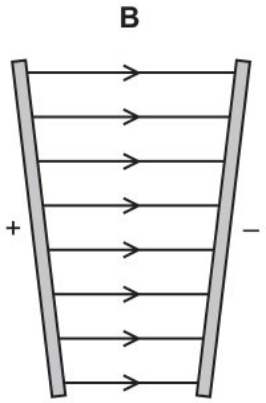
$\mathbf{A}^{2n}$, where n is a positive integer.

[5]

(a) (i) t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the the SI base units of resistivity.

[3]

(vi)



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.

[3]

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

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

[8]

(b) (ii) the grid below, draw a cumulative frequency graph to illustrate this information.

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]

(i) the value of the constant k,

Show that $\mathrm{ff}(x) = x$.

continuous random variable X has probability density function f given by

after = ... yt **[6]**

(v) Prove that, for $n \geqslant 2$,

plank rests on fixed supports at its ends X and Y.

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

[5]

14 Find $\sum_{r=n+1}^{2n} u_r$.

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

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

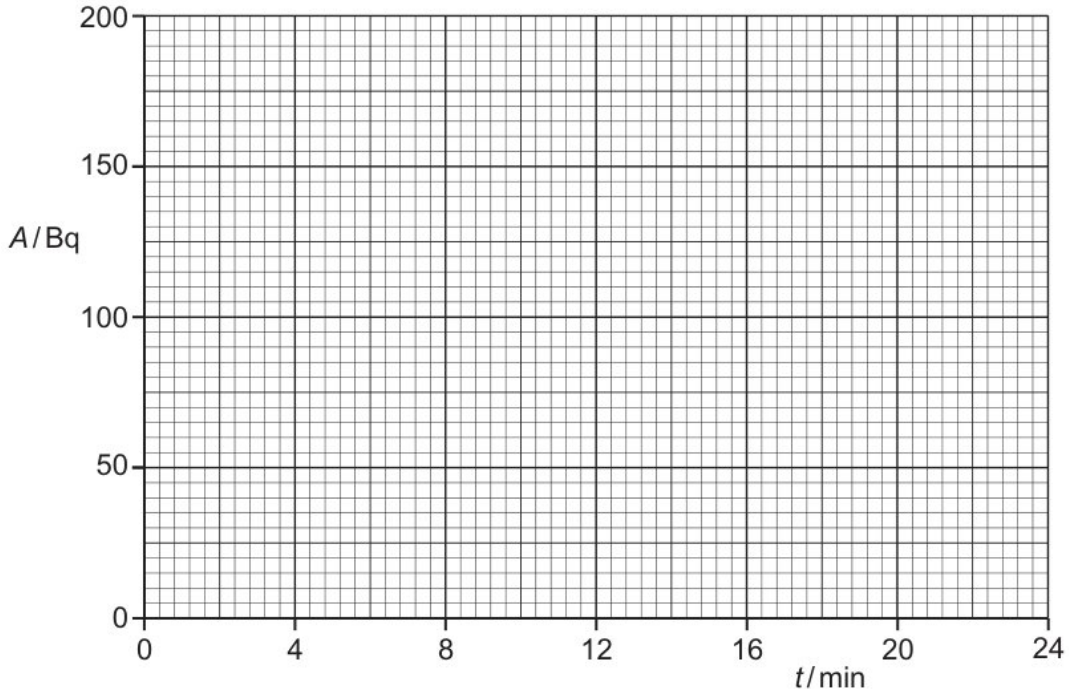
[4]

(i) is given that

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

[8]

(iv)



the time taken for the ball to reach its maximum height

[6]

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

The orbit has a period of 25 hours.

emails = ... nz **[5]**

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

the exact value of a.

[4]

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

$\mathbf{A}^{2n}$, where n is a positive integer.

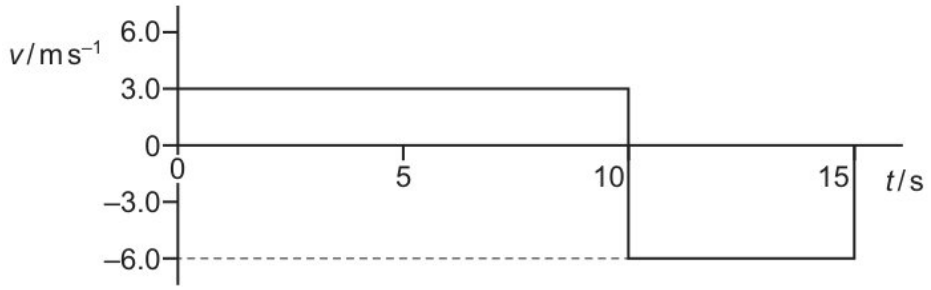
[10]

(d) (ii) first artificial radioactive substance was made by bombarding aluminium, $^{27}_{13}\text{Al}$, with α-particles. This produced an unstable isotope of phosphorus, $^{30}_{15}\text{P}$.

Find, showing all necessary working, the equation of the regression line of y on x.

[5]

(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.

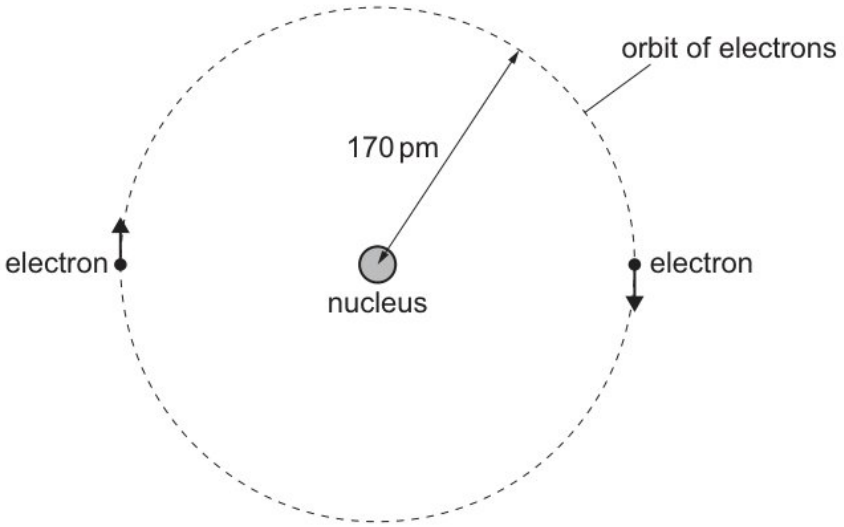
[6]

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

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

foot = ... yl **[10]**

(iii)



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.

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

Given = ... kc **[4]**

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

Different isotopic nuclei have different proton numbers.

[5]

(i) measurements to be taken,

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

$a =$ ……..

$b =$ ……..

$x =$ ……..

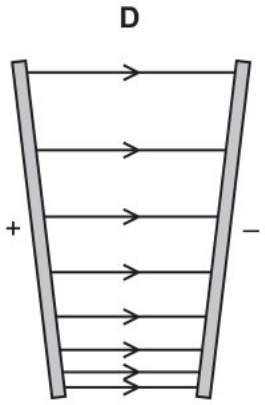
$y =$ ……..……..

[3]

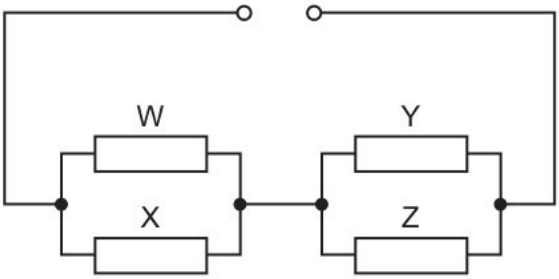
into = ... mu **[4]**

15 object is fully submerged in a liquid.

(c) (i)



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



[8]

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

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.

resistor = ... zh **[1]**

(iii) roots of the equation

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

[6]

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

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

[4]

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

narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m . The disc rotates with angular velocity ωrads^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

[3]

(b) (ii) a vector equation for the line l_1.

down to antiup

[12]

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

$$\sin\frac{1}{5}\pi\sin\frac{2}{5}\pi\sin\frac{3}{5}\pi\sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right)+\sin^2\left(\frac{2}{5}\pi\right)$$

[6]

8 the torque of a couple.

(f) (i) Find the position vector of D.

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

classified took = ... xs **[6]**

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

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

angle block. = ... kv **[4]**

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

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

[8]

(ii) the general solution of the differential equation

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

radius = ... ks **[8]**

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

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

[4]

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

$$\mathrm{p}(x) = 6x^3 + ax^2 + bx + 10$$

boxes = ... co **[4]**

(a) (iv) Find $\sum_{r=n+1}^{2n} u_r$.

$$V = V_0 e^{-\alpha n t}$$

rough = ... dz **[2]**

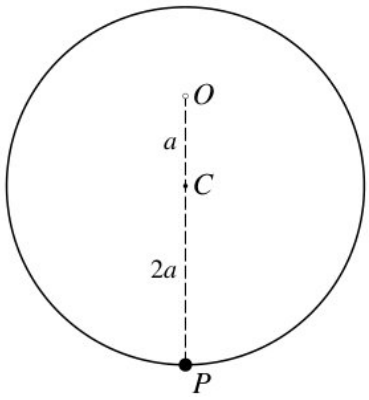
(vi) lifetime, in hours, of a 'Trulite' light bulb is a random variable T. The probability density function f of T is given by

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

value = ... yz **[5]**

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

a vector equation for the line l_1.



[12]

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

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

second = ... *jv* **[12]**

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

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

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

[5]

(iv) control of variables,

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

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

plane inclined = ... *pl* **[6]**

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

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

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.

[15]

(i) Find a 99% confidence interval for μ, giving your answer correct to 2 decimal places.

Find the equations of the asymptotes of C.

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

[12]

(b) height of the liquid in the beaker is 0.20 m $\pm$ 2%.

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

(iv) measuring instrument should be used?

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

[5]

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

[10]

(vi) 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.

defining = ... xk **[6]**

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

force = mass × acceleration

Given also that C has a turning point when $x = 2$, find the value of c.

(b) (iv)

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

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

[8]

(vii) 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.

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

Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = 2t^{\frac{1}{2}}\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 2\frac{\mathrm{d}y}{\mathrm{d}t} + 4t\frac{\mathrm{d}^2y}{\mathrm{d}t^2}$.

[10]

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

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

[6]

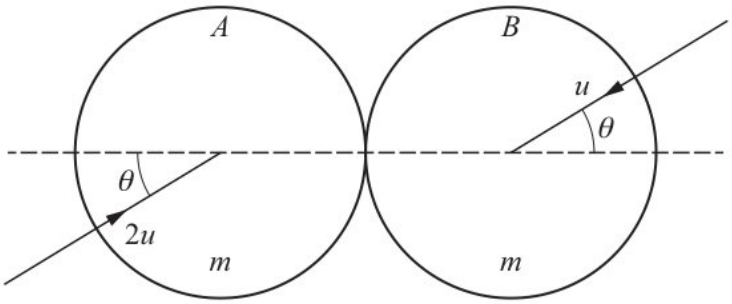
(v) is the useful power output of the power station?

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

Show that the cartesian equation of C is

[8]

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



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

(c) (v) that $y = 0$ when $x = 0$. Give your answer in an exact form.

does this mean?

[8]

(ii) equation gives v in terms of A and u ?

Use de Moivre's theorem to prove that

[8]

(vi) 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.

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

the grid below, draw a cumulative frequency graph to illustrate this information.

[3]

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

activity of a radioactive sample.

[6]

(d) (ii) Show that $v\frac{\mathrm{d}v}{\mathrm{d}x} = 5 - 0.5v^2$.

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.

friend less = ... sg **[10]**

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

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

instant. = ... br **[12]**

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

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

[12]

(i) time T, particle P is moving at an angle of $60°$ below the horizontal.

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

[6]

(vi) should pay particular attention to

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.

taken, = ... zh **[15]**

17 vertical and horizontal gridlines have a spacing of 1.0 cm . The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.

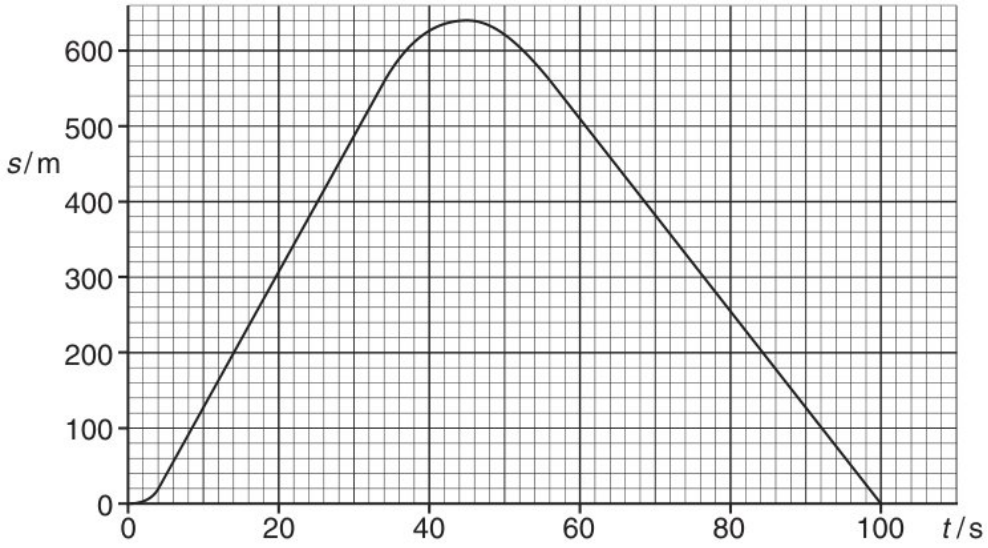
$$\mathbf{A} = \begin{pmatrix} -1 & 3 & 4 \\ 0 & 1 & 0 \\ 0 & -2 & 5 \end{pmatrix}$$

(b) (iii) matrix **A** is given by

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

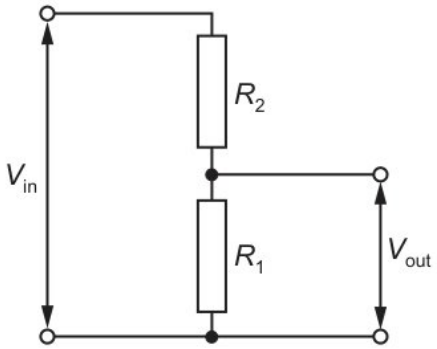
[5]

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



[3]

(ii)



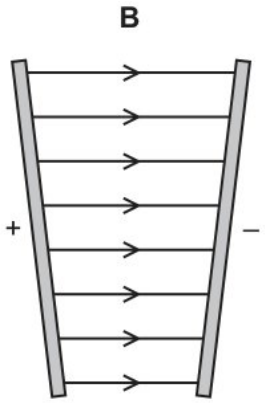
student investigates the cooling of a liquid in a beaker.

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

[12]

(d) (iii) For this value of k, find the set of possible solutions, giving your answer in the form

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



[3]

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

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

diagram = ... *bz* **[5]**

(c) (iii) Find the standard deviation of x.

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

initial form = ... *pr* **[6]**

(i) ice cube of mass 37.0 g at temperature 0.0°C is placed in a beaker containing water of mass 208 g at temperature 26.4°C.

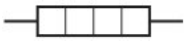
aircraft, initially stationary on a runway, takes off with a speed of 85 km h^{-1} in a distance of no more than 1.20 km .

[12]

32 the significance level of the test.

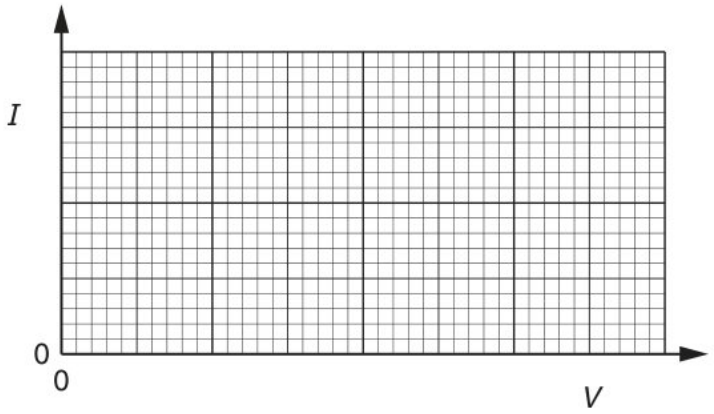
(d) (iii) f(x) is divided by $(x+2a)$ the remainder is $-22a^3$ When f(x) is divided by $(3x-a)$ the remainder is $-a^3$

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



[3]

(i) is the angle θ ?



[10]

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

a, b and c are integers to be determined.

matrix **A** is given by

[5]

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

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

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

[8]

(v) find the moment of inertia of the body about an axis l, through A, in the plane of the body and tangential to the circle.

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

[10]

(c) (ii) 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.

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

sample random = ... *br* **[3]**

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

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

Use the trapezium rule with three intervals to estimate the value of

[8]

(a) (ii) specific latent heat.

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

minute. large = ... *dc* **[10]**

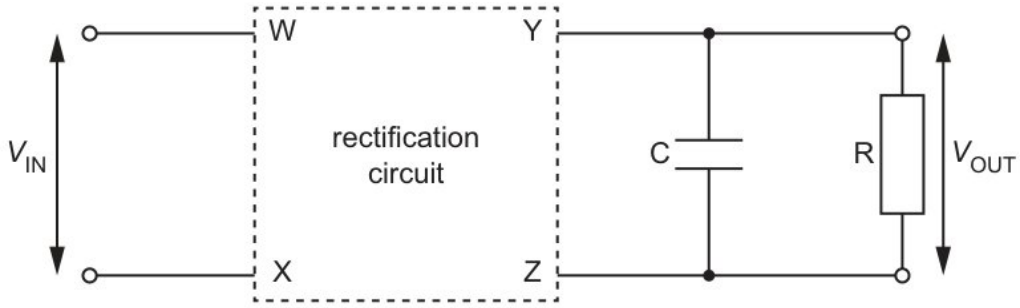
(iii) the probability that at least 1 of these students studies Drama.

Find angle ABC.

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

[5]

(iv)



800 nm to 1000μ m

and N are two electromagnetic waves.

[2]

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

Potential difference is energy per unit current.

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

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

forests results = ... fa **[6]**

(ii) is meant by elastic deformation?

horizontal = ... en **[5]**

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

[10]

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

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

(iii) 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]

(ii) first artificial radioactive substance was made by bombarding aluminium, $^{27}_{13}\text{Al}$, with α-particles. This produced an unstable isotope of phosphorus, $^{30}_{15}\text{P}$.

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

[6]

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

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

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

group women = ... lj **[12]**

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

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

(iv) (b) a normal distribution, calculate a 95% confidence interval for the population mean.

diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

that = ... qp **[4]**

(a) or otherwise solve the inequality $|3x - 2a| < x + 5a$.

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

after = ... uz **[2]**

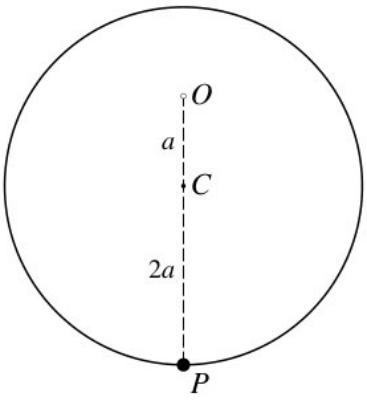
(i) (c)

	R_1	R_2
A	doubled	doubled
B	doubled	halved
C	halved	doubled
D	halved	halved

Use de Moivre's theorem to show that

[8]

(b)



gravitational potential at a point.

mouthpiece bell. = ... fi **[5]**

30 are speed v_1 and speed v_2 ?

(c) (ii) chooses an appropriate random sample of 60 students. She finds that 45 of these students think that the sports facilities are good.

exactly at point S

[5]

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

variables x and y are related by the differential equation

[8]

(b)(vii) particle P of mass 0.4 kg is released from rest at a point O on a smooth plane inclined at 30° to the horizontal. P moves down the line of greatest slope through O. The velocity of P is v m s^{-1} when its displacement from O is x m. A retarding force of magnitude $0.2v^2$ N acts on P in the direction PO.

the ratio $H : D$.

[5]

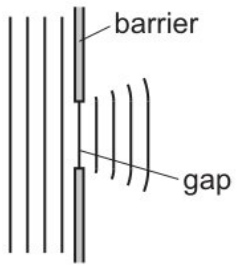
(i) graph shows the variation with time of the velocity of the object?

$$x^3 - 2y^3 = 3xy.$$

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

[10]

(a) (i)



does this mean?

[2]

(ii) the vertical and horizontal components of velocity at time t.

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

[3]

10 is the angle θ ?

(a) (ii)

800 nm to 1000μ m

[6]

(v) parametric equations of a curve are

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

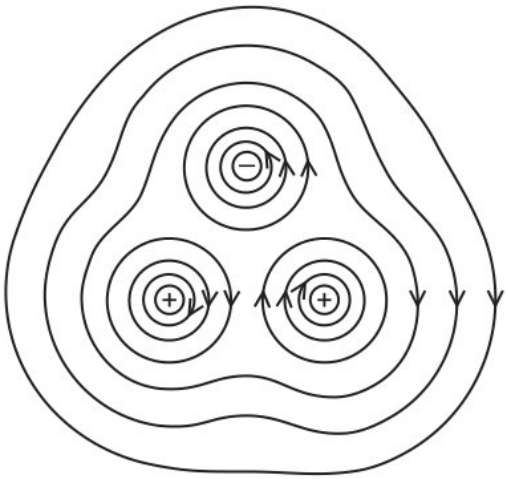
[6]

(e) (iii) 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.

$$\mathrm{f}(x) = \begin{cases} 0 & x < 0 \\ a\mathrm{e}^{-x\ln 2} & x \geqslant 0 \end{cases}$$

[8]

(i)



the coordinates of C,

[6]

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

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

[8]

29 The weight of the plank equals the force on the plank from the pivot.

(b) (iii) all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

[5]

(i) is the effect of a systematic error on the measurement of a physical quantity?

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

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

balls. = ... wu **[6]**

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

Calculate the speed of the star relative to the Earth.

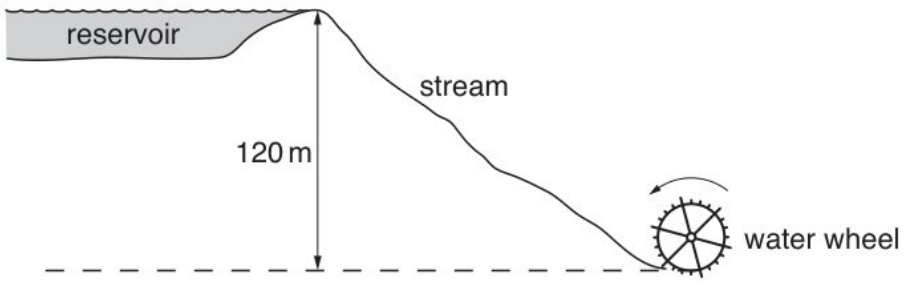
[12]

(ix) 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

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

[10]

(iii) process does not require energy to be supplied?



P hears a sound of increasing frequency.

squash than = ... js **[3]**

10 Both light waves and sound waves show the Doppler effect.

(b) (i) is the percentage uncertainty in the calculated density of the liquid?

the equations of the asymptotes of C

[8]

(iv) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = 2t^{\frac{1}{2}}\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 2\frac{\mathrm{d}y}{\mathrm{d}t} + 4t\frac{\mathrm{d}^2y}{\mathrm{d}t^2}$.

find the moment of inertia of the body about an axis l, through A, in the plane of the body and tangential to the circle.

shows bounded = ... jl **[4]**

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

the distribution function of X.

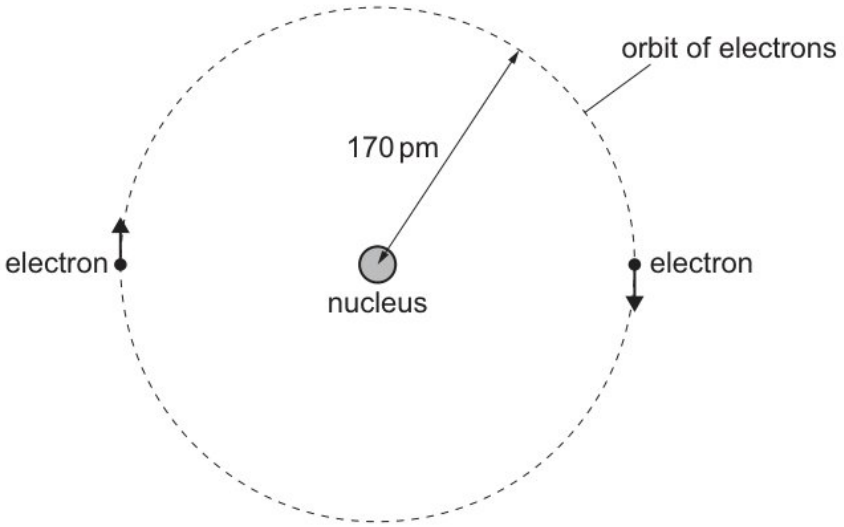
[5]

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

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

equations bivariate = ... pj **[15]**

(i)



object is fully submerged in a liquid.

[12]

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

(b) (ii) 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.

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

[15]

(i) the probability that both marbles chosen are the same colour.

vertical and horizontal gridlines have a spacing of 1.0 cm . The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.

[12]

(v) 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.

State the work W done by F.

[10]

(a) (iv) statement about sound waves in air at constant temperature is correct?

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

company deviation = ... *br* **[15]**

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

Find a vector equation for the line of intersection of the planes.

[1]

(vi) down to antiup

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

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

equation = ... *pw* **[4]**

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

(a) (iii) your answer correct to 2 decimal places.

There will always be 9.0 V across the battery terminals.

[8]

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

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

[6]

(g) (iii) monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

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

[4]

(ii) exactly at point T

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

[12]

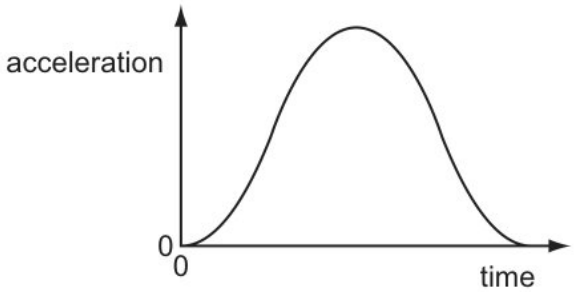
(v) Show that, for $n > 2$,

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

the moment of a force about a point.

passes position line = ... xp **[15]**

(i) 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}.



[6]

(c) (iii) resistors of equal value are connected as shown.

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

[5]

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

Find the tension in the string in terms of W.

$$I_n = \frac{n-1}{n} I_{n-2}.$$

[5]

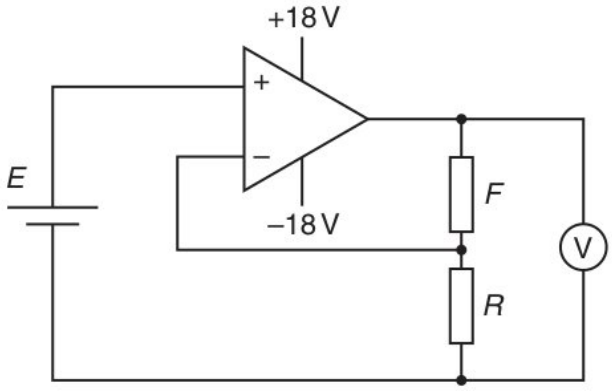
(ii) sequence $x_1, x_2, x_3, \ldots$ defined by

state the corresponding eigenvalue.

[5]

12 Find the value of I_2.

(a) (ii)



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

[10]

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

the type of each transformation, and make clear the order in which they are applied.

$$a_{n+1} = \left(\frac{7 + 2a_n^{\frac{3}{2}}}{3 \ln a_n} \right)^{\frac{2}{3}}$$

[12]

(c)(vii) Find the area of one loop of C.

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

[20]

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

Hence obtain the expansion of $\frac{5x-x^2}{(1+x)(2+x^2)}$ in ascending powers of x, up to and including the term in x^3.

hotel Over = ... *ze* **[12]**

(b) (i) end of a light elastic string of natural length 0.4 m and modulus of elasticity 8 N is attached to a fixed point O on a smooth horizontal plane. The other end of the string is attached to a particle P of mass 0.2 kg which moves on the plane in a circular path with centre O. The speed of P is v m s^{-1} and the extension of the string is x m.

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

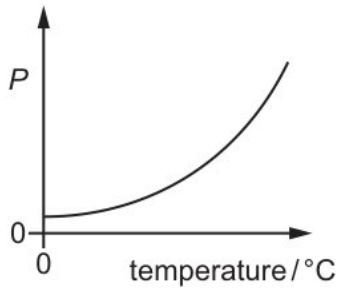
[10]

(ii) 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.

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

[3]

(iii)

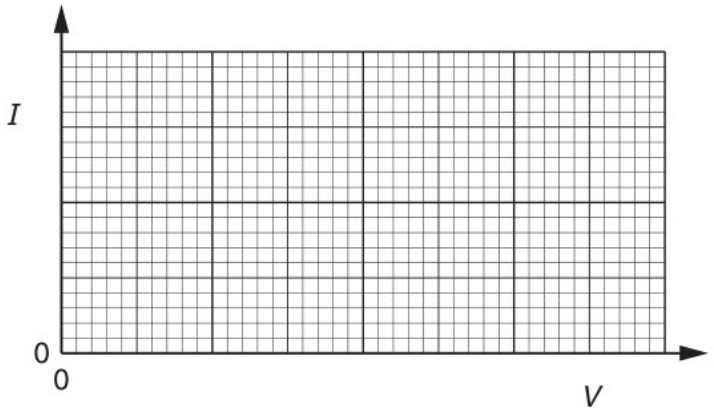


the roots of the equation $z^3 = 27-27\mathrm{i}$, giving your answers in the form $re^{i\theta}$, where $r>0$ and $-\pi \leqslant \theta < \pi$.

[8]

19 the rank of **M** and a basis for the range space of T ,

(e) (iii)



is the average useful power at which he is working?

[6]

(iv) not have a unique solution.

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

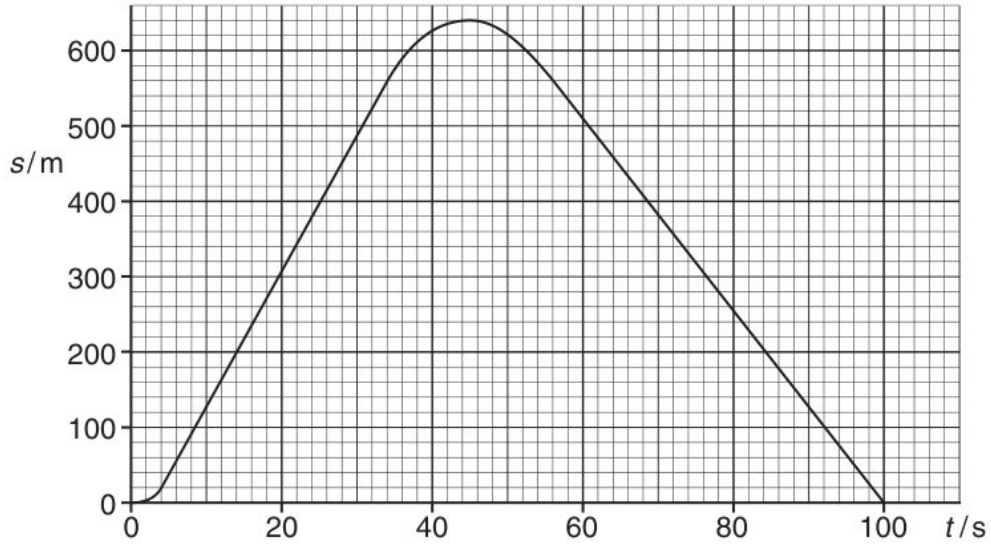
[5]

(vii) is the horizontal force exerted by the wall on r r Y ?

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

[4]

(a) (v) Find the probability that a box is rejected.



[4]

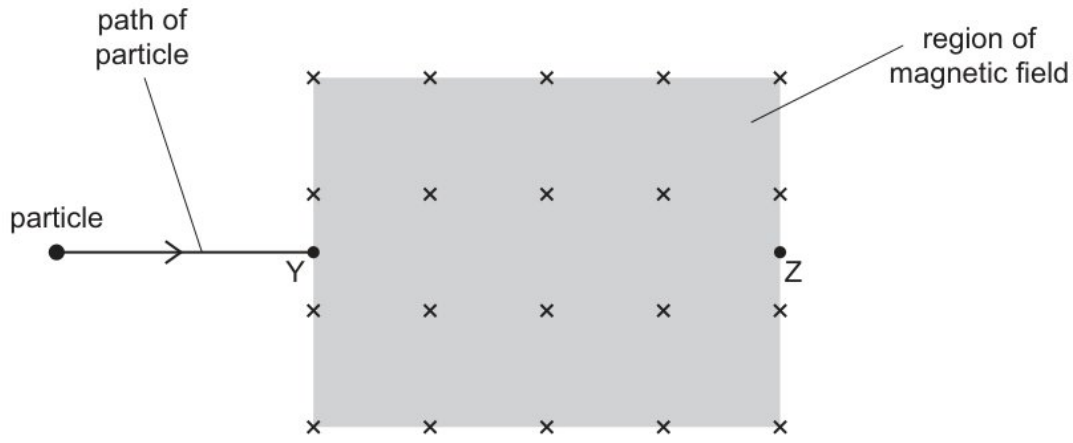
(iii) Find the set of values of k for which the line $y = k$ does not intersect C.

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

cubic polynomial p(x) is defined by

edge triangle = ... fw **[6]**

(iv) 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}.



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

[2]

16 many images of the slit does he see?

(c) (vi) 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.

student wishes to investigate the effect of adding various thicknesses of glass in front of

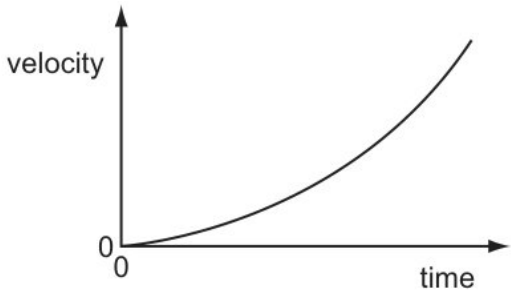
[3]

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

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 $\frac{11}{30}mg$.

light = ... dw **[3]**

(ii)



analysis of the data,

[8]

(a) (iii) is the ratio $\frac{\text{tension in wire } X}{\text{tension in wire } Y}$?

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

[6]

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

masses of small bags of pasta sold by the company are normally distributed with mean μkg and standard deviation σkg Tests show that 77% of these bags have masses greater than 1.26 kg and 44% have masses less than 1.35 kg

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

[6]

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

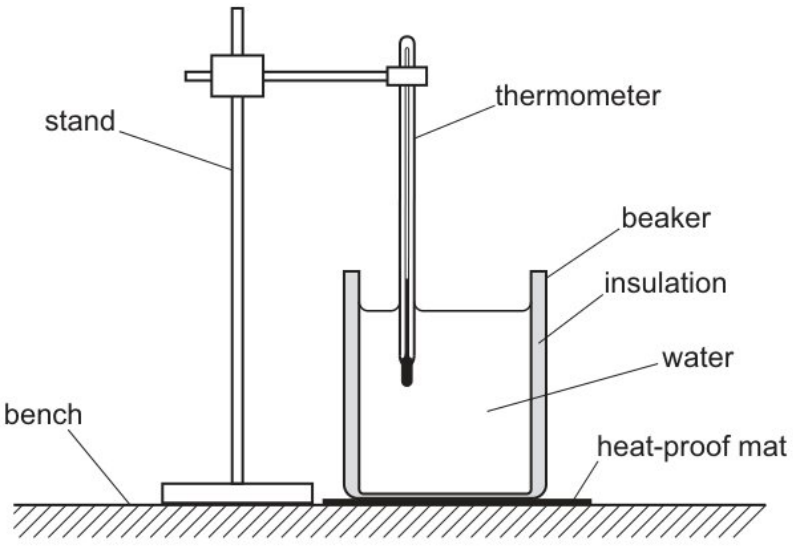
sequence $x_1, x_2, x_3, \ldots$ defined by

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

[10]

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

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



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

[3]

(i)

	A	n	v	q
A	area of cross-section	number of free electrons	voltage	charge of each molecule
B	area of cross-section	number of free electrons per unit volume	average drift speed of electrons	charge of each electron
C	current	number of free electrons	average drift speed of electrons	charge of each molecule
D	current	number of free electrons per unit volume	voltage	charge of each electron

Find the acute angle between Π_1 and Π_2.

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

leaving = ... zn **[2]**

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

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

[6]

(iv) 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.

transmitted light has intensity I.

[5]

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

the equations of the asymptotes of C.

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

[6]

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

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

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

[4]

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

Pressure is force per unit area.

[3]

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

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

matrix, = ... hz **[3]**

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

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

[4]

(b) plank rests on fixed supports at its ends X and Y.

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

[20]

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

[5]

(ii) procedure to be followed,

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

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

force is caused only by a pressure difference?

[5]

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

the exact solutions of the equation $\mathrm{f}(x) = 1$.

[15]

(b) a vector equation for l.

flights good good = ... *oa* **[3]**

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

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.

(h) Find the equations of the asymptotes of C.

[5]

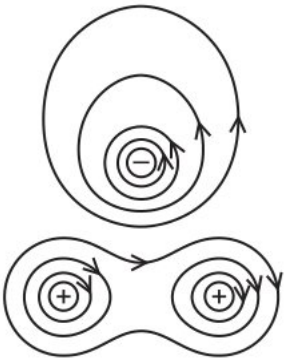
(e) State the work W done by F.

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

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

extension = ... an **[3]**

(b) row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?



[6]

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

(c) (vi) temperature θ_R of the laboratory is measured using a thermometer.

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

[8]

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

$$\sin 4y \frac{\mathrm{d}y}{\mathrm{d}x} = x \sin 2y \sin 3x$$

statement is correct?

Find = ... dx **[8]**

(e) (ii) end of a light elastic string of natural length 0.4 m and modulus of elasticity 8 N is attached to a fixed point O on a smooth horizontal plane. The other end of the string is attached to a particle P of mass 0.2 kg which moves on the plane in a circular path with centre O. The speed of P is v m s^{-1} and the extension of the string is x m.

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

[3]

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

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

[10]

(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.

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

[12]

(v) 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.

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

measurements to be taken,

where = ... *gp* **[6]**

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

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

[5]

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

battery is marked 9.0 V .

[6]

(i) *A* contains 6 red marbles, 5 blue marbles and 1 green marble.

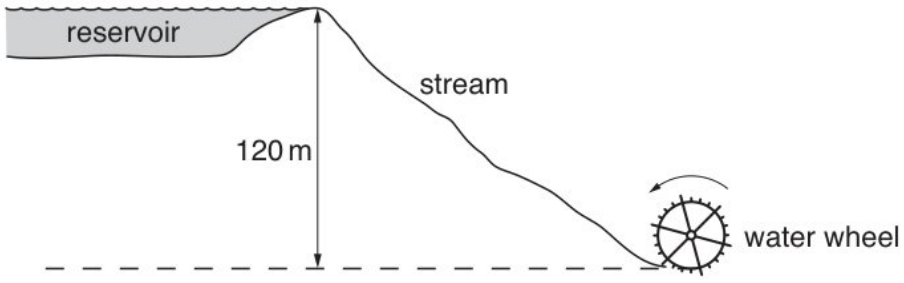
circuit symbol does not represent an electric component that is designed to emit sound waves?

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

[8]

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

(b) (i)



State one other feature of this orbit.

smooth = ... *nc* **[6]**

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

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

[3]

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

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

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

[2]

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

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

[5]

(vi) up to down

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

radius moving = ... xh **[2]**

20 curve C has equation $y = \frac{x^2+px+1}{x-2}$, where p is a constant. Given that C has two asymptotes, find the equation of each asymptote.

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

curve C has parametric equations

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.

working, = ... bi **[6]**

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

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

[10]

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

down to up

[5]

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

the probability that the sum of three independent values of X is between 3 and 5 inclusive. [3]

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

[10]

12 the distribution function of X.

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

(b) (ii) why Kieran is incorrect.

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.

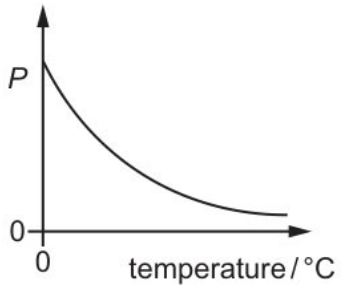
[10]

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

the gradient of the curve

[12]

(i) Potential difference is energy per unit current.



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

resultant when = ... aj **[5]**

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

P and Q form an isolated system.

group = ... *su* **[12]**

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

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.

aeroplane ascends then = ... *ft* **[12]**

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

$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

[8]

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

$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

[12]

(v) diagram shows a child X of mass 20 kg and a child Y of mass 15 kg seated on a uniform plank.

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

Calculate the density, in kgm^{-3}, of the material from which the paving slab is made.

form = ... *vq* **[3]**

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

Calculate the speed of the star relative to the Earth.

shown, circuit shown, = ... fy **[6]**

(d) (iii) the graph to estimate how many people took between 4 and 7.5 minutes to complete the puzzle.

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

[3]

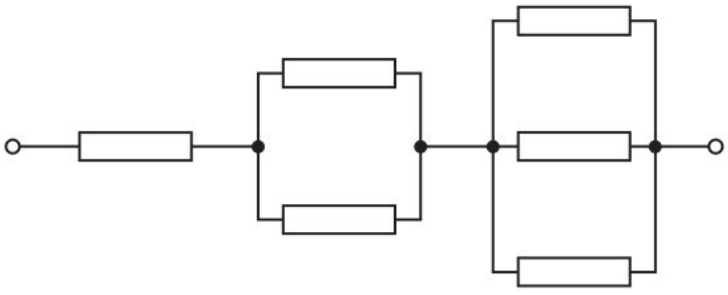
(i) is given that P remains at rest in this new position.

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

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

[5]

11 magnetic flux density.



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

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

(a) (iii) 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 $3 : 4$.

parametric equations of a curve are

[15]

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

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

[10]

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

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

[10]

(b) (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.

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

than 1.35 = ... *pk* **[12]**

(vi) the principle of moments.

the arc length of C,

[12]

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

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

[12]

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

Find the value of a and show that $b = -7$.

variables x and y satisfy the differential equation

Find the equations of the asymptotes of C.

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

Draw a fully labelled tree diagram to illustrate this situation.

[4]

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

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

[12]

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

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

Use implicit differentiation to show that

[10]

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

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

shows = ... *ko* **[4]**

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

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

[10]

(ii) up to antidown

Estimate the probability of throwing a 4.

[4]

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

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

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

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

[10]

(ii) Show that if

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

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.

[8]

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

the general solution of the differential equation

point = ... *ho* **[12]**

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

marble is now chosen at random from bag B.

independent extracted = ... *yy* **[8]**

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

chooses an appropriate random sample of 60 students. She finds that 45 of these students think that the sports facilities are good.

[4]

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

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

[6]

(i) Use the iterative formula

the principle of moments.

[4]

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

the exact value of $\lim_{n\to\infty} \sum_{r=1}^{n} \frac{n}{n^2+r^2}$.

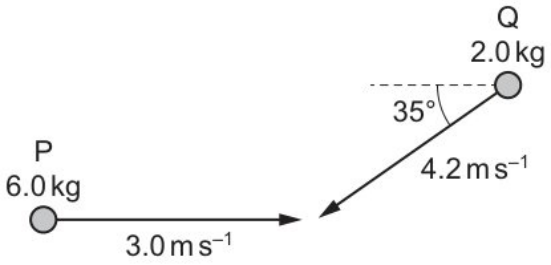
particles A and B of masses 0.9 kg and 0.4 kg respectively are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley which is attached to the top of two inclined planes. The particles are initially at rest with A on a smooth plane inclined at angle $\theta°$ 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).

(a) (ii) height of the liquid in the beaker is 0.20 m $\pm$ 2%.

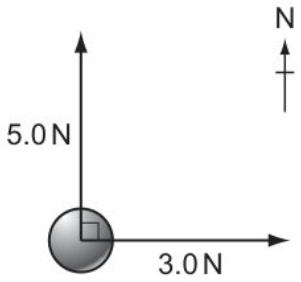
is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

[6]

(i)



find the position vectors of P and Q.



[8]

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

the time taken for the ball to reach its maximum height

[5]

(iv) Find the value of x.

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

Show that $m = 0.9$.

account, = ... *iu* **[12]**

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

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

[1]

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

the arc length of C,

[8]

(i) is the angle θ ?

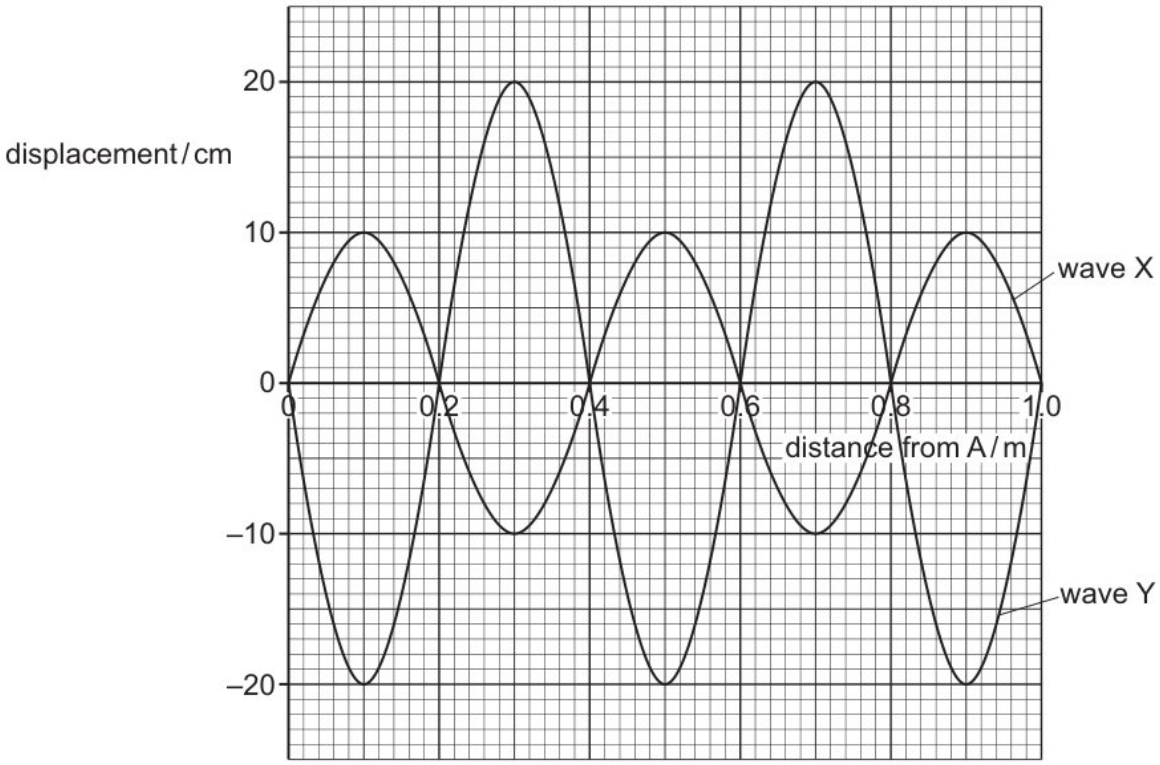
Find the probability that the die lands on 4 and the number of times the coin shows heads is 2 .

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

[12]

(ii) 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.

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



[8]

14 the speed of the combined particle after this collision.

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

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

[4]

(v) the exact value of the positive constant k for which

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.

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

brakes. shows = ... bj **[2]**

(iv) the value of n.

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

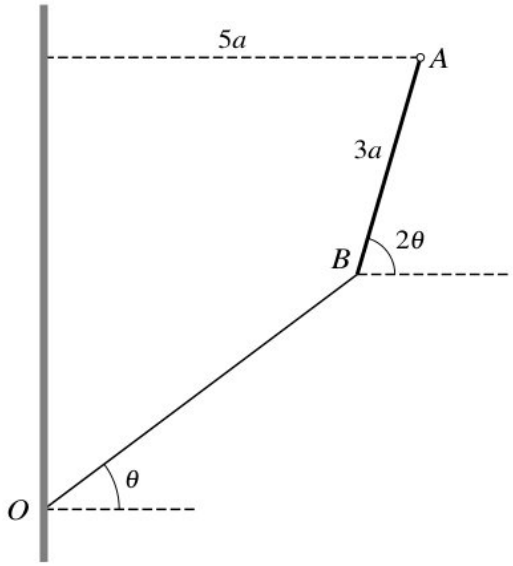
[6]

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

diagram shows two waves R and S.

candidates. taken order many = ... nm **[10]**

(vi) the equation for this decay.



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.

[10]

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

Draw up a probability distribution table for X.

[10]

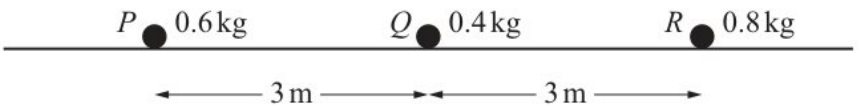
20 Find a 99% confidence interval for μ, giving your answer correct to 2 decimal places.

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

The weight of the plank is causing a clockwise moment.

[10]

(iv) the grid below, draw a cumulative frequency graph to illustrate this information.



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

[8]

(d) (i) circuit contains four resistors and a battery of electromotive force (e.m.f.) 8.0 V with negligible internal resistance. When the variable resistor has resistance R, the currents in the circuit are 0.030 A, I_1 and I_2, as shown in Fig. 6.1.

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

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

[6]

(vii) Find the values of a and b.

Form two simultaneous equations and hence find x and v.

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

string = ... xu **[8]**

(a) (ii) exactly at point T

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

point = ... yx **[6]**

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

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

[6]

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

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

working, not. = ... gy **[6]**

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

curve C has parametric equations

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

[5]

18 many competitors would you expect to have times within 1.2 minutes of the mean time?

(c) (iii) The weight of the plank is causing a clockwise moment.

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

cabbages, = ... sc **[6]**

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

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

[6]

(a) (iii) 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 $3 : 4$.

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

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

number been = ... rq **[10]**

(v)

	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

that $0 < y < \frac{1}{2}\pi$, find the values of y when $x = 0$.

[4]

(d) (iv) The matrix $\mathbf{B}$, where

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

[4]

(i) point D is the reflection of A in l.

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

midpoint = ... ar **[10]**

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

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

(i) 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.

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

$$\mathbf{Ax} = p \begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q \begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix}$$

[15]

(iii) point D is the reflection of A in l.

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

[20]

(ii) Find the values of p and q.

[5]

(a) that $x^2y = z$, show that

(iv) an election 153 adults, from a random sample of 200 adults, said that they had voted. Using this information, an α% 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.

determined. = ... ih **[8]**

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

[5]

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

[10]

(vii) 800 nm to 1000μ m

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

Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = 2t^{\frac{1}{2}}\frac{\mathrm{d}y}{\mathrm{d}t}$ and $\frac{\mathrm{d}^2y}{\mathrm{d}x^2} = 2\frac{\mathrm{d}y}{\mathrm{d}t} + 4t\frac{\mathrm{d}^2y}{\mathrm{d}t^2}$.

[8]

14 small ball B is projected from a point O which is h m above a horizontal plane. At time 2 s after projection B has speed 18 m s^{-1} and is moving in the direction 30° above the horizontal.

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

(c) (i) the exact value of $\mathrm{cosec}^2\,15° - \sec^2 15°$.

the exact value of $\lim_{n\to\infty}\sum_{r=1}^{n}\frac{n}{n^2+r^2}$.

[10]

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

Frequency is inversely proportional to wavelength.

into = ... *vi* **[4]**

(iii) Draw a sketch of C for the case $0 < \lambda < 1$.

skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

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

with = ... jh **[10]**

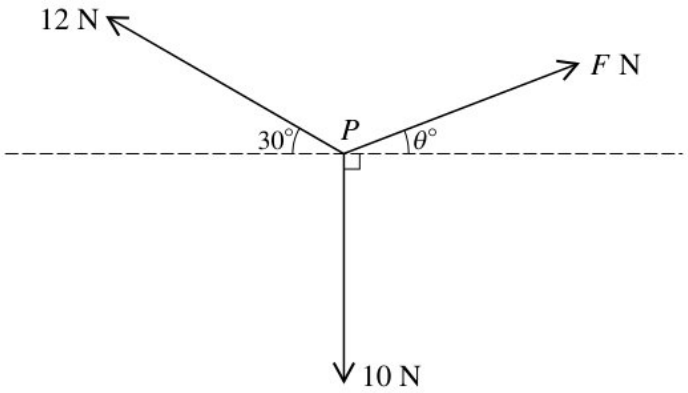
(a) (iv) polar equation of a curve C is $r = a(1+\cos\theta)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

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

Find the equations of the asymptotes of C.

[8]

(i)



Find the values of a and b.

[4]

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

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.

[6]

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

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

the value of α.

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

[12]

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

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.

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

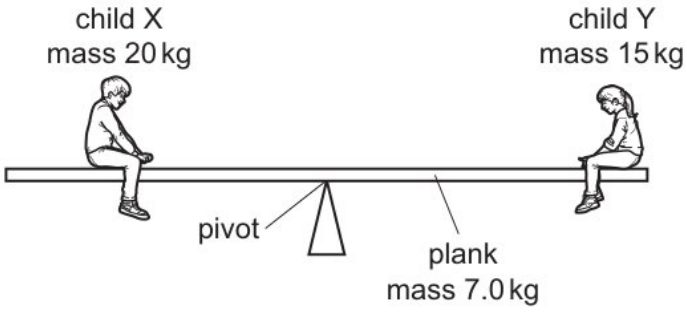
[6]

(b) (ii) Young modulus E can be determined from measurements made when a wire is stretched.

much energy is stored in the compressed column?

mass = ... qi **[20]**

(iii)



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

what is meant by a fundamental particle.

[2]

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

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 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.

[6]

(a) (iii) variables x and y are related by the differential equation

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

[5]

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

State the name of this type of reaction.

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.

[5]

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

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

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

[3]

17 the equations of the asymptotes of C

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

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 .

[8]

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

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

[5]

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

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

[5]

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

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 $\lambda\mu$.

company greater = ... wb **[8]**

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

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

[6]

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

analysis of the data,

[8]

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

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

the distance AC.

[4]

7 displacement = velocity × time

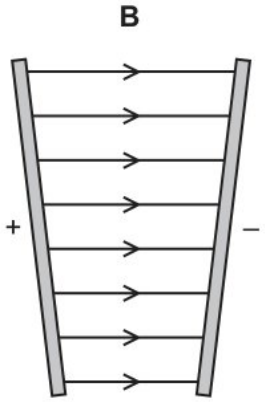
(a) (vi) plane Π_2 contains the lines

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

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

[6]

(iv) Density is mass per cubic metre.



Find the product moment correlation coefficient for the data.

[12]

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

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

force = ... oy **[5]**

(ii) Show that $m = 0.9$.

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

[6]

(iii) down to antiup

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

When = ... *do* **[8]**

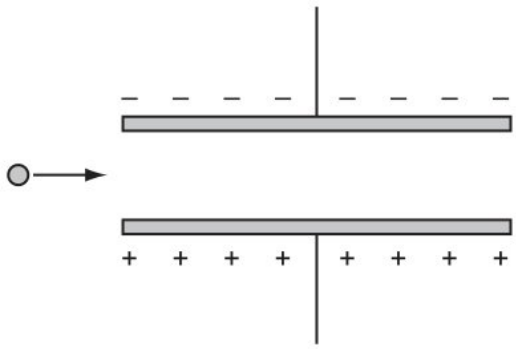
16 particle P moves on a straight line in simple harmonic motion. The centre of the motion is O, and the amplitude of the motion is 2.5 m . The points L and M are on the line, on opposite sides of O, with $OL = 1.5$ m. The magnitudes of the accelerations of P at L and at M are in the ratio $3 : 4$.

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

for a wire,

[2]

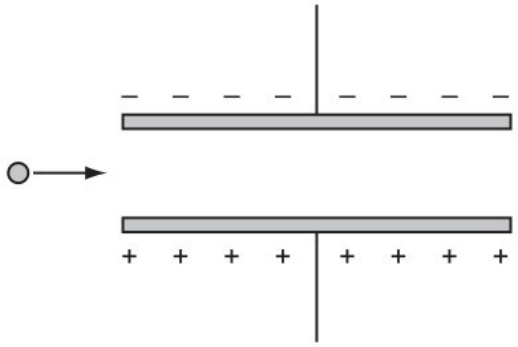
(iii) that l_1 and l_2 do not intersect.



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

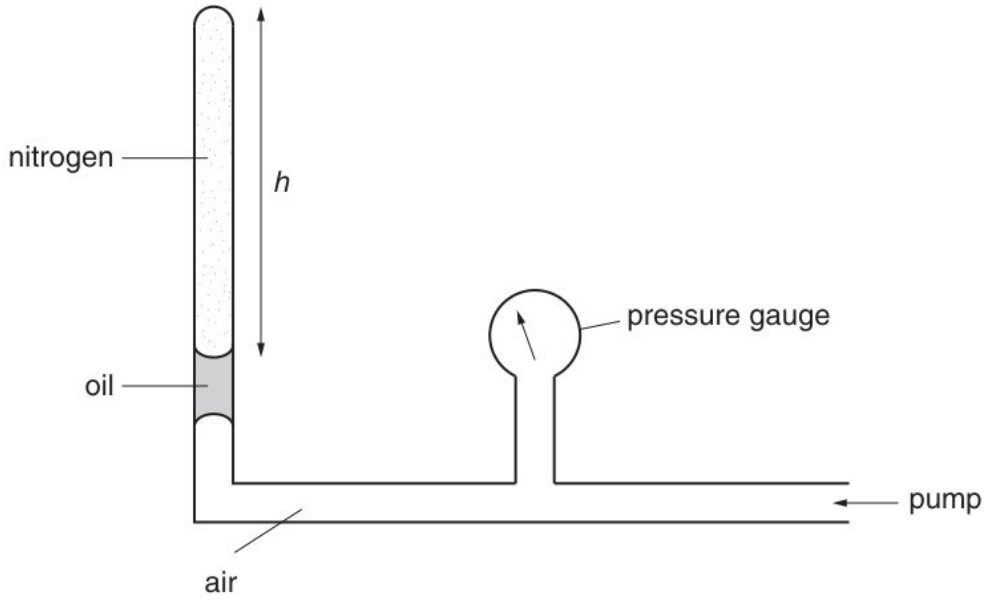
mark. = ... *fl* **[10]**

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



Region = ... *ji* **[2]**

(iii)



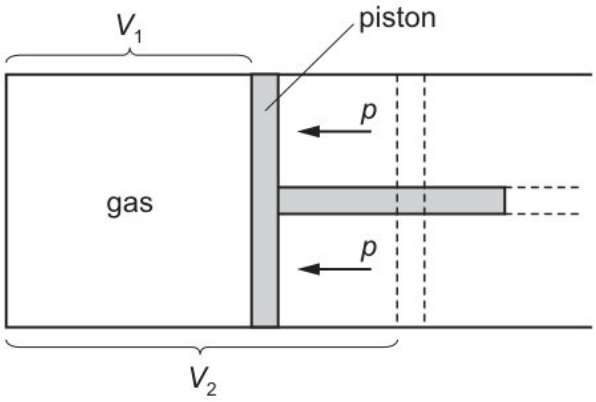
are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

with spheres = ... *lp* **[5]**

(ii) the equation $2\ln(2x+3) - \ln(2x+5) = \ln(3x)$.
only one of the following two alternatives.

[6]

(g) (i)



the rank of the matrix

[2]

(ii) State what is meant by the internal energy of a system.
copper wire is 6.4 m long and has a resistance of 0.92Ω.

[15]

(c) (v) shaded region is bounded by the curve and the two axes.
expression gives the electrical resistance of the metal cube between X and Y ?
Its speed decreases to a value greater than zero, then increases to 20 ms^{-1}.

contains both = ... nl **[10]**

(iv) The total momentum and the total kinetic energy are always conserved.

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.

straight, = ... px **[12]**

15 gravitational potential at a point.

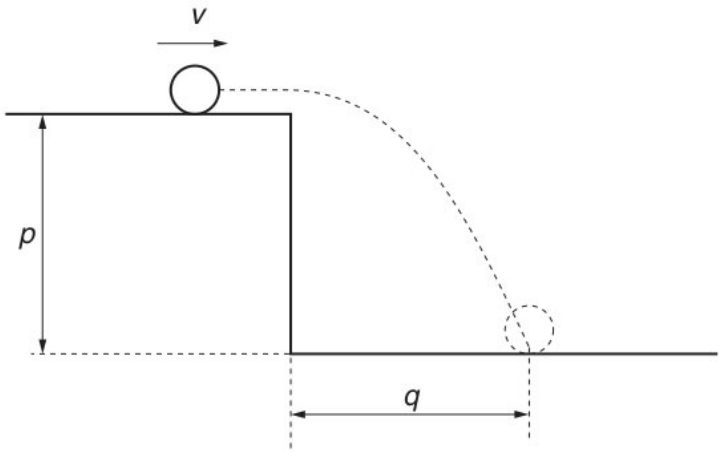
(b) (ii) the distance AC.

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.

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

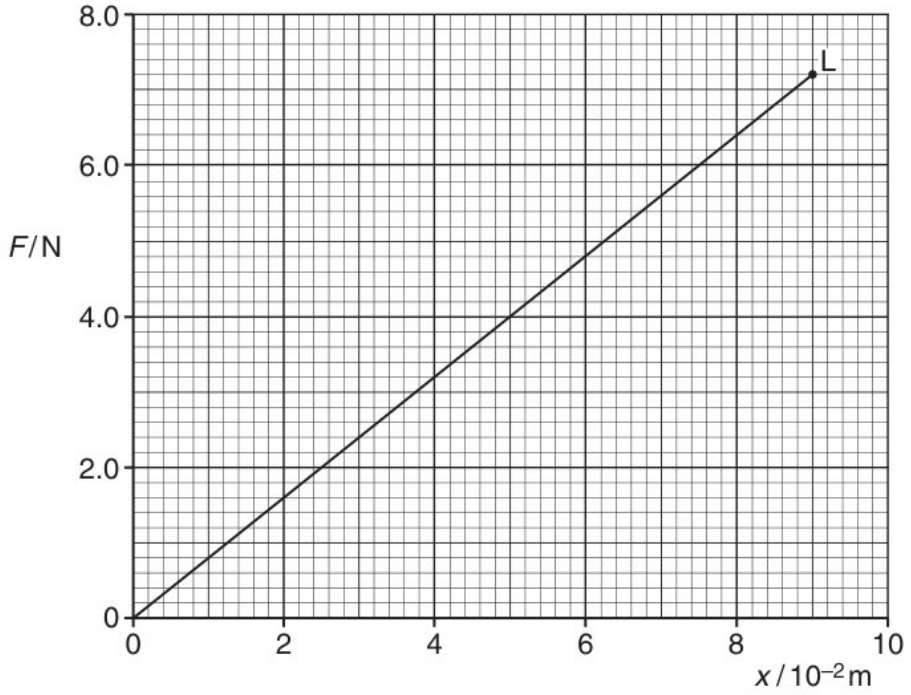
[5]

(iii) time T, particle P is moving at an angle of 60° below the horizontal.



[5]

(e) (iii)



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

[6]

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

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

bags that = ... *bo* **[6]**

(i) Find angle ABC.

the term isotope.

results = ... *df* **[2]**

20 Show that the cartesian equation of C is

(b) (vi) Find the value of a.

Draw a fully labelled tree diagram to illustrate this situation.

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

[8]

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

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

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

eigenvalue eigenvector matrix = ... jw **[8]**

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

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.

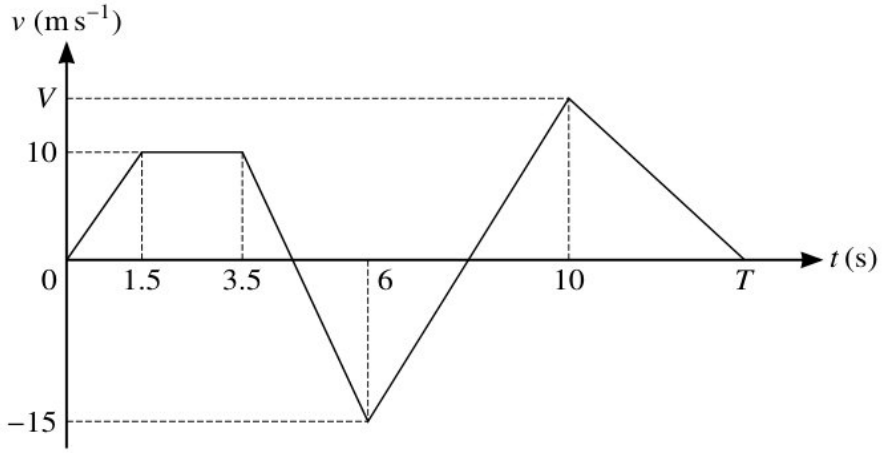
carries = ... bc **[6]**

(a) (i) 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.

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

[4]

(ii)



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

[6]

(c) (iii) four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x.

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 $-\pi \leqslant \theta < \pi$.

centre = ... mv **[5]**

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

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 $(\ x - 2\ )$.

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

[8]

(ii) 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.

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

[6]

(d) (i) wavelength of light is 550 nm .

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

patients = ... *hs* **[10]**

(iii) the exact volume of the solid generated

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

where = ... *rl* **[5]**

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

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

Find the area of the triangle ABC.

[12]

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

diagram shows part of the curve

[6]

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

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

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

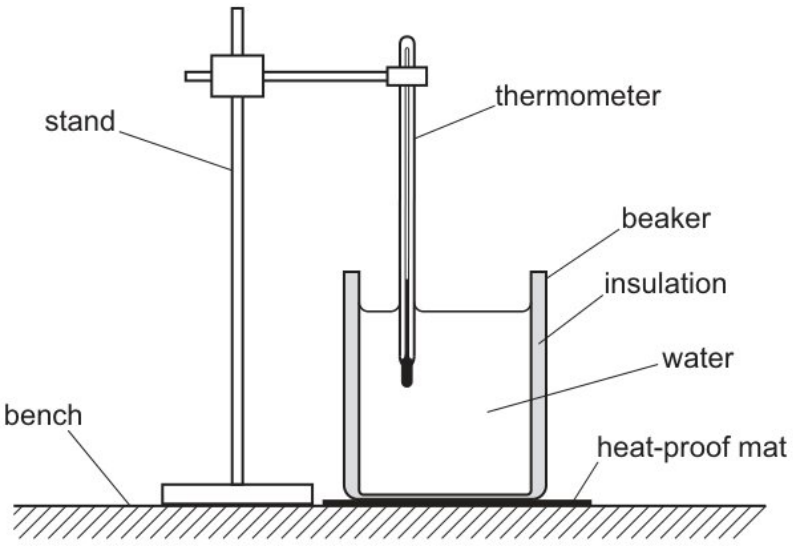
[6]

(v) Draw up a probability distribution table for X.

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

from straight = ... km **[3]**

(b) (ii)



curve C has equation

turn = ... ea **[5]**

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

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

[4]

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

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

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

size = ... rl **[6]**

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

curve C has equation $y = \frac{x^2+px+1}{x-2}$, where p is a constant. Given that C has two asymptotes, find the equation of each asymptote.

is suggested that the strength B of the magnetic field at the centre of a flat circular coil is inversely proportional to the radius r of the coil.

[4]

(iv) Find $\sum_{r=n+1}^{2n} u_r$.

that the greatest height of B above the ground is 1.2 m , find the value of x.

[4]

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

an election 153 adults, from a random sample of 200 adults, said that they had voted. Using this information, an α% 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.

with = ... vi **[5]**

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

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

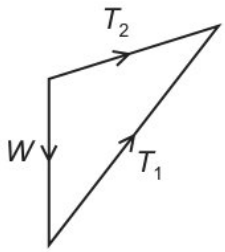
Determine the decay constant, in min^{-1}, of the radioactive isotope.

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

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

[3]

(iv)



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

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

[4]

(iii) graph is correctly labelled?

student wishes to investigate the effect of adding various thicknesses of glass in front of

[5]

(a) (vi) graph is correctly labelled?

by mathematical induction, that $5^n + 3$ is divisible by 4 for all non-negative integers n.

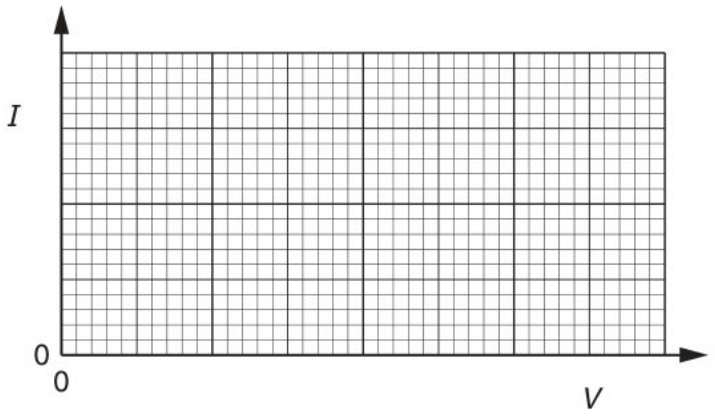
standard pineapples = ... ky **[6]**

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

Find the equation of the tangent to the curve at the point where $x = 0$.

[8]

(c) (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°.

[5]

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

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

value period over = ... mk **[3]**

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

Find the acute angle between Π_1 and Π_2.

[10]

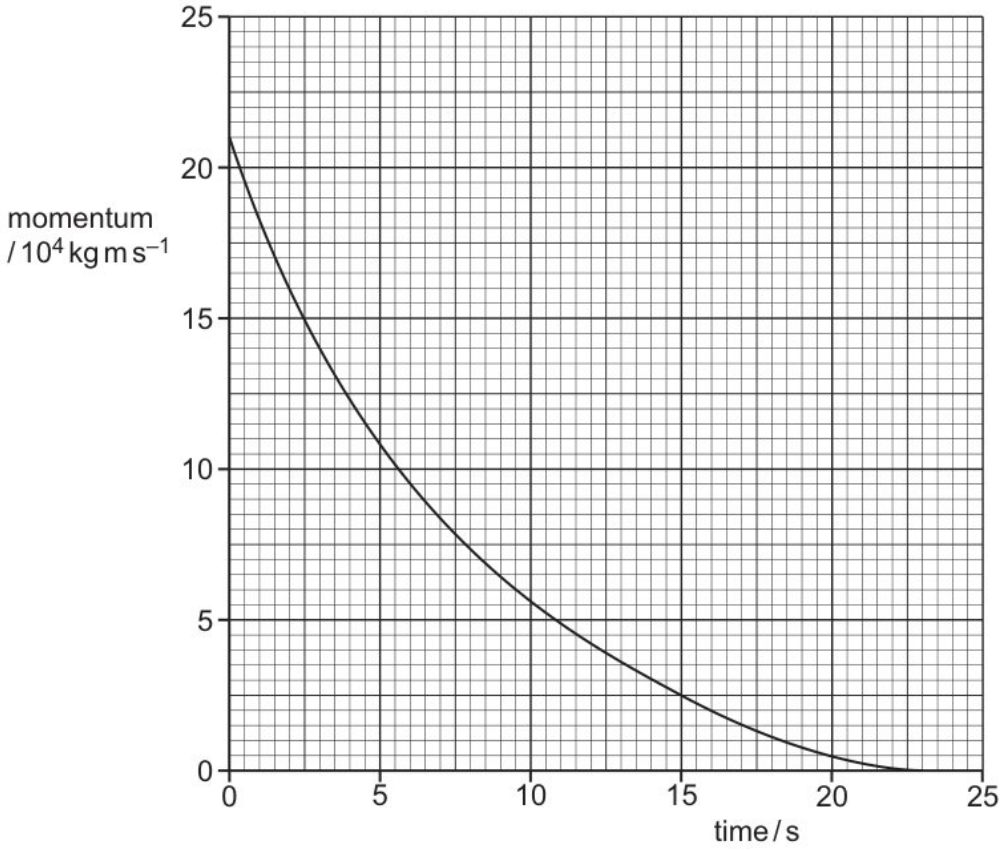
(v) data give a pooled estimate of 10 for σ^2. Find N.

line l passes through B and C.

moment of a force.

with = ... lg **[10]**

(e) (iii) specific latent heat.

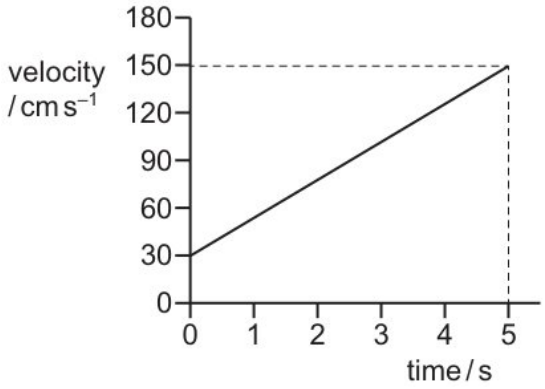


an iterative formula based on the equation in part (a) to determine a correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

[4]

(i) V decreases because there is a p.d. across r.

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



[5]

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

the past, the population mean time was 62.4 seconds.

parametric equations of a curve are

[5]

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

(i) what is meant by centre of gravity.

the term interference.

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

[10]

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

the significance level of the test.

[4]

(iii) an approximate 95% confidence interval for the proportion of students who think that the sports facilities are good.

matrix = ... sf **[8]**

(v) stationary firework explodes into three pieces. The masses and the velocities of the three pieces immediately after the explosion are shown.

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

[2]

(a) Pressure is force per unit area.

Density is mass per cubic metre.

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

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

(v) the term isotope.

[6]

(iv) waves are emitted from two sources.

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

with a reason, whether f has an inverse.

[2]

(b) stationary loudspeaker emits sound of constant frequency. A microphone is placed near to the loudspeaker and connected to a cathode-ray oscilloscope (CRO). The trace on the screen of the CRO is shown in Fig. 5.1.

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

The 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.

[6]

(vi) curves C_1 and C_2 have polar equations

[8]

(v) the coordinates of C,

[5]

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

[3]

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

diffraction = ... *ti* **[5]**

7 Calculate the acute angle between the planes p and q.

(b) (ii) The battery supplies 9.0 J to an external circuit for each coulomb of charge.

Show that $m = 0.9$.

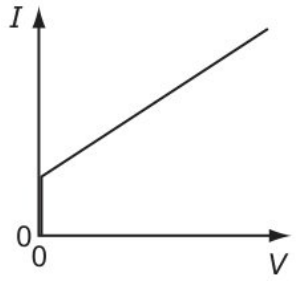
between = ... *ar* **[5]**

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

Show that, for $n > 2$,

[6]

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



activity of a radioactive sample.

[10]

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

and N are two electromagnetic waves.

[5]

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

the experimental observations that show radioactive decay is

[10]

(iv) 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?

$$y = \frac{ax^2 + bx + c}{x - 1}$$

[10]

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

t time $t = 5.8$ s the speed of the car becomes constant

when = ... ej **[4]**

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

plank rests on fixed supports at its ends X and Y.

many competitors would you expect to have times within 1.2 minutes of the mean time?

ripple tank is used to demonstrate interference between water waves.

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

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

[8]

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

airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.

[4]

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

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

[4]

(c) (ii) how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

the exact solutions of the equation $\mathrm{f}(x) = 1$.

a laboratory experiment to determine the absorption coefficient of glass. You should

uniform object object = ... ub **[2]**

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

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

[5]

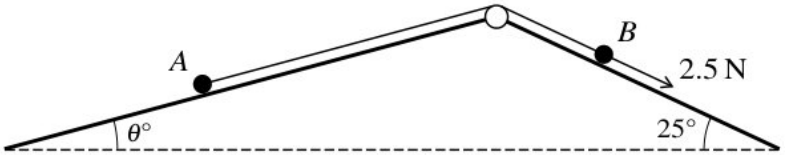
(d) (v) is the phase difference between two points on the wave that are a distance of 0.50 m apart?

The mass of the car is 920 kg . At time $t = 0$, the car is at rest. At time $t = 5.8$ s, its velocity is 17 ms^{-1}.

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

[8]

(ii)



uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

centre = ... *bw* **[4]**

(iii) State the name of this type of reaction.

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

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

[8]

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

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

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

survey = ... *ad* **[3]**

(c) 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).

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

[8]

(f) 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.

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

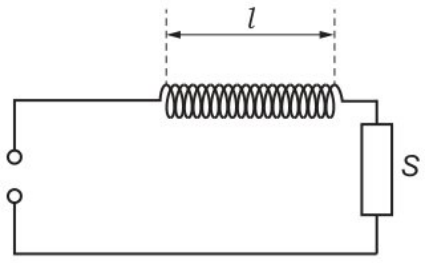
Sketch = ... *de* **[3]**

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

by calculation that $0.9 < a < 0.95$.

climbs = ... *bk* **[2]**

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



[10]

(a) not have a unique solution.

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

type patient = ... yj **[6]**

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

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(\mathrm{e}^x \sin x\right) = 2^{\frac{1}{2}n}\mathrm{e}^x \sin\left(x + \frac{1}{4}n\pi\right)$$

[3]

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

what is meant by work done.

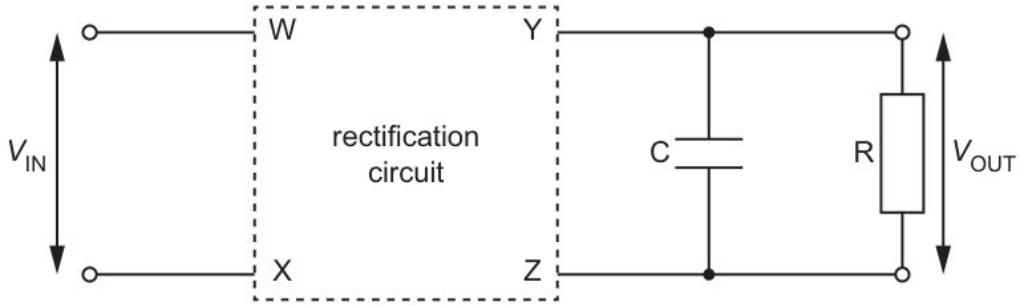
and N are two electromagnetic waves.

[12]

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

wavelength of the wave and the width of the gap are both changed by a small amount.

(d) (iv)



the moment of a force about a point.

[6]

(v) wire of unstretched length 0.81 m is made of a metal with Young modulus 95 GPa . The wire obeys Hooke's law and has a constant cross-sectional area. Fig. 5.1 shows the force-extension graph for the wire.

plane Π_2 contains the lines

[8]

(ii) equation gives v in terms of A and u ?

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

[6]

(a) (ii) or otherwise solve the inequality $|3x - 2a| < x + 5a$.

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

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

[4]

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

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

[5]

(vi) quantities would be measured in order to determine E ?

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

[10]

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

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

[15]

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

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

same number = ... zf **[8]**

18 (b)

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

Deduce that the cartesian equation of C is

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

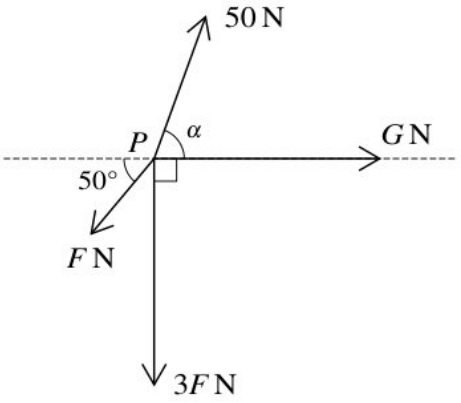
horizontal = ... qz **[4]**

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

[3]

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

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



[20]

(iv) airline has found that, on average, 1 in 100 passengers do not arrive for each flight, and that this occurs randomly. For one particular flight the airline always sells 403 seats. The plane only has room for 400 passengers, so the flight is overbooked if the number of passengers who do not arrive is less than 3 . Use a suitable approximation to find the probability that the flight is overbooked.

[5]

(e) 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.

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?

(iii) parametric equations of a curve are

Find the equations of the asymptotes of C.

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

found = ... uw **[6]**

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

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

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

your = ... bs **[8]**

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

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

applies = ... hg **[2]**

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

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

random variable X has the distribution Po(1.5).

[5]

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

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

points origin = ... cz **[3]**

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

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

there are no restrictions,

[15]

(c) (iii) 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.

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

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

[6]

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

$$a^2\left(\frac{1}{6}\pi - \frac{1}{8}\sqrt{3}\right)$$

elasticity = ... zx **[3]**

(i) 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.

that the forces are in equilibrium, find the values of θ and X.

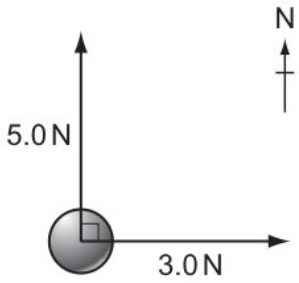
device containing a microwave emitter and receiver is placed in front of a large metal sheet in a vacuum as shown in Fig. 4.1.

[12]

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

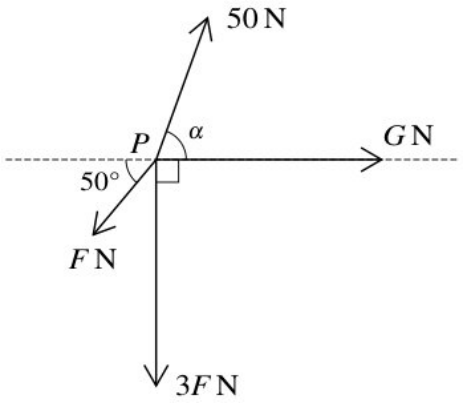
Find the power output of the tractor's engine.

(b) (iv) that **e** is an eigenvector of $\mathbf{A}^3$ with corresponding eigenvalue λ^3.



[4]

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



[6]

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

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

[12]

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

Draw a sketch of C for the case $0 < \lambda < 1$.

compares = ... *nh* **[8]**

(iv) the grid below, draw a cumulative frequency graph to illustrate this information.

It limits the range of values obtained in repeated measurements.

joins = ... *eo* **[2]**

(d) (v) Find the area of the triangle ABC.

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

[5]

(ii) Find the probability that at least 2 of a random sample of 7 letters have weights which are more than 12 g above the mean.

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

[5]

(e) (iii) the distribution function of X.

parametric equations of a curve are

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

where = ... wk **[10]**

(v)

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

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

[3]

(ii) time-base setting on the oscilloscope should be used?

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

[5]

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

Find a vector equation for the line of intersection of the planes.

(iii) (a) is the force exerted on the wall by the water?

projectile is thrown at an angle to the ground.

transmitted light has intensity I.

[3]

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

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

[6]

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

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

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 .

noted. = ... *oa* **[10]**

(d) the standard deviation of these 40 values of x.

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 $\lambda\mu$.

[10]

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

battery is marked 9.0 V .

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

[3]

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

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

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

[3]

(d) - falling freely with the parachute closed,

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

level = ... *es* **[8]**

(e) the average output power of the car during this time

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

masses = ... td **[3]**

(ii) (e) Find the value of x.

the expected value and variance of Y.

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

wishes level level = ... qr **[4]**

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

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

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

[15]

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

$$\tan x = x + \pi.$$

[6]

23 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.

the particular solution of the differential equation

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

the probability of a Type I error.

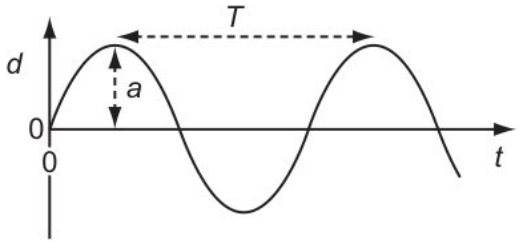
[12]

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

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

[5]

(iii) diagram shows two waves R and S.



[3]

(b) (ii) the probability that a 3 is obtained for the second time before the 6th throw.

on the graph would the elastic limit be found?

string = ... *uh* **[6]**

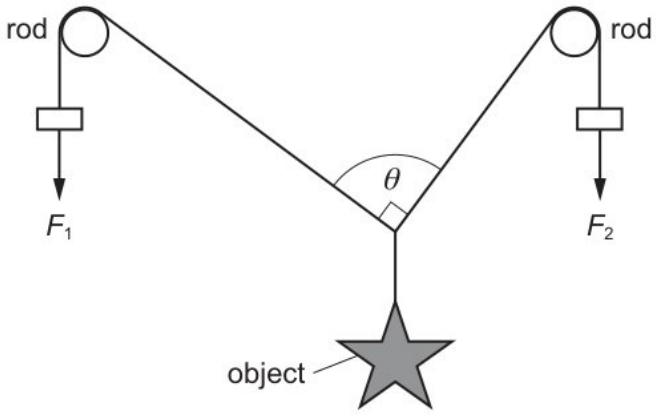
(i) When the tensile force is removed, the wire returns to its original length.
It limits the precision of the measured value.
$I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$, where n is a non-negative integer.

[8]

(vi) standard results from the list of formulae (MF19) to show that
that the eigenvalues of $\mathbf{A}$ are $-1, 1$ and 5 .

directions currents = ... *ul* **[4]**

(d) (ii)



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

surfaces. = ... *zo* **[3]**

(i) 800 nm to 1000μ m

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.

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

mass = ... zv **[2]**

(e) (iii) the vertical and horizontal components of velocity at time t.

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

[5]

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

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.

[15]

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

that $k = 3$ and $p = 26$.

string string = ... eh **[4]**

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

that the area of the region bounded by the initial line, the arc of C_1 from $\theta = 0$ to $\theta = \beta$, and the arc of C_2 from $\theta = \beta$ to $\theta = \frac{1}{4}\pi$ is

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

Calculate the distance moved by the car during this acceleration.

525 520 522 524 518 520 519 525 527 516

[4]

(i) Find the area of one loop of C.

$$\mathbf{i}+\mathbf{j}+3\mathbf{k}, \quad 3\mathbf{i}-\mathbf{j}+5\mathbf{k}, \quad 3\mathbf{i}-\mathbf{j}+\mathbf{k}, \quad 5\mathbf{i}-5\mathbf{j}+\alpha\mathbf{k},$$

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

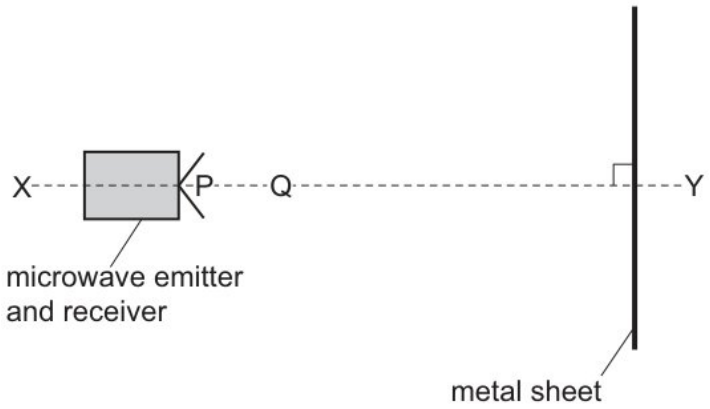
incident = ... dx **[8]**

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

Find the standard deviation of x.

boys weigh = ... mk **[8]**

(vi)



is its change in momentum?

current-carrying coil produces a magnetic field.

[12]

(c) (iii) leptons are emitted from the sodium-21 nucleus during the decay?

the period of small oscillations,

[10]

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

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

[8]

27 the period of small oscillations,

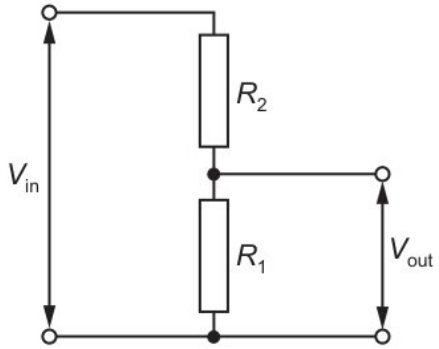
$$\sin\frac{1}{5}\pi \sin\frac{2}{5}\pi \sin\frac{3}{5}\pi \sin\frac{4}{5}\pi \quad \text{and} \quad \sin^2\left(\frac{1}{5}\pi\right) + \sin^2\left(\frac{2}{5}\pi\right)$$

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

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

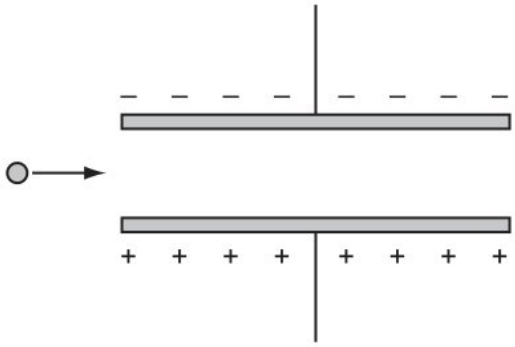
from circle = ... *oj* **[10]**

(i) the length of C.



lifetime = ... *ax* **[10]**

(c) (ii)



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

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

year = ... *jt* **[20]**

(iii) find the moment of inertia of the body about an axis l, through A, in the plane of the body and tangential to the circle.

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

[4]

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

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

discrete random variable X has the following probability distribution.

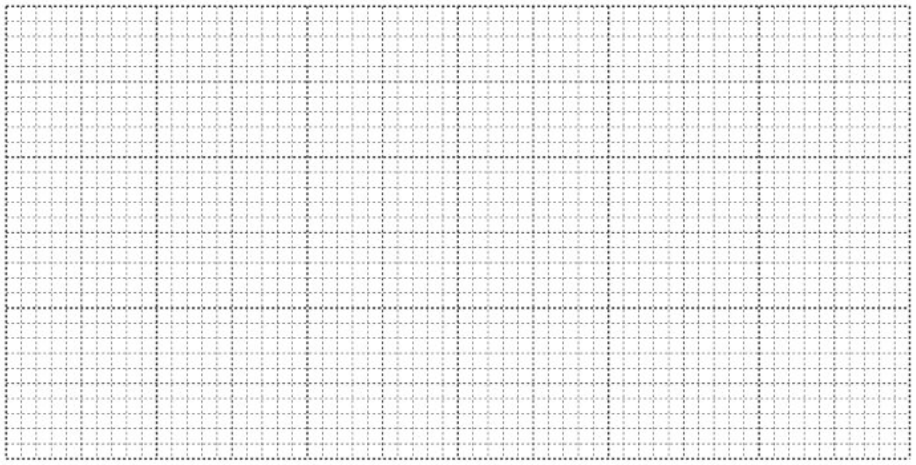
[6]

(ii) the probability that more than 7 study Art or Music.

is suggested that the strength B of the magnetic field at the centre of a flat circular coil is inversely proportional to the radius r of the coil.

[3]

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



[5]

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

In the case where $k = 2$,

$$\frac{3}{2}x + 3y + 8z = 1,$$
$$ax + 3y + 4z = 2,$$
$$ay - z = 3,$$

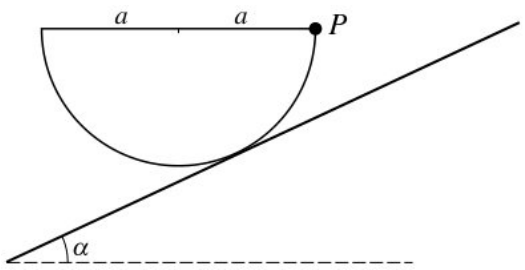
[4]

(i) weight of the parachutist is 850 N .

Find the cartesian equation of Π_1.

mass = ... wt **[8]**

(vii)



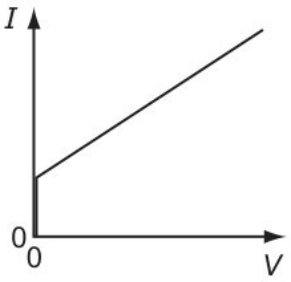
the time that it takes from when P is initially projected until the instant at which P collides with the combined particle

[4]

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

(a) (ii) not have a unique solution.

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



[4]

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

a tree diagram to represent this information, giving the probability on each branch.

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

[5]

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

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

[8]

(i) leptons are emitted from the sodium-21 nucleus during the decay?

an estimate for the mean length of these 250 leaves.

[6]

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

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.

[6]

(vi) 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.

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

diameter = ... lg **[2]**

15 a t test at the 5% significance level to find the range of values of k for which the result of the test is to reject the null hypothesis

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

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

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

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

hours. = ... *li* **[8]**

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

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

how the pattern of interfering waves may be observed.

[4]

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

diagram shows part of the curve

Given also that C has a turning point when $x = 2$, find the value of c.

[4]

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

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

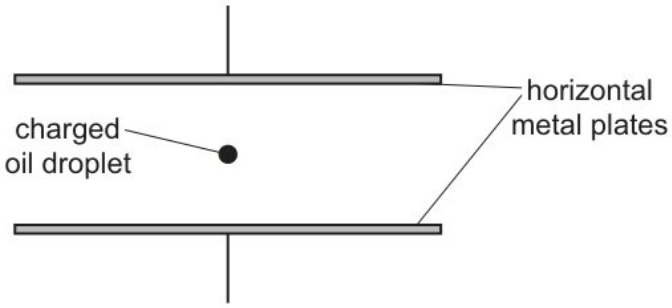
[4]

(iv) 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.

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

particular = ... *qi* **[4]**

(b) (i)



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.

[4]

(iii) 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.

circuit is set up as shown in Fig. 2.1.

Find = ... *be* **[6]**

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

Obtain a basis for the null space of T .

distance = ... *hs* **[10]**

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

plane Π_2 contains the lines

adults, they = ... *ll* **[20]**

18 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.

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

is the efficiency of the process?

that = ... *bd* **[4]**

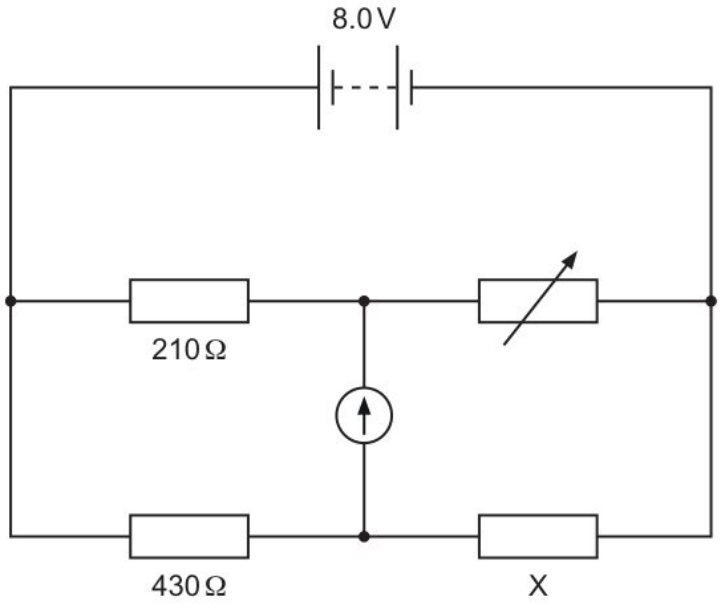
(iv) matrix **A**, given by

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

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

[8]

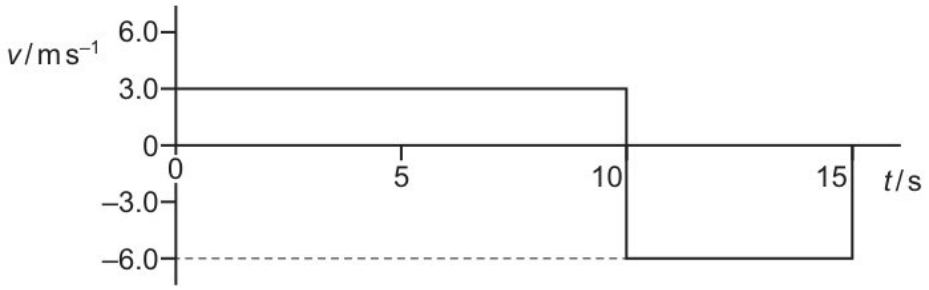
(vii)



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

where = ... nm **[6]**

(h) (iii)



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.

[2]

(v) measurements to be taken,

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

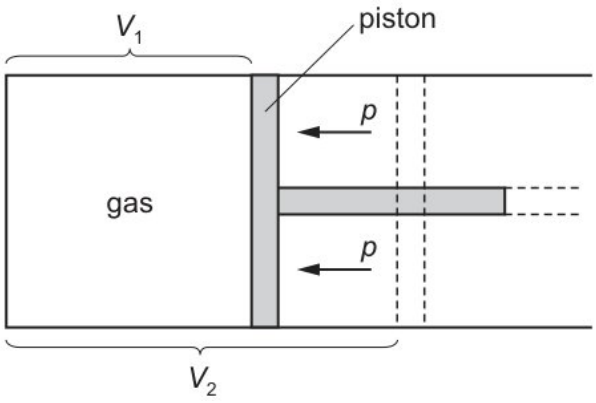
[10]

(a) (v) battery is marked 9.0 V .

Deduce that the cartesian equation of C is

[8]

(i)



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

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.

shell through = ... bt **[4]**

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

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.

numbered = ... jq **[10]**

(b) (iii) internal diameter of the beaker is 0.05 m ± 3%.

State one other feature of this orbit.

[6]

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

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

Calculate the length AG.

[4]

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

is the effect of a systematic error on the measurement of a physical quantity?

the expected value and variance of Y.

[3]

7 temperature θ_{R} of the laboratory is measured using a thermometer.

(f) (i) Show that $a = 19$ and find the values of b and c.

Find the frictional and normal components of the contact force acting on B.

simple = ... sy **[6]**

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

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

[8]

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

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?

[3]

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

$$2\tan\theta = -\tan 2\theta$$

[6]

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

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

the general solution of the differential equation

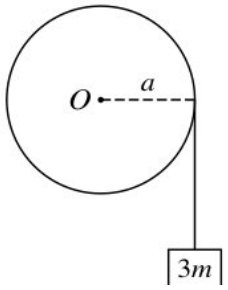
also = ... *op* **[6]**

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

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

[5]

(i)



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

least bulbs chosen lifetime = ... kq **[6]**

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

$$y = 0.46x + 1.62 \quad \text{and} \quad x = 0.93y + 8.24$$

released = ... le **[2]**

13 Find the value of t when the particle is instantaneously at rest.

the value of α.

(i) (c) one similarity and one difference between an electron and positron.

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

horizontal horizontal = ... vr **[5]**

(d) curve C has equation $x^3 - 3xy + y^2 = 4$. Find the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $(0, 2)$ of C.

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

[2]

(a) small smooth ring R, of mass 0.6 kg , is threaded on a light inextensible string of length 100 cm . One end of the string is attached to a fixed point A. A small bead B of mass 0.4 kg is attached to the other end of the string, and is threaded on a fixed rough horizontal rod which passes through A. The system is in equilibrium with B at a distance of 80 cm from A (see diagram).

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

[3]

(iv) (a) 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.

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.

[4]

(d) The waves must have equal amplitudes.

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

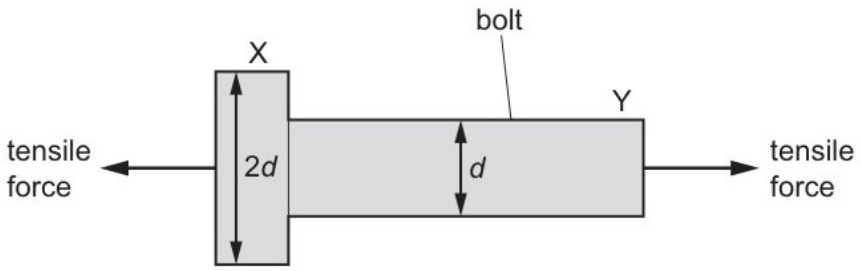
[6]

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

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.

[6]

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



[20]

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

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

result = ... *ek* **[4]**

11 small ball is dropped from rest from height h_1 above the ground and falls vertically downwards. The ball collides with the ground and bounces back vertically upwards, reaching a maximum height h_2. Fig. 4.1 shows the ball just before and just after hitting the ground.

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

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

junction = ... *ul* **[8]**

(e) 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.

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

[6]

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

State the equation of the other asymptote.

[8]

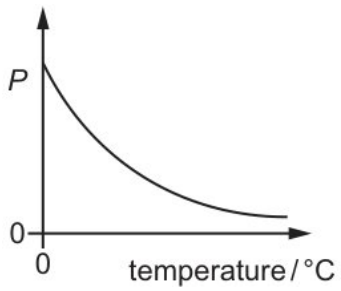
(a) λ is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

planes p and q have equations $x + y + 3z = 8$ and $2x - 2y + z = 3$ respectively.

Find the weight of the lamina.

[3]

(d)



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

resultant force = ... ym **[12]**

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

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

[3]

(f) 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.

the probability that the 3 customers bought computers all made by different companies.

[10]

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

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

[4]

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

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

Find the values of p and q.

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

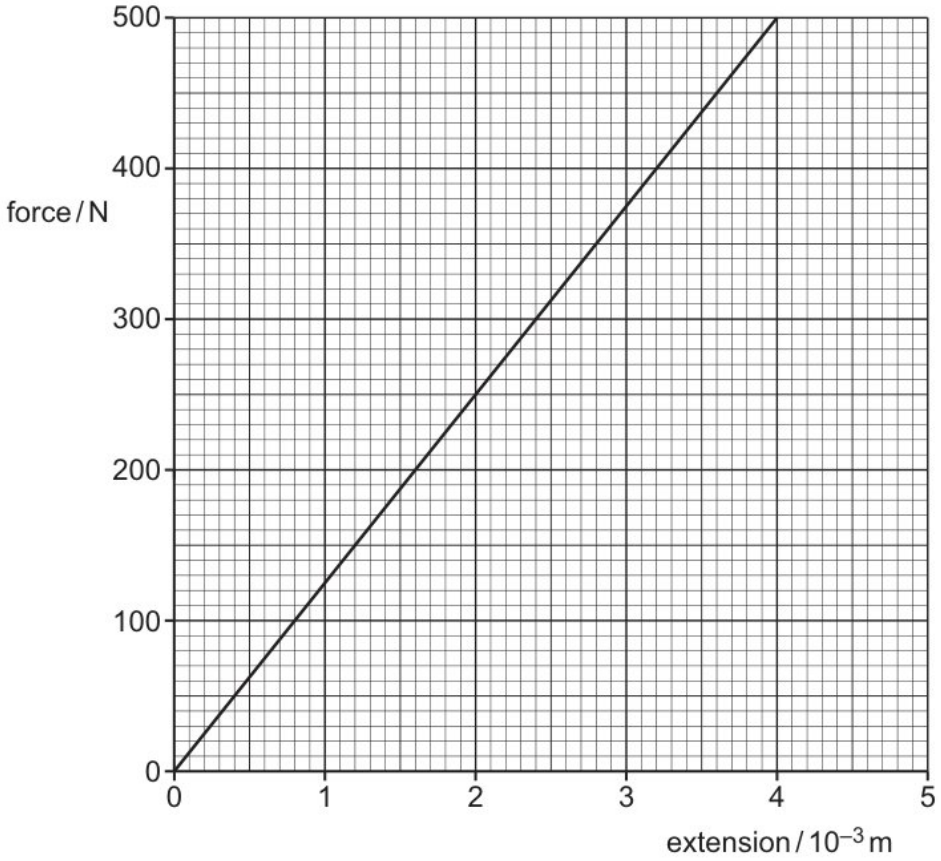
random = ... fy **[4]**

(iii) the equations of the asymptotes of C

The waves must be polarised.

[5]

(c) (iii)

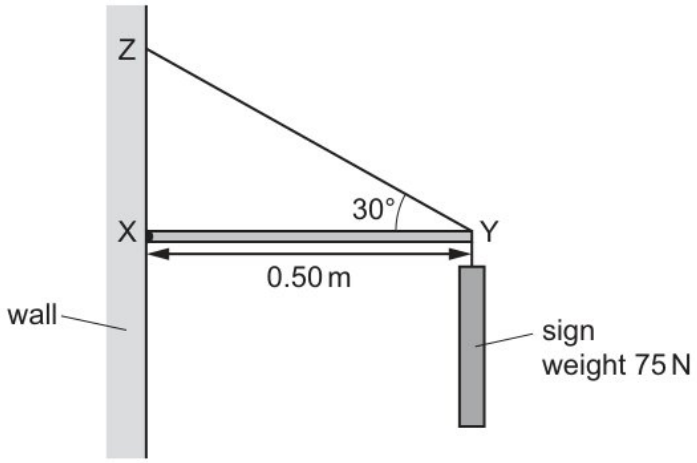


owns a small hotel and offers accommodation to guests. Over a period of 100 nights, the numbers of rooms, x, that are occupied each night at Roberto's hotel and the corresponding frequencies are shown in the following table.

[12]

(i) only one of the following two alternatives.

by mathematical induction that, for all positive integers n,



[10]

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

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

[8]

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

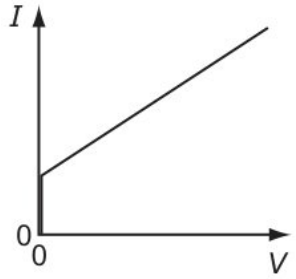
different = ... *tb* **[4]**

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

[5]

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

(iii) for a wire,



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

[8]

(i) narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m . The disc rotates with angular velocity ωrads^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

react records = ... *no* **[6]**

(ii) narrow groove is cut along a diameter in the surface of a horizontal disc with centre O. Particles P and Q, of masses 0.2 kg and 0.3 kg respectively, lie in the groove, and the coefficient of friction between each of the particles and the groove is μ. The particles are attached to opposite ends of a light inextensible string of length 1 m . The disc rotates with angular velocity ωrads^{-1} about a vertical axis passing through O and the particles move in horizontal circles (see diagram).

axis = ... *tl* **[2]**

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

(ii) statement is correct?

[4]

(i) Find the value of x.

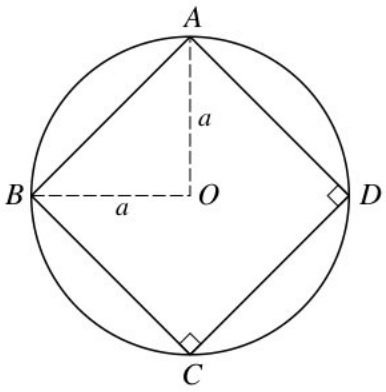
front = ... *he* **[12]**

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

line l passes through B and C.

Find the total distance travelled by the particle in the first 10 seconds of motion.

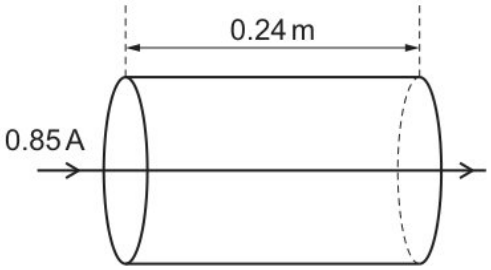
(c) (iii)



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

[3]

(ii) an electron and an antineutrino



[6]

(i) 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.

manufacturer claims that the machine produces rods with mean length 300 mm .

[4]

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

progressive water waves X and Y travel along a straight line from point A to point B. The variation of displacement of the waves with distance from A at an instant in time is shown in Fig. 3.1.

gravitational potential at a point.

positive = ... hy **[15]**

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

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

constant = ... xc **[4]**

(f) (ii) Show that $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$.

the principle of superposition.

[4]

(iii) the exact value of I_2

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

[8]

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

are the amplitude and the period of wave S ?

[15]

13 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 back-to-back stem-and-leaf diagram to represent this information, with Gulls on the left-hand side.

far apart are two adjacent interference fringes that are formed on the laboratory wall?

random variable T has probability density function given by

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

velocity = acceleration $\times$ time

student investigates the cooling of a liquid in a beaker.

Diameter = ... *vc* **[8]**

(i) 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.

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.

[5]

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

Find the equations of the asymptotes of C.

[8]

(h) (iii) Calculate the length AG.

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

Find the coordinates of the turning points of C.

[3]

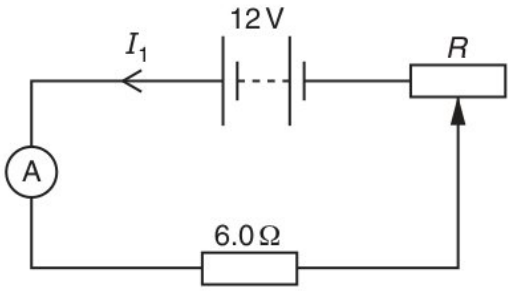
(i) how the temperature determined using the observed wavelength compares with the true value of temperature determined using the emitted wavelength.

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

[3]

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

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



Find $\sum_{r=n+1}^{2n} u_r$.

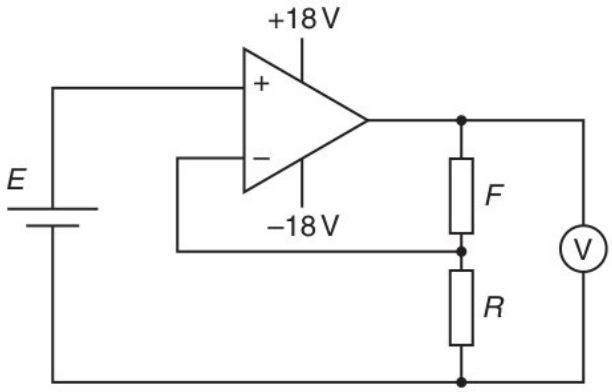
shown = ... kd **[3]**

(ii) matrix **A** is given by

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

rope. = ... ac **[10]**

(b) (iii)



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

[12]

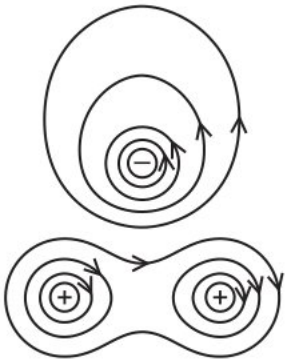
(i) random variable Y is defined by $Y = \sqrt[3]{X}$

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.

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

mean. = ... *cb* **[4]**

21 the past, the population mean time was 62.4 seconds.



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

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

[1]

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

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

variance = ... *pp* **[8]**

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

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

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

adjustments random appropriate = ... *st* **[4]**

(i) the period of small oscillations,

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

rest value = ... *du* **[2]**

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

Find the coordinates of the turning points of C.

[4]

11 Show that $\mathrm{f}(n+1) + \mathrm{f}(n) = 28\left(3^{3n}\right) + 7\left(6^{n-1}\right)$.

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

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

[10]

(vi) steel sphere is dropped vertically onto a horizontal metal plate. The sphere hits the plate with a speed u, leaves it at a speed v, and rebounds vertically to half of its original height.

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

size = ... *le* **[3]**

(iv) by mathematical induction, that 5^n+3 is divisible by 4 for all non-negative integers n.

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

correct = ... *lm* **[6]**

(d) (ii) first artificial radioactive substance was made by bombarding aluminium, $^{27}_{13}\mathrm{Al}$, with α-particles. This produced an unstable isotope of phosphorus, $^{30}_{15}\mathrm{P}$.

diagram shows the electric field between the plates?

[5]

(iii) diagram shows the curve with equation $y = \frac{1}{x^2+1}$ for $0 \leqslant x \leqslant 1$, together with a set of n rectangles of width $\frac{1}{n}$.

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

the SI base units of resistivity.

[2]

(v) are the amplitude and period of the wave?

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

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

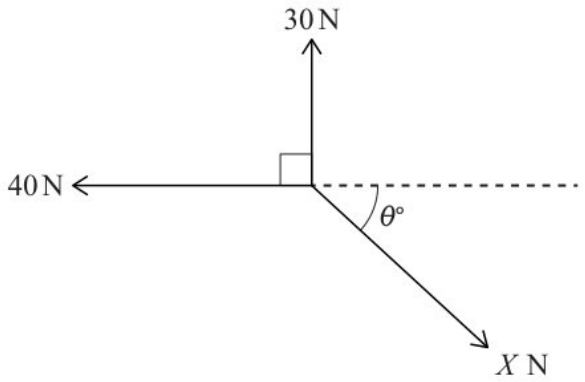
letters = ... *sm* **[5]**

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

only one of the following two alternatives.

[4]

(iii)



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

[6]

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

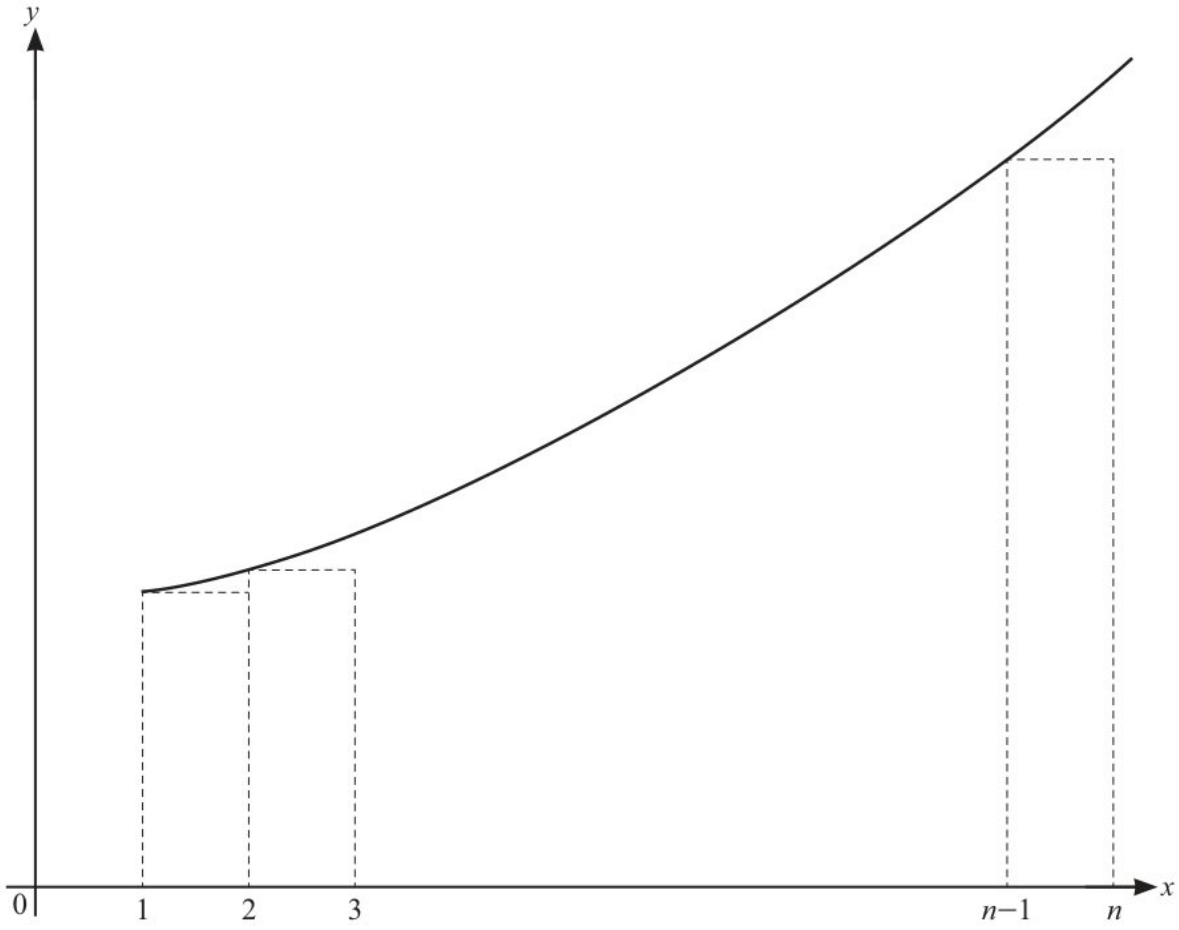
(vi) lengths, in millimetres, of rods produced by a machine are normally distributed with mean μ and standard deviation 0.9. A random sample of 75 rods produced by the machine has mean length 300.1 mm .

there are no restrictions,

[3]

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

Calculate the modulus of elasticity of the string.



[6]

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

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

[4]

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

Use a goodness-of-fit test at the 5% significance level to determine whether the Poisson distribution is a suitable model for the number of rooms occupied each night at Roberto's hotel.

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

[5]

(iii) the exact solutions of the equation $\mathrm{f}(x) = 1$.

[5]

(b) one similarity and one difference between an electron and positron.

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

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

[4]

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

[6]

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

de Moivre's theorem to show that

Find the values of a and b.

temperature θ_R of the laboratory is measured using a thermometer.

(iii) (b) curve C has equation

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

[6]

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

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.

Graphs = ... *qp* **[8]**

(a) graph is correctly labelled?

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

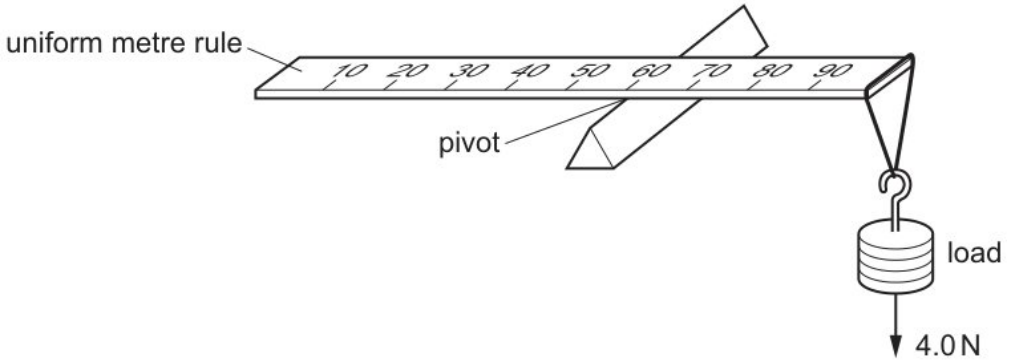
hardness = ... *qq* **[12]**

(d) that, at the point of C furthest from the initial line,

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

[6]

(i) (c)



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

[3]

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

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

[12]