24 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.

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.

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

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.

[3]

(iii) bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

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

[5]

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

State the equation of the other asymptote.

[6]

(iii) 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.

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

[5]

(ii) and N are two electromagnetic waves.

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

Find the values of p and q.

[2]

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

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

is the current in the load resistor?

(f) (ii) the probability of a Type I error.

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

the probability density function of Y,

value = ... ox **[4]**

(i) and N are two electromagnetic waves.

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

[4]

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

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

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

[3]

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

State the equation of the other asymptote.

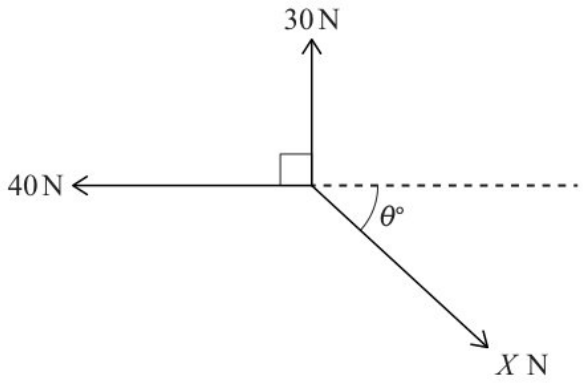
[2]

(b) (iii) Hence solve the equation

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

[15]

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



[8]

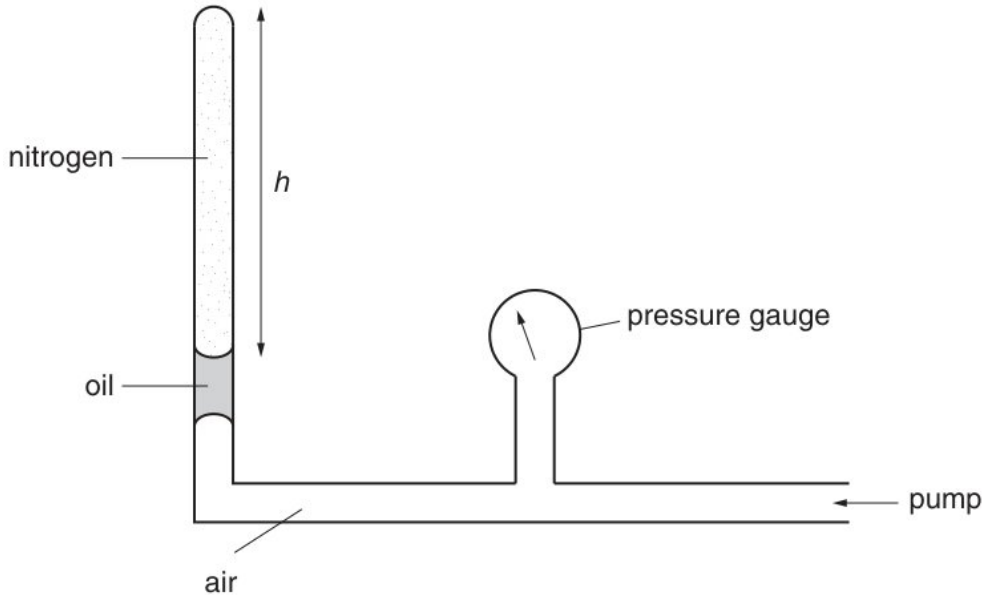
(iv) the arc length of C,

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

man has a mass of 80 kg . He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1}.

[6]

(e) (iv)



charge of 4.0 C passes through the resistor.

$$p\begin{pmatrix} 1 \\ 3 \\ 5 \\ -2 \end{pmatrix} + q\begin{pmatrix} -1 \\ -1 \\ -8 \\ 3 \end{pmatrix} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}.$$

[4]

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

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

[6]

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

is its change in momentum?

[5]

20 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.

Find the value of x.

(c)(vii) the coordinates of any stationary points on C

variables x and y satisfy the differential equation

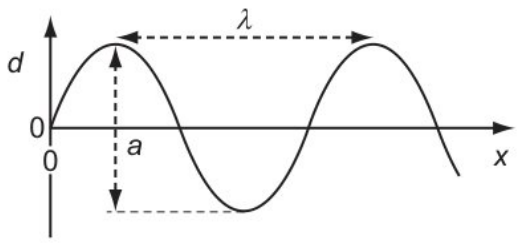
[5]

(ii) 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.

Find the tension in the string.

[8]

(b) (i)



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

[8]

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

matrix $\mathbf{A}$, given by

[5]

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

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

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

[6]

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

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

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

[6]

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

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

[6]

(c) (i) Find the values of a and b.

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

the probability generating function of Z to find $\mathrm{E}(Z)$.

[8]

(iii) not have a unique solution.

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

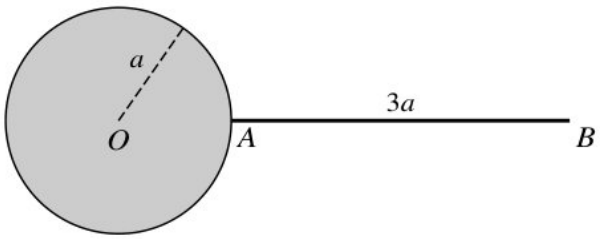
$0.695 = \ldots\ldots\ldots\ldots\ dx$ **[5]**

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

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

[6]

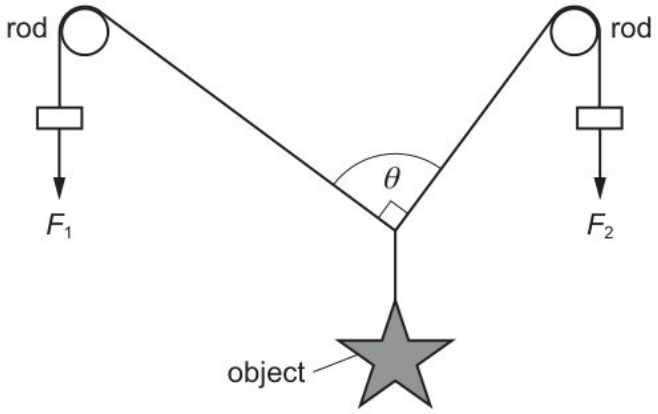
(b) (i)



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

[3]

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



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

[2]

(iv) 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.

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

524 526 520 523 530

[8]

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

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}.

[8]

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

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

process does not require energy to be supplied?

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

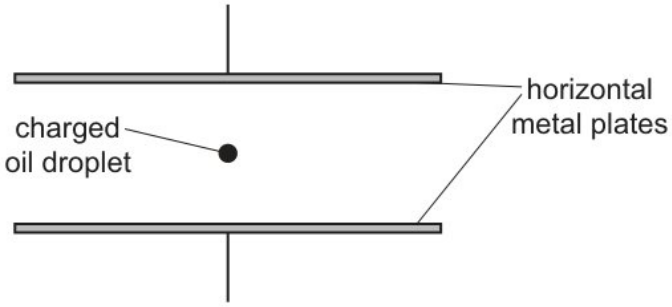
$$\sqrt{3}x^5 - 10x^4 + 40x^2 - 32 = 0$$

Find the tension in the string in terms of W.

[6]

(iii) bolt is subjected to a tensile force, as shown.

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



[6]

(b) (ii) Find the area of the triangle ABC.

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

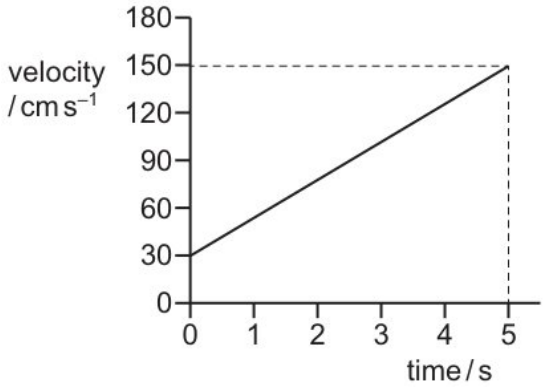
[3]

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

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

[5]

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



[12]

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

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

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.

[5]

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

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

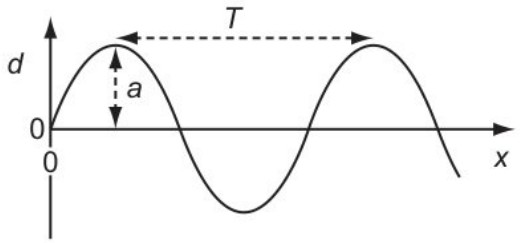
[2]

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

the values of a, b, x and y.

[3]

(e) (iii)



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.

[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.

support at end X exerts a force F vertically upwards on the plank.

[8]

(i) 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.

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

[5]

(v) Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

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

is its change in momentum?

[5]

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

(a) (ii) radius of the circle in which P moves and the radius of the circle in which Q moves, your answer correct to 2 decimal places.

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

[4]

(v) wavelength of light is 550 nm .

Calculate the greatest deceleration of P.

525 520 522 524 518 520 519 525 527 516

[1]

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

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

[6]

(b) (ii) are no resistive forces acting on the block.

the principle of moments.

[2]

(iv) statement about the weight of the plank is correct?

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

[8]

(iii) statement is correct?

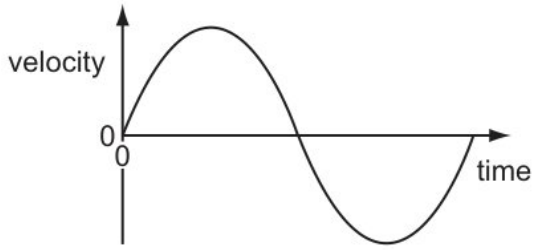
points A, B and C have position vectors $2\mathbf{i} - \mathbf{j} + \mathbf{k}, 3\mathbf{i} + 4\mathbf{j} - \mathbf{k}$ and $-\mathbf{i} + 2\mathbf{j} + 4\mathbf{k}$ respectively.

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

[3]

9 Express v in terms of x.

(d) (vi) 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?



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

[4]

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

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

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

[6]

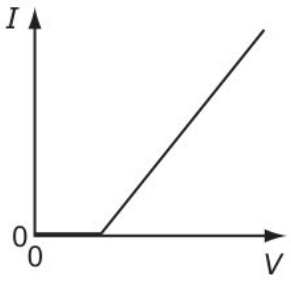
(iv) Find the work done by the tension.

curve C has equation

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

[5]

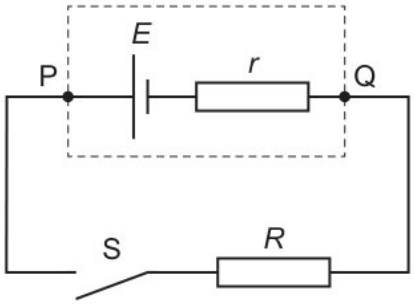
(b) (iv)



car of mass 1400 kg is travelling on a straight, horizontal road at a constant speed of 25 m s^{-1}. The output power from the car's engine is 30 kW .

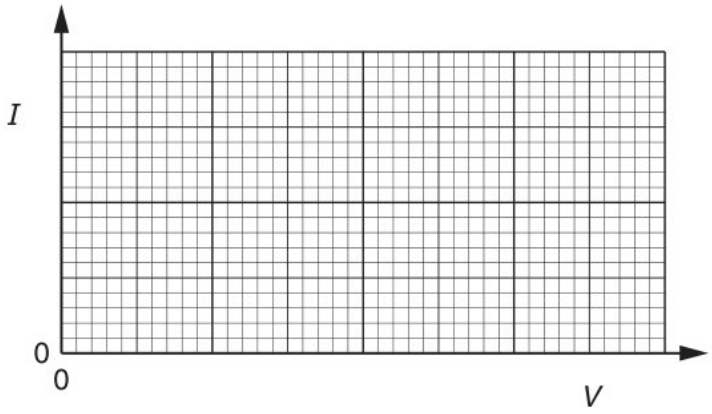
[5]

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



[4]

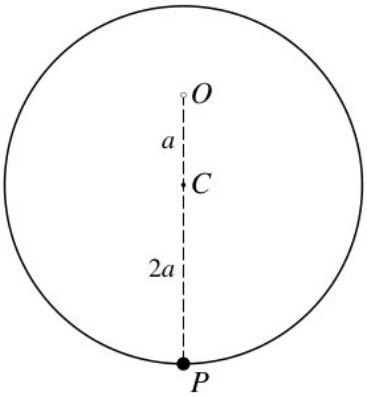
(a) (i)



Find the probability that a box is rejected.

[3]

(v)

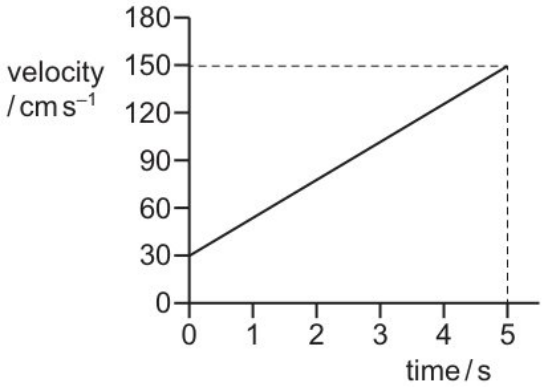


point $P(2, 1)$ lies on the curve with equation

[5]

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

(c) (iii)



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

[5]

(i) 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.

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

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

[6]

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

the distribution function of X.

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

[2]

(b) (ii) $\frac{\text{force}}{\text{length} \times \text{time}}$

the principle of moments.

[2]

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

much energy is stored in the compressed column?

[8]

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

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

[6]

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

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

[8]

(iii) Pressure is force per unit area.

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

[4]

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

$$\cos\theta + 4\cos 2\theta = 3,$$

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

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

Show that $b = 1 - a$.

(a) (ii) 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.

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

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

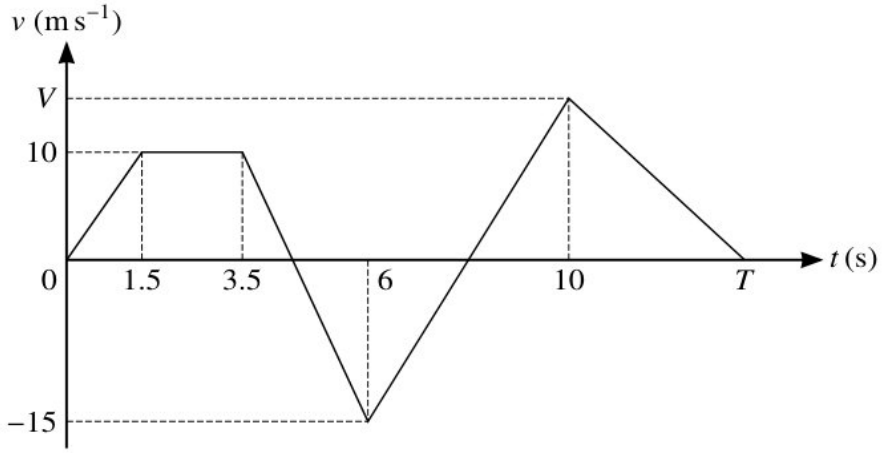
[8]

(vii) It results in the measured value being different from the correct value.

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

[3]

(e) (iii)



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

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

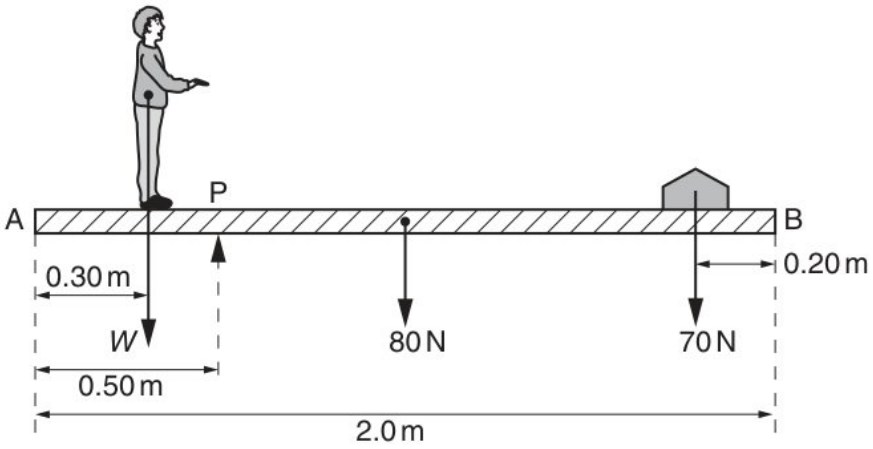
[5]

(vi) projectile is thrown at an angle to the ground.

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

[4]

(ii)



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

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

[4]

(f) (iv) sample contains a single radioactive isotope that decays to form a stable isotope.

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

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

[10]

(iii) leptons are emitted from the sodium-21 nucleus during the decay?

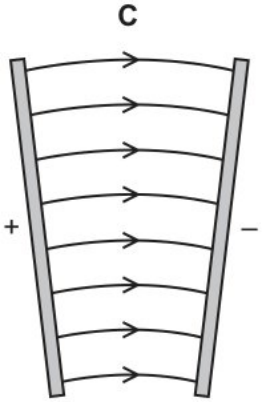
adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

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

grams = ... rd **[3]**

8 for a wire,

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

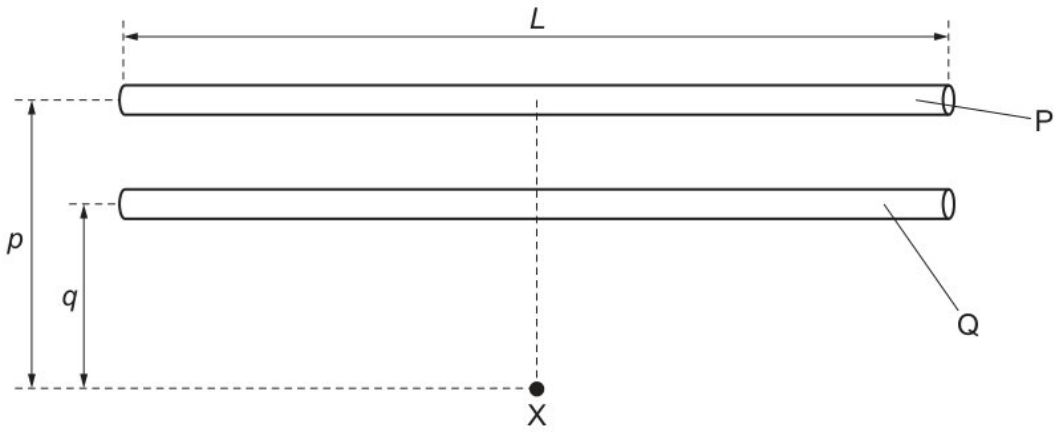


(d) (i) the characteristic equation of $\mathbf{A}$ to show that $(\mathbf{A} - 2\mathbf{I})^3 = a\mathbf{A}^2 + b\mathbf{A} + c\mathbf{I}$ where a, b and c are constants to be determined.

the speed of the combined particle after this collision.

[6]

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



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

[4]

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

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

$$2\tan\theta = -\tan 2\theta$$

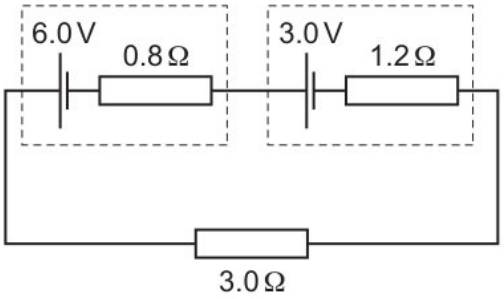
[12]

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

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

[10]

(iii)



this compression, work W is done on the gas.

Find the area of the triangle ABC.

[1]

(iv) matrix **A** is given by

By using the substitution $y = \frac{1}{x^2}$, find the cubic equation with roots $\frac{1}{\alpha^2}$, $\frac{1}{\beta^2}$ and $\frac{1}{\gamma^2}$.

[5]

15 the speed of the aeroplane.

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

The waves must not be polarised.

$$\mathbf{A} = \begin{pmatrix} \frac{3}{2} & 3 & 8 \\ 0 & 3 & 4 \\ 0 & 0 & -1 \end{pmatrix}.$$

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

(b) (i) Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.

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

[8]

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

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

[6]

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

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

[4]

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

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.

[10]

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

of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

[4]

(i) 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 $ax + by + cz = d$.

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

[8]

(iii)

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

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

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

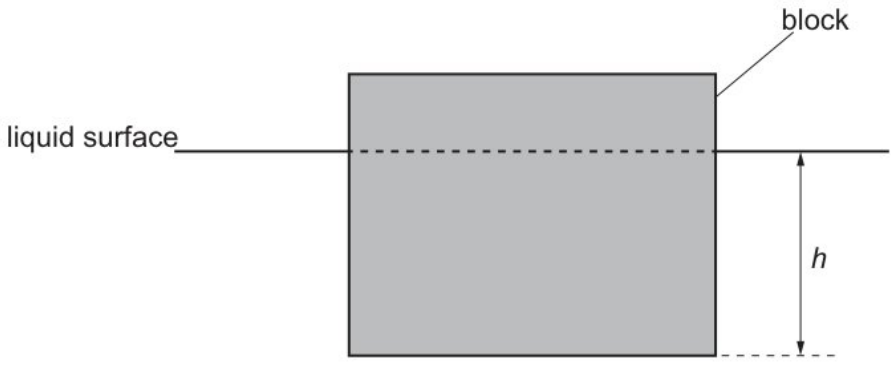
[10]

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

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

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.

(d) (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.



[2]

(ii)

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

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.

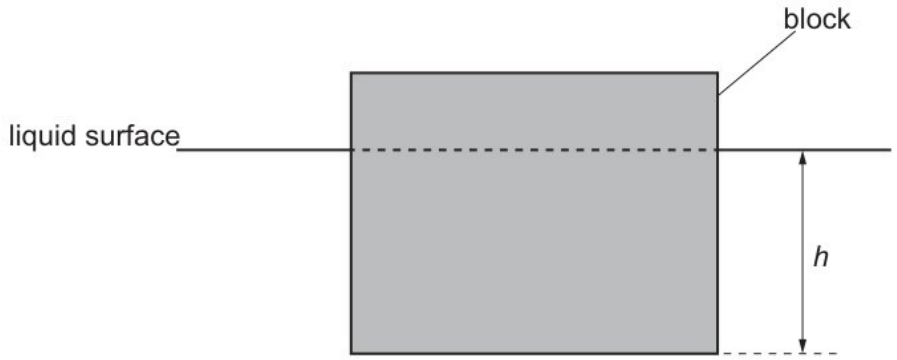
[4]

(f) (iv) random variable T has probability density function given by

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

[3]

(i) 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 $\frac{1}{n}$.



is given that $y = \frac{1}{12}\pi$ when $x = \frac{1}{2}\pi$.

[8]

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

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

object weighs 6.0 N on Earth.

[3]

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

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

[6]

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

find corresponding eigenvectors.

[4]

16 the principle of moments.

is the speed of the projectile at this time?

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

the moment of a force about a point.

[12]

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

Find angle ABC.

[3]

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

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.

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

[5]

(iii) Find also the value of $\frac{1}{\alpha^2\beta^2} + \frac{1}{\beta^2\gamma^2} + \frac{1}{\gamma^2\alpha^2}$.

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

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

[5]

(d) (iv) relationship is used in the derivation of the equation shown?

that the forces are in equilibrium, find the values of θ and X.

Find the standard deviation of x.

[5]

(iii) the range of f,

It limits the range of values obtained in repeated measurements.

[4]

(b) (ii) the value of σ.

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

[6]

(iv) 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.

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

[3]

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

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

[4]

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

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?

[4]

(i) the value of the constant k,

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

[10]

21 throws three coins at the same time.

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

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

Deduce that the cartesian equation of C is

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

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

$$\Sigma x = 210.9 \quad \Sigma(x - \bar{x})^2 = 151.2$$

[6]

(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 $t = 2$.

power = force × velocity

times = ... *be* **[15]**

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

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

be written as a quadratic equation in x.

[6]

(a) (ii) process does not require energy to be supplied?

this question the use of a calculator is not permitted.

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

[15]

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

State the work W done by F.

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

[2]

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

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

only one of the following two alternatives.

[6]

(d) (iii) is an approximate value for the speed of sound in air?

diagram shows the electric field between the plates?

[6]

(i) Find the rank of **M**.

[4]

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

restaurant manager buys 160 of these large bags of pasta.

[12]

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

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

[6]

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

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

wire = ... ks **[8]**

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

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

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.

[6]

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

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

[12]

(v) procedure to be followed,

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

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

[15]

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

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

(i) (b)

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

speed = ... ka **[12]**

(c) supermarket is open 7 days a week.

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

[5]

(f) polynomial p(x) is defined 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'.

[5]

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

Find the coordinates of the turning points of C.

[4]

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

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

[6]

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

P hears a sound of increasing frequency.

[6]

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

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

[8]

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

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

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

[2]

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

only one of the following two alternatives.

[6]

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

The waves must not be polarised.

[4]

(iii) (d) Find the value of k for which the set of linear equations

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

[6]

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

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

Show that the tension in the string is 10 N .

[10]

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

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

[4]

(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 $\frac{1}{n}$.

Both light waves and sound waves show the Doppler effect.

[6]

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

[6]

(d) 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.

(v) the equation representing this decay.

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.

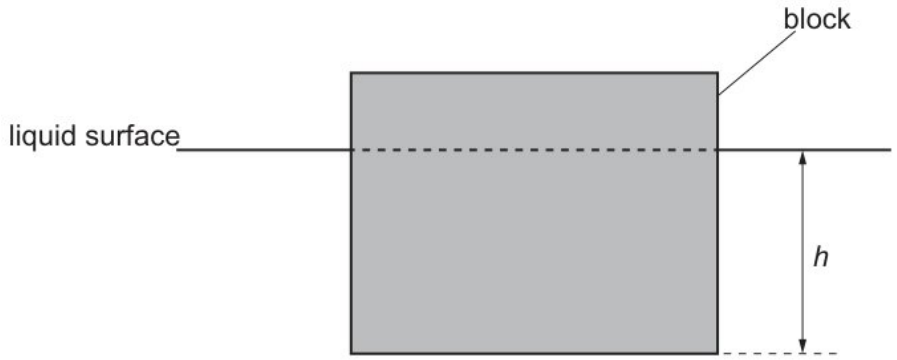
[3]

(iv) does this mean?

[6]

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

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



[6]

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

points A, B, C have position vectors

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

$$\Sigma(x - 25) = 133, \quad \Sigma(x - 25)^2 = 3762.$$

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

[6]

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

[3]

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

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.

[10]

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

(a) (iii) three quantities that are conserved during the decay.

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

[5]

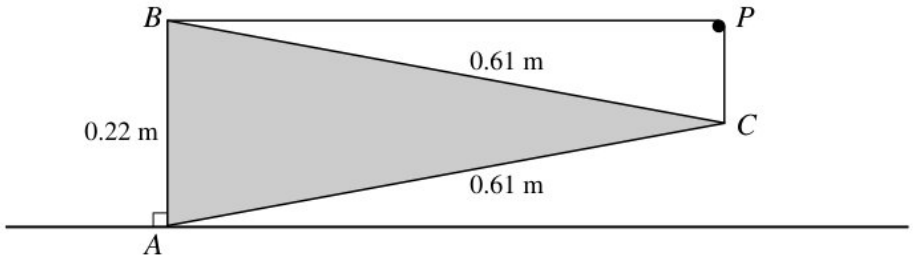
(iv) Find the angle that the force acting on the rod at A makes with the horizontal.

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

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

[3]

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



[10]

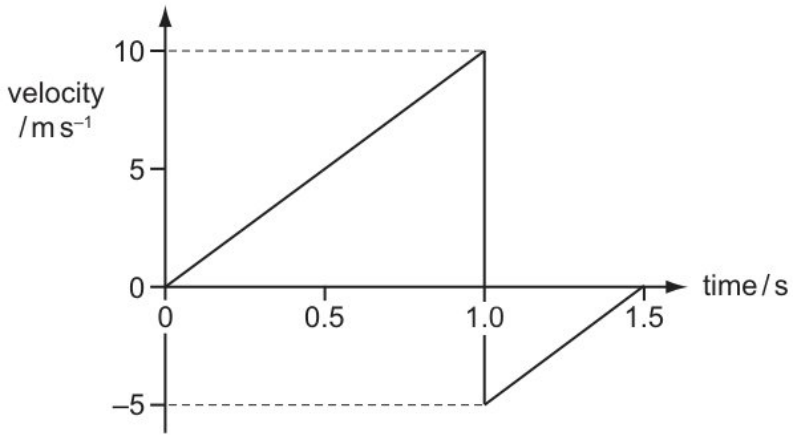
(d) (iii) van is 2.50 m long with the wheels at a distance of 0.600 m from the front of the van and 0.400 m from the rear of the van.

this question the use of a calculator is not permitted.

[2]

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

row of the table gives an angle θ of $90°$?



[10]

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

p and q are given real numbers, then

[6]

14 (d) a positron and a neutrino

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

[8]

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

[6]

(ii) what is meant by centre of gravity.

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

[8]

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

(vi) gravitational potential at a point.

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

[8]

(iii) 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.

[8]

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

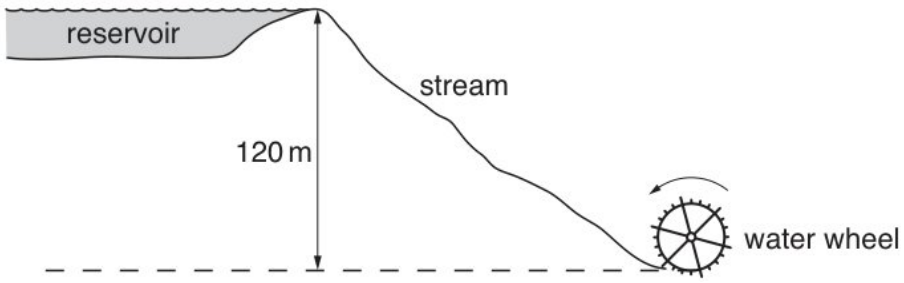
[6]

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

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

[4]

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



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

[6]

15 thermistor is connected to a cell with negligible internal resistance.

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

(c) (i) It consists of two quarks that do not need to be the same flavour.

Show that $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$.

[6]

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

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.

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

[8]

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

$$T = \frac{\lambda}{l}(a - l).$$

[4]

(a) (ii) is a general description of a baryon?

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

[4]

(iii) Show that $v^2 = u^2 + \frac{14}{5}ag$.

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

[5]

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

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

[6]

(iii) Using a 5% significance level, test whether there is non-zero correlation between the variables.

lamina is freely suspended at A and hangs in equilibrium.

[15]

(ii) Find the standard deviation of the weights of the letters.

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

[10]

12 by calculation that a lies between 2 and 2.1.

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

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

of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

[5]

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

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.

[3]

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

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

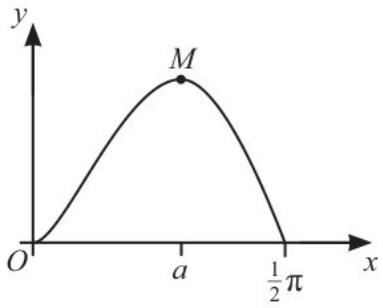
[8]

(a) (i) uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

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

[8]

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



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.

[6]

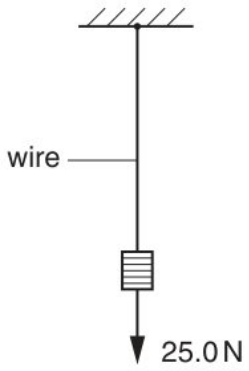
(ii) Find the x-coordinate of M.

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.

By using the substitution $y = \frac{1}{x^2}$, find the cubic equation with roots $\frac{1}{\alpha^2}$, $\frac{1}{\beta^2}$ and $\frac{1}{\gamma^2}$.

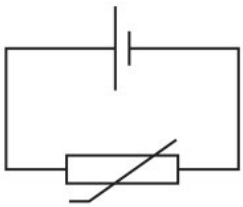
[6]

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



[2]

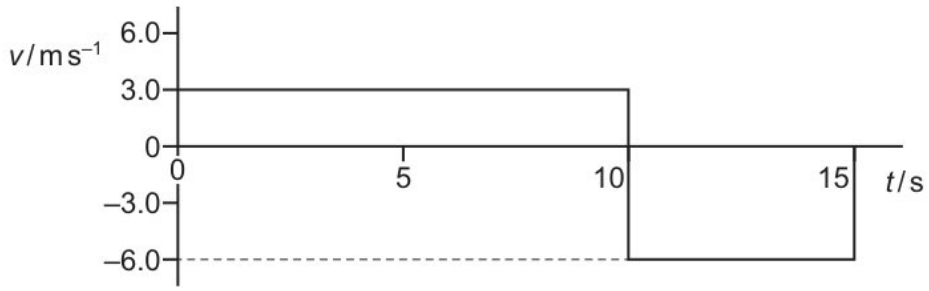
(iii)



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

[10]

(i)



Find the standard deviation of the weights of the letters.

[5]

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

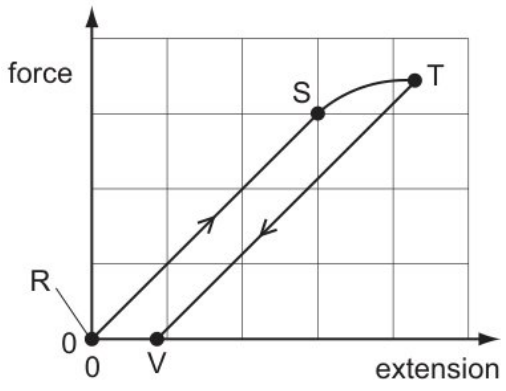
(c) (ii) obtain the roots of the equation

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

[5]

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

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



[5]

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

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

[8]

(i) Show that $v^2 = u^2 + \frac{14}{5}ag$.

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

[6]

(ix) 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

quantities would be measured in order to determine E ?

[2]

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

a, b and c are integers to be determined.

could M and N be?

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

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

Find the cartesian equation of Π_2.

[6]

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

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

[6]

(iii) block is released from rest at the top of a slope inclined at an angle to the horizontal. The slope has length L as shown in the diagram.

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

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

sold with = ... fy **[12]**

(a) (i) is also known that the standard deviation of the times taken by all 50 runners is 1.38 seconds.

$$f(x) = \begin{cases} \frac{1}{4}(x+1) & 0 \leqslant x \leqslant 2 \\ 0 & \text{otherwise} \end{cases}$$

diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

[6]

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

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

[6]

(d) (ii)

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

that the mean of these 40 values is 124.0 , find the value of k.

[8]

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

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

[4]

(iv) 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.

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

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

[8]

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

$$\mathbf{D} = \begin{pmatrix} 1 & -1 & 1 \\ -6 & -3 & 4 \\ -9 & -3 & 7 \end{pmatrix},$$

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

[8]

(i) 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 .

line l_1 passes through the point with position vector $8\mathbf{i} + 8\mathbf{j} - 7\mathbf{k}$ and is parallel to the vector $4\mathbf{i} + 3\mathbf{j}$. The line l_2 passes through the point with position vector $7\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$ and is parallel to the vector $4\mathbf{i} - \mathbf{k}$. The point P on l_1 and the point Q on l_2 are such that PQ is perpendicular to both l_1 and l_2. In either order,

[12]

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

an expression for $\tan\theta$ in terms of e.

line l_1 passes through the point with position vector $8\mathbf{i} + 8\mathbf{j} - 7\mathbf{k}$ and is parallel to the vector $4\mathbf{i} + 3\mathbf{j}$. The line l_2 passes through the point with position vector $7\mathbf{i} - 2\mathbf{j} + 4\mathbf{k}$ and is parallel to the vector $4\mathbf{i} - \mathbf{k}$. The point P on l_1 and the point Q on l_2 are such that PQ is perpendicular to both l_1 and l_2. In either order,

[12]

22 manufacturer claims that the machine produces rods with mean length 300 mm .

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

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

(b) (ii)

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

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.

[5]

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

the solution of the differential equation

[5]

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

Hence find the solutions of the equation

[2]

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

- decelerating at a constant rate with the parachute open,

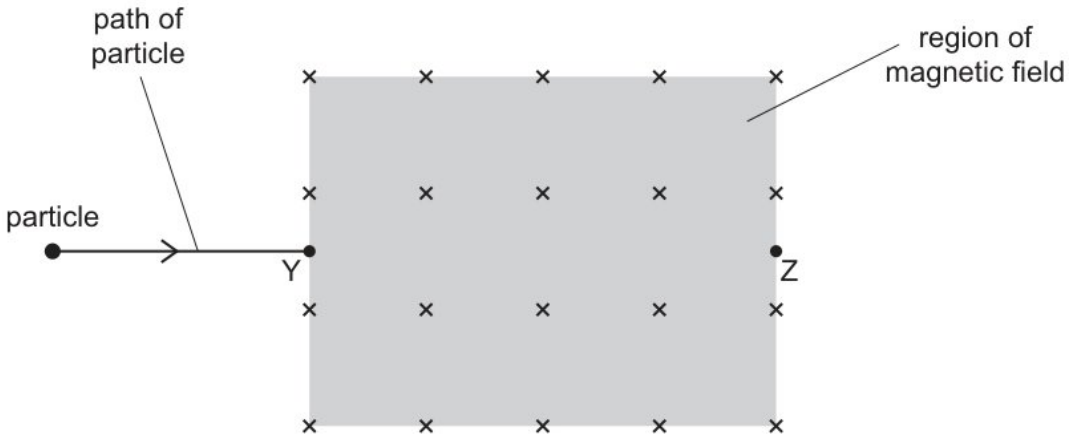
[8]

(ii) 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.

Find the cartesian equation of Π_2.

[5]

(c) (i)



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

[3]

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

3×3 matrix **A** has eigenvalues $-1, 1, 2$, with corresponding eigenvectors

held = ... mn **[8]**

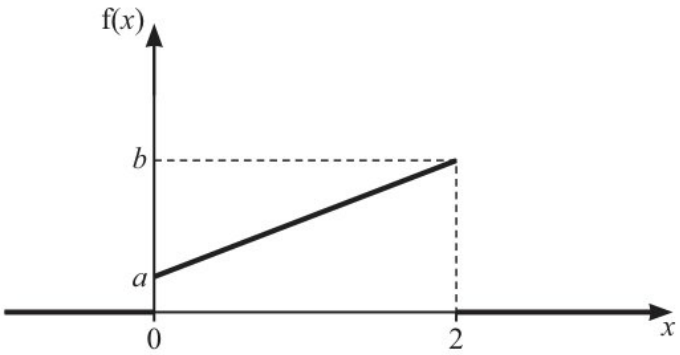
(ii) Show that the moment of inertia of the object, consisting of rod, shell and inner sphere, about the axis l is $\frac{289}{15}ma^2$.

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

[3]

8 Express f(x) in partial fractions.

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



[6]

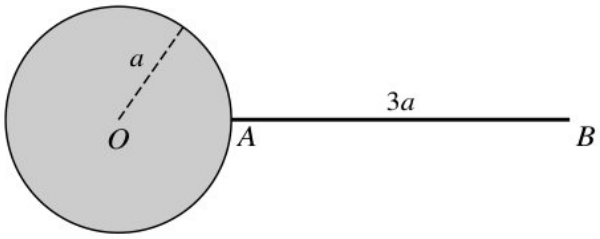
(iv)

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

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

[4]

(d) (iv)



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

[15]

(iii) 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

lowest mark was 17 and the highest mark was 74 .

[5]

(a) (iv) 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?

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

randomly = ... *ye* **[4]**

(ii) for a wire,

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

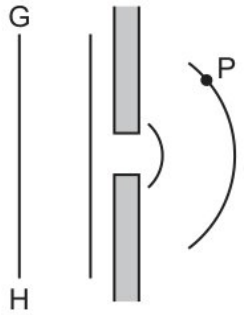
[8]

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

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

[3]

26 $\frac{\text{mass} \times (\text{ time })^2}{\text{length}}$



the average power of the aeroplane's engines.

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

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

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

should pay particular attention to

[5]

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

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

[5]

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

The orbit has a period of 25 hours.

de Moivre's theorem to show that

apart. beams = ... *he* **[10]**

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

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

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

[2]

13 (a) 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.

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

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

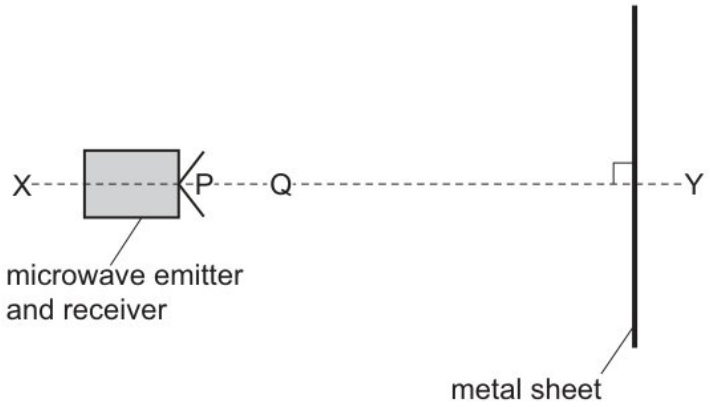
	weight/N	mass/kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

[5]

(vi) Find the work done by the tension.

[12]

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



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

[8]

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

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

[5]

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

B contains 5 red marbles and 3 blue marbles.

[5]

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

[4]

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

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

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

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

[6]

(iii) statement about the weight of the plank is correct?

[10]

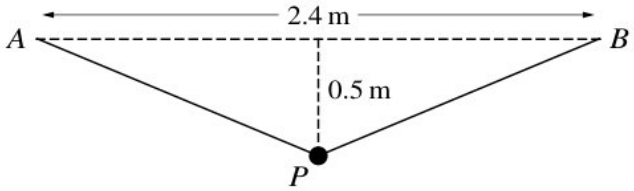
(v) monochromatic plane wave of speed c and wavelength λ is diffracted at a small aperture.

[6]

14 Find the rank of **M**.

projectile is thrown at an angle to the ground.

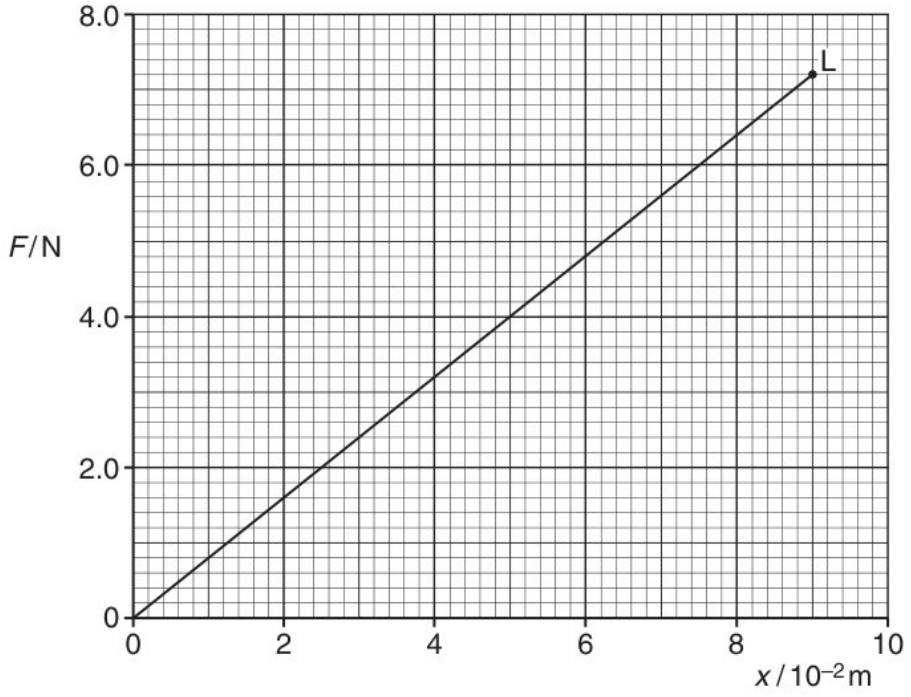
(b) (ii) X and Y are connected in series to a cell.



Q hears a sound of decreasing frequency.

[3]

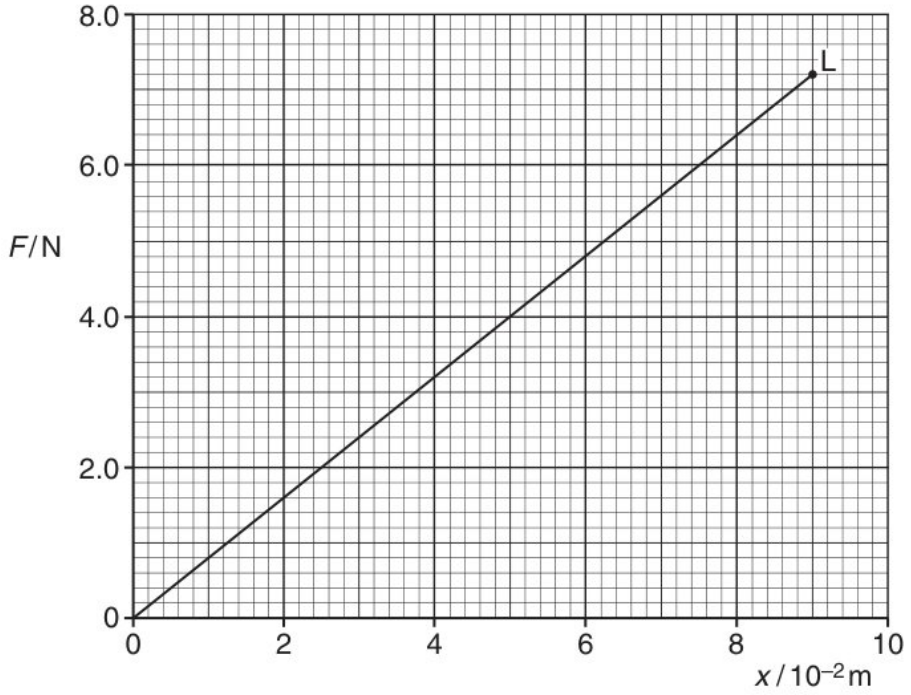
(ix)



Velocity is proportional to wavelength.

[5]

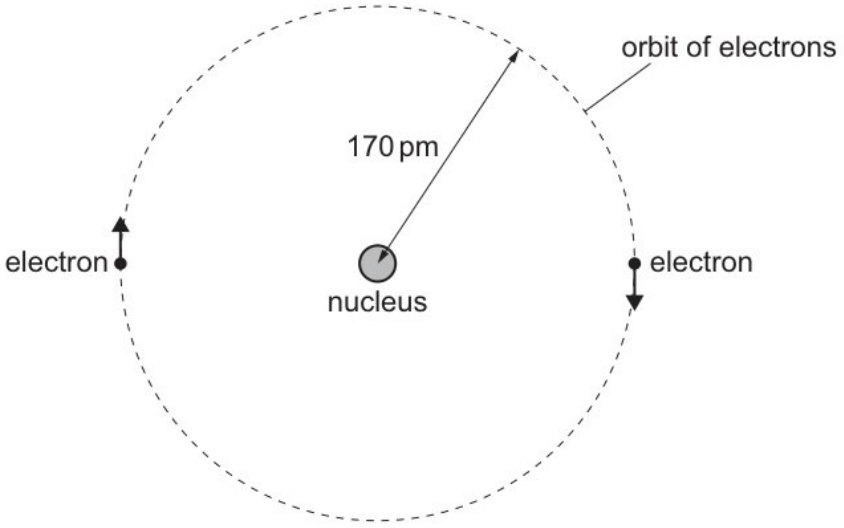
(c)(vii)



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

[12]

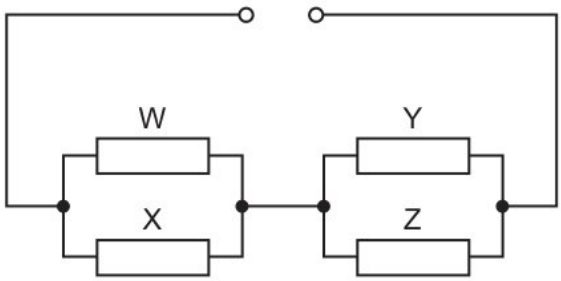
(v)



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

[8]

(ii)



the probability density function of Y,

[3]

26 Find the area of the region enclosed by C.

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

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

lowest mark was 17 and the highest mark was 74 .

(d) (ii) 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.

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

[5]

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

Amplitude is inversely proportional to velocity.

specific latent heat.

[20]

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

parametric equations of a curve are

[2]

(iv) 800 nm to 1000μ m

Use de Moivre's theorem to show that

only one of the following two alternatives.

[2]

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

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

[2]

(iii) 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}.

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

[6]

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

is the reading on the ammeter?

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

[12]

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

$$y = \frac{ax^2 + bx + c}{x - 1}$$

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

[8]

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

is the efficiency of the process?

a, b and c are integers to be determined.

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

random variable X is the number of heads obtained.

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

[6]

(i) the value of the constant k,

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

[12]

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

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.

[3]

(e) (v) the probability of a Type II error.

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

[5]

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

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

[6]

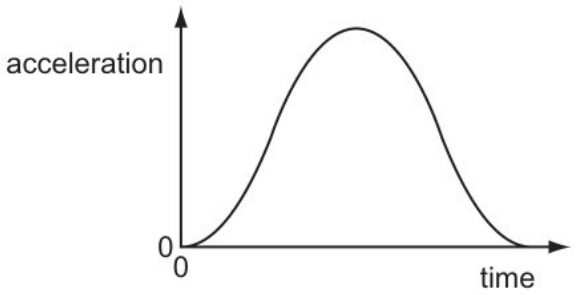
(iii) Find the probability that exactly two of the selected balls have the same number.

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

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

[1]

(iv)



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

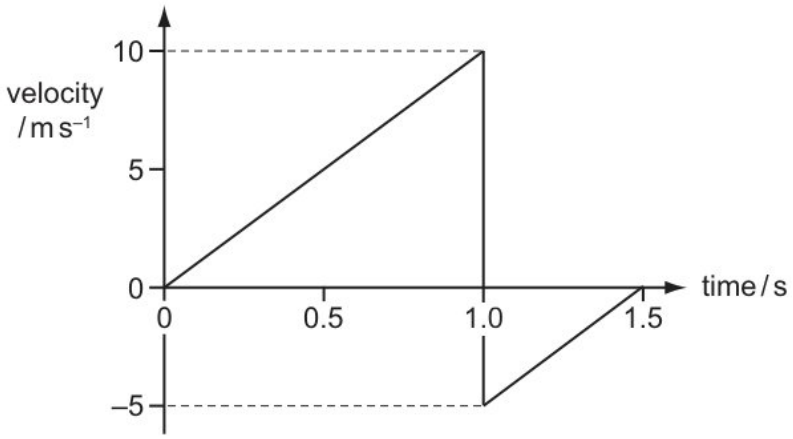
[10]

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

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

[5]

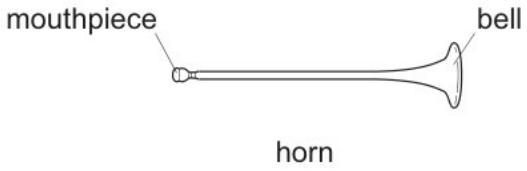
(iii)



Find the equations of the asymptotes of C.

[6]

(a) (i)



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

wavelength of the wave and the width of the gap are both changed by a small amount.

point = ... jb **[3]**

(iii) 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.

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

[3]

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

(b) (iii) a time 8.4 minutes later, the activity is 120 Bq .

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.

[8]

(i) anywhere between point R and point S

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

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.

[8]

(ii) 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 .

an expression for $\tan\theta$ in terms of e.

[4]

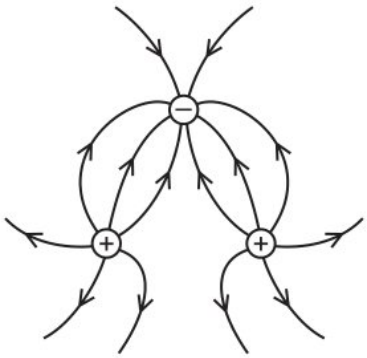
(vi) that u_{2n} is divisible by u_n for $n \geqslant 1$.

$$\Sigma(x - 25) = 133, \quad \Sigma(x - 25)^2 = 3762.$$

[5]

(a) (ix) 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 $\frac{1}{3}$.

state the corresponding eigenvalue.



[20]

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

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

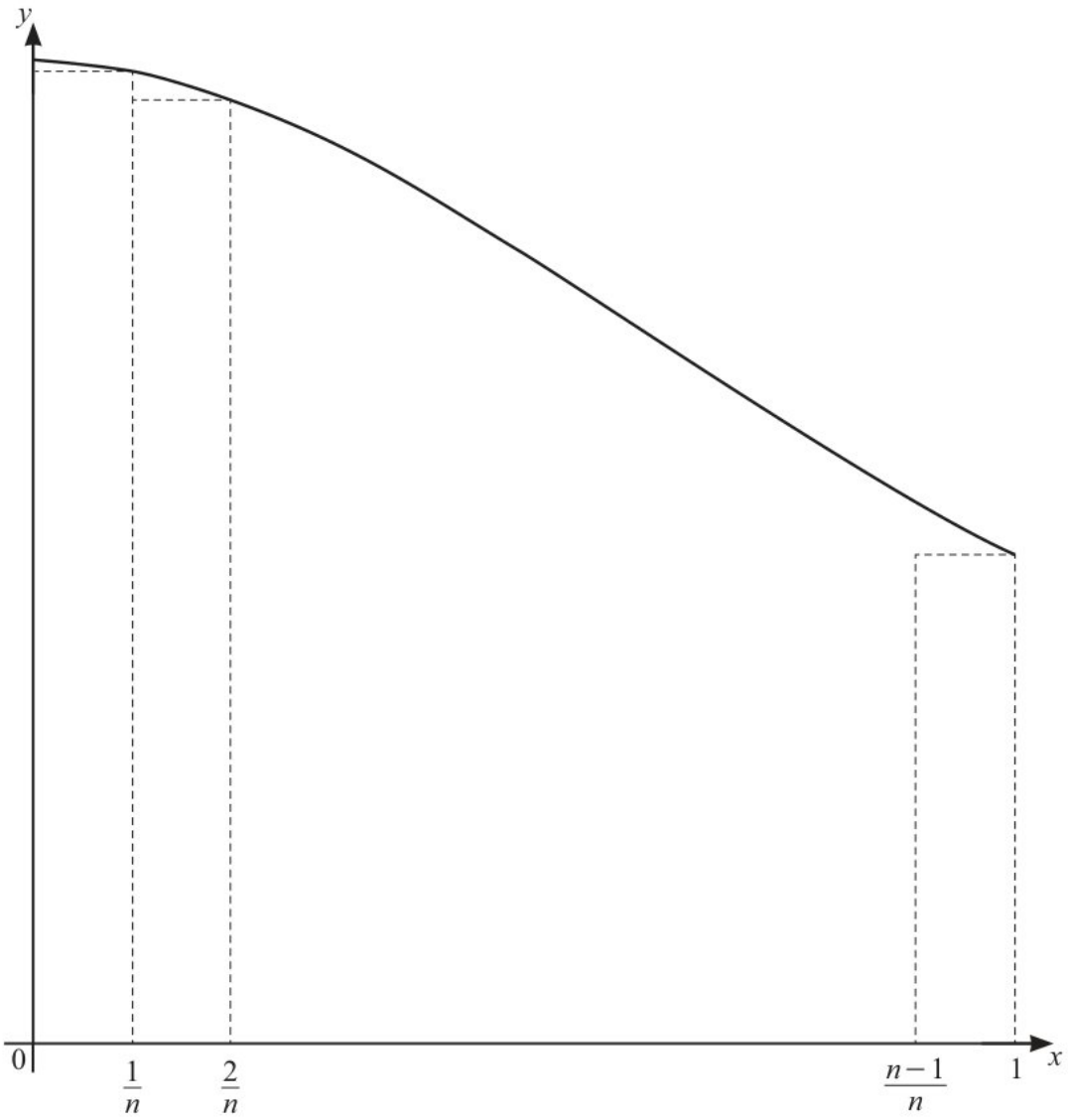
[4]

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

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

[2]

(iii)



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

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

[2]

(g) (ii)

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

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

[4]

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

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

[8]

32 could M and N be?

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

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

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

[10]

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

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?

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

[5]

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

momentum = mass × velocity

[8]

(b) (iii) P and Q form an isolated system.

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

[10]

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

Find the area of one loop of C.

[6]

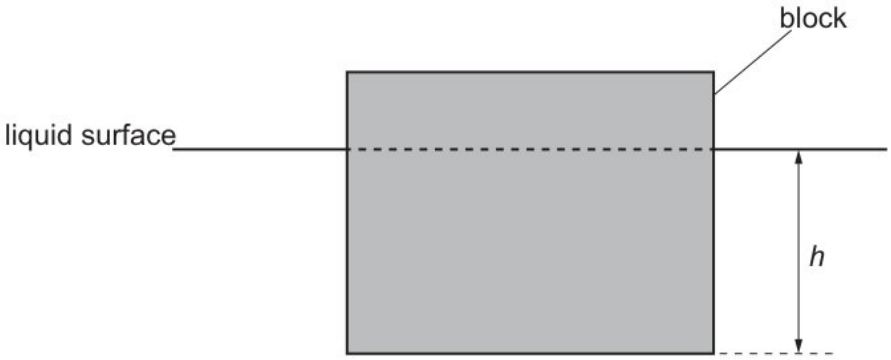
(i) all solutions in the interval $0° \leqslant \theta \leqslant 360°$.

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

Member	A	B	C	D	E	F	G	H
x	24.2	23.8	22.8	25.1	24.5	24.0	23.8	22.8
y	23.9	23.6	22.8	24.5	24.2	23.5	23.6	22.7

[3]

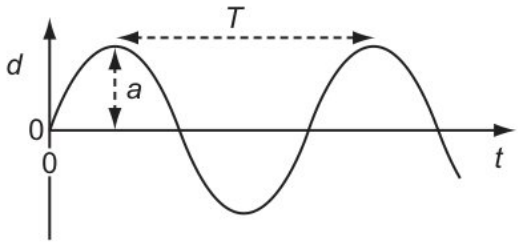
(d) (i)



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.

[5]

(iv) diagram shows the force-extension graph produced.



[8]

26 - decelerating at a constant rate with the parachute open,

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

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.

[10]

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

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

first, second and third terms of a geometric progression are $2k + 3, k + 6$ and k, respectively. Given that all the terms of the geometric progression are positive, calculate

[5]

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

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

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

[5]

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

the experimental observations that show radioactive decay is

The total momentum is conserved only in elastic collisions.

[8]

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

Find the frictional and normal components of the contact force acting on B.

[6]

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

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.

[6]

(iv) be written as a quadratic equation in x.

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.

speed down = ... xi **[5]**

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

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

[6]

17 curve C has equation

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

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

an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

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

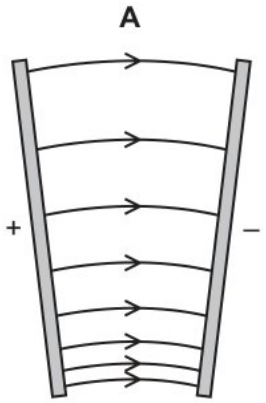
[5]

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

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

[4]

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



[3]

(d) (v) paving slab has a mass of 68 kg and dimensions 50 mm × 600 mm × 900 mm.

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

two assumptions of the simple kinetic model of a gas.

[10]

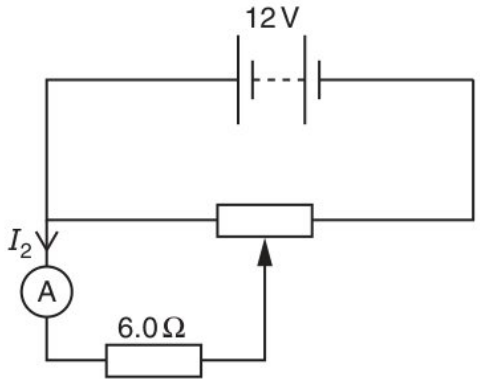
(ii) the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

x	1	2	3	6
$\mathrm{P}(X = x)$	0.15	p	0.4	q

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

[6]

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



[10]

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

(a)(vii) the probability generating function of Z to find $\mathrm{E}(Z)$.

discrete random variable X has the following probability distribution.

Find the probability density function of Y.

[6]

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

the equations of the asymptotes of C

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

[3]

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

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

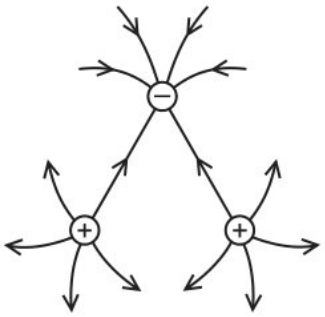
[6]

(b) (iii) When the tensile force is removed, the wire returns to its original length.

Prove that, for $n \geqslant 2$,

[12]

(i)



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

[8]

(c) (ii) Find the value of I_2.

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

[6]

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

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

[12]

17 It results in repeated measurements having different values from each other.

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave $\boldsymbol{x}$ = not a property of an electromagnetic wave
A	✓	χ	✓	
B	✓	χ	×	
C	×	✓	✓	
D	×	✓	×	

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

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

[4]

(a) 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 .

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

which = ... jg **[15]**

(b) 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.

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

[4]

(i) (a)

the expected value and variance of Y.

[8]

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

of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

[10]

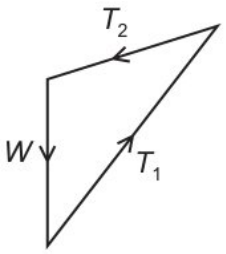
25 person's eye colour may be categorised as "brown", "blue" or "other". A scientist claims that these eye colours are uniformly distributed and hence are equally likely to occur in the population. A survey of 120 people from this population found that 38 people had brown eyes, 52 people had blue eyes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

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

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

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

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



[6]

(iii) the exact volume of the solid generated

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

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

[1]

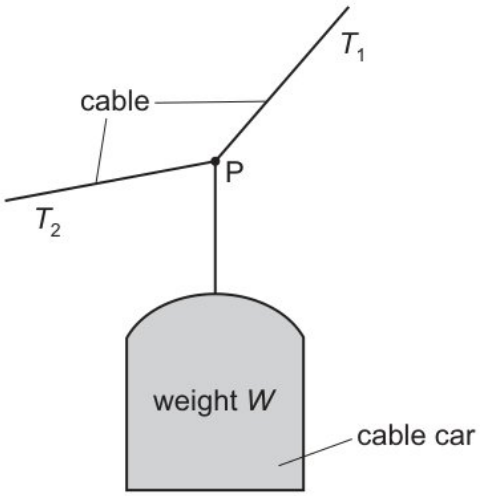
(iv) sample of a radioactive substance emits particles that are positively charged and have a continuous range of kinetic energies.

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

[8]

(c) (v) parametric equations of a curve are

weight of the parachutist is 850 N .



[10]

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

man has a mass of 80 kg . He ties himself to one end of a rope which passes over a single fixed pulley. He pulls on the other end of the rope to lift himself up at an average speed of 50 cm s^{-1}.

[8]

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

(b)(vii) process does not require energy to be supplied?

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

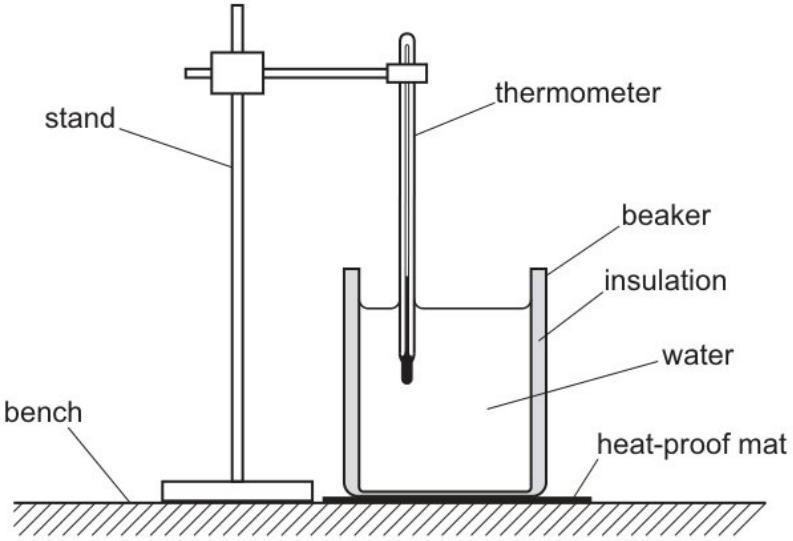
[6]

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

Find a set of corresponding eigenvectors.

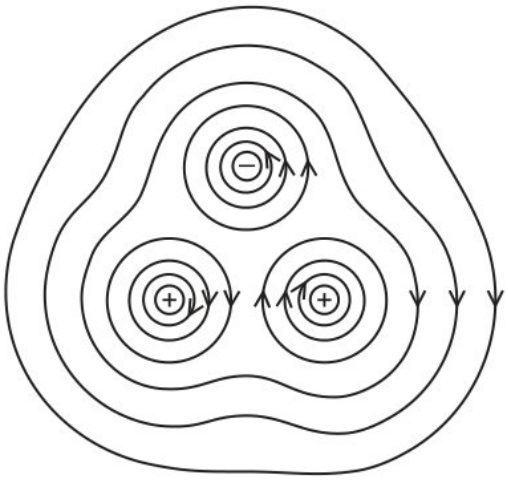
[12]

(i) 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.



[5]

(a) (v)

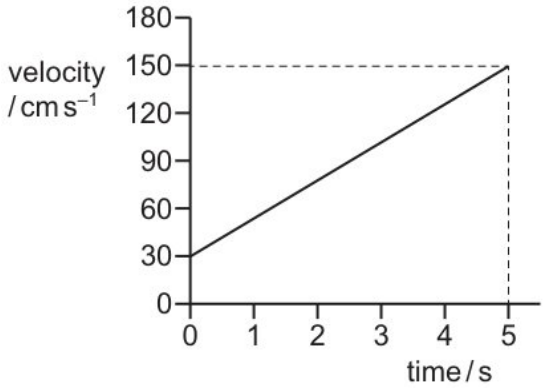


row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

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

[4]

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



[15]

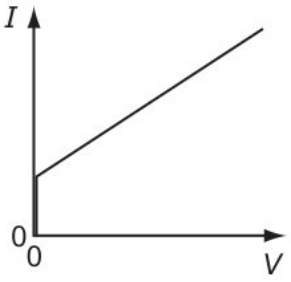
(i) line l_3 has equation $\mathbf{r} = \mathbf{i} + 10\mathbf{j} + 3\mathbf{k} + v(2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$. Find the shortest distance between l_1 and l_3.

source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

charge of 4.0 C passes through the resistor.

[4]

(g) (i)



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

[2]

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

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

[8]

(ii) 1 Which quantity is a scalar quantity?

Find the values of a and b.

[6]

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

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

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

[12]

(iv) 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 $\lambda\mu$.

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.

[10]

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

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

[5]

12 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.

Amplitude is inversely proportional to velocity.

Q hears a sound of decreasing frequency.

(c) (v) no digit can be repeated,

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

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.

[3]

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

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

[12]

(iii) a laboratory experiment to determine the absorption coefficient of glass. You should

polynomial $ax^3 - 3x^2 - 11x + b$, where a and b are constants, is denoted by $\mathrm{p}(x)$. 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 12 .

[8]

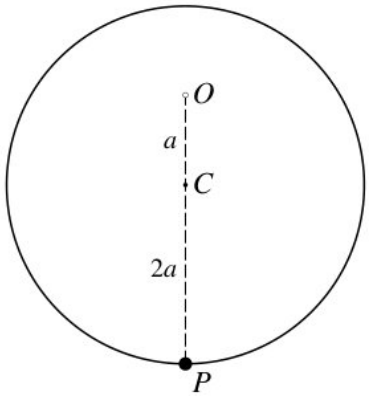
(d) (iii) Find the angle that this tangent makes with the x-axis.

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

is 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.

[12]

(iv) 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.



[8]

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

what is meant by the de Broglie wavelength.

[8]

(a) (iv) Find the perpendicular distance of the point A from the line BC.

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

[10]

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

this compression, work W is done on the gas.

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

[6]

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

(a) (i) is given that a is a positive constant such that

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

[12]

(ii) 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

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

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

[6]

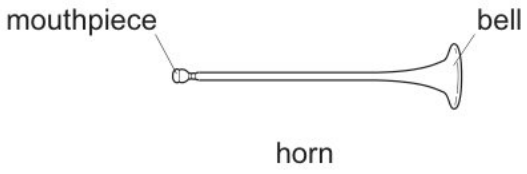
(c) (i) experiment consists of throwing a biased die 30 times and noting the number of 4 s obtained. This experiment was repeated many times and the average number of 4 s obtained in 30 throws was found to be 6.21.

the distribution function of X.

[6]

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

the value of σ.



[2]

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

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.

an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

[3]

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

the time taken for the ball to reach its maximum height

The weight of the plank is causing an anticlockwise moment.

[4]

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

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

[2]

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

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

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

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

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

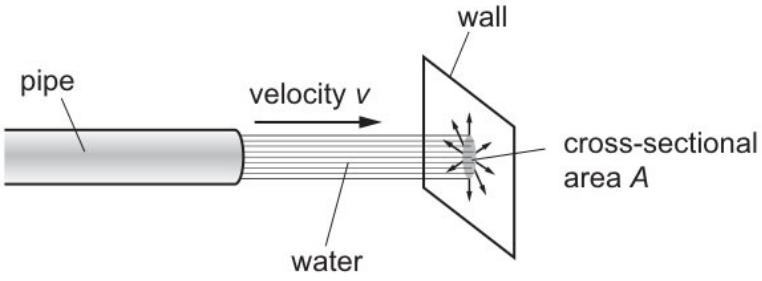
[6]

(iii) 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.

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]

(a) (ii) 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°.



[8]

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

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

[5]

12 400 nm to 700 nm

In the case where $k = 1$,

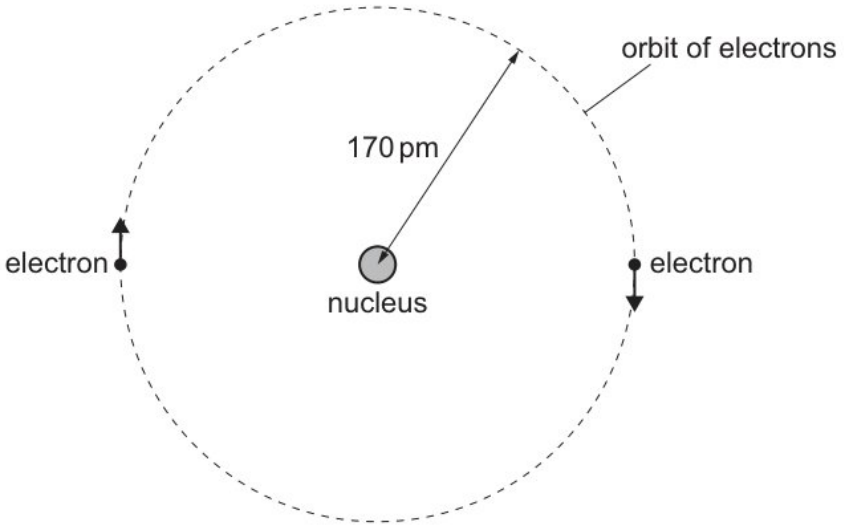
Explain why the observed wavelength and the emitted wavelength have different values.

(a) (i) displacement = velocity × time

is given that

[6]

(iv)



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

[6]

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

diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. 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 $y = 3$.

[3]

(iii)

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

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 .

are the amplitude and period of the wave?

[10]

(iv) specific latent heat.

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

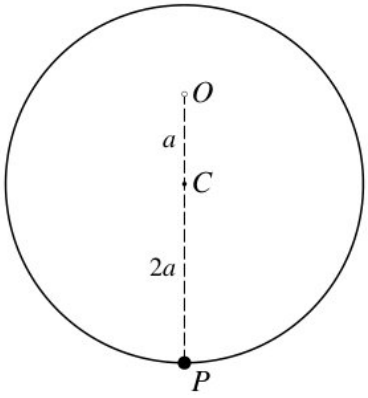
[6]

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

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.

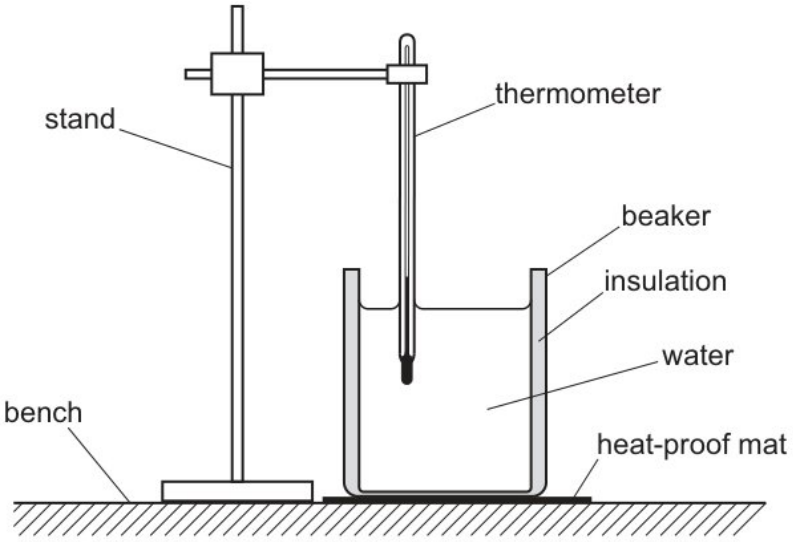
[10]

22 is the useful power output of the power station?



the kinetic model of gases and Newton's laws of motion to explain how a gas exerts a pressure on the sides of its container.

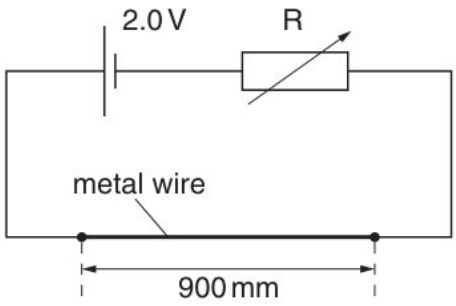
(a) (ii) Find the value of $(\beta + \gamma)(\gamma + \alpha)(\alpha + \beta)$.



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

[6]

(iii)



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

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

[1]

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

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

[4]

(iii)

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

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

[2]

(c) (i) Show that $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$.

by calculation that a lies between 2 and 2.1.

[5]

(iv) State one other feature of this orbit.

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

[3]

(iii) 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

the team contains more boys than girls.

[10]

(d) (iii) none of them

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

[10]

(iv) one similarity and one difference between an electron and positron.

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

[8]

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

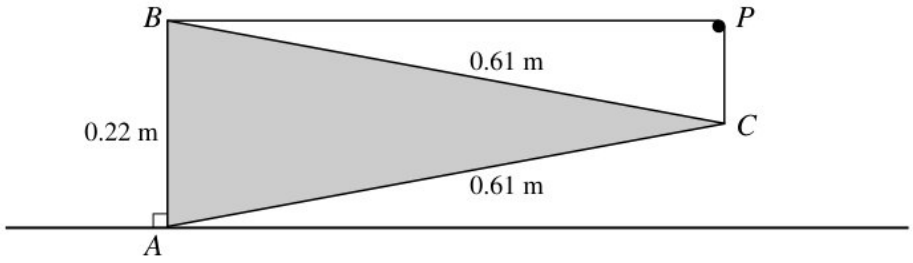
mean, $\bar{x}$, is 28.325 .

[5]

19 line l_2 has equation $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 5\mathbf{k} + \mu(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$.

the expected value and variance of Y.

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).



(c) (iv) the term interference.

beyond point S but before point T

[4]

(iii) For some nuclei, the nucleon number can be less than the proton number.

diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. 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 $y = 3$.

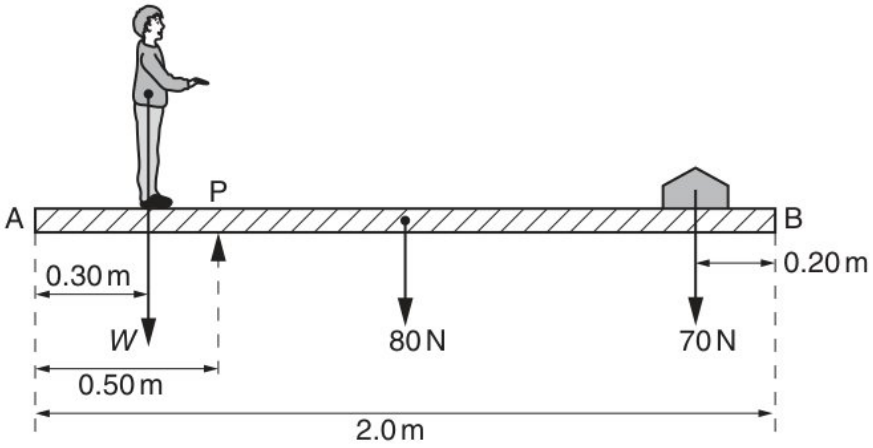
[5]

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

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

[10]

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



[6]

(d) (i) 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.

quantities would be measured in order to determine E ?

[5]

(iii) 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.

waves are emitted from two sources.

[5]

8 (i) car is accelerated by a constant resultant force of 300 N for 5.0 s .

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

$$x^2 \sin y + \cos 3y = 4$$

[8]

(f) the coordinates of any stationary points on C.

[5]

(iv) the tension in the string and the acceleration of the particles.

(c) 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.

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 .

[5]

(b) 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.

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

state the corresponding eigenvalue.

[4]

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

(b) 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.

[10]

(a) Show that the tension in the string is 10 N .

[4]

14 the speed of the aeroplane.

(b) (i) Show that $v^2 = u^2 + \frac{14}{5}ag$.

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

[5]

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

$$x = \ln(\tan t), \quad y = \sin^2 t,$$

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

smooth same = ... zz **[6]**

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

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.

[5]

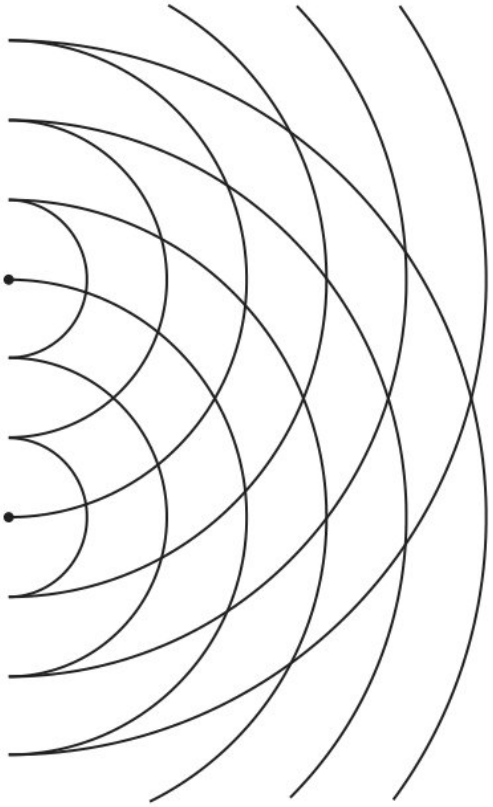
(a) (iii) It limits the precision of the measured value.

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

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

[10]

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



[2]

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

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

[5]

(f) (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.

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

[5]

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

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

[3]

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

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

Find the solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}$ of the form $\mathbf{x} = \begin{pmatrix} 4 \\ 9 \\ \alpha \\ \beta \end{pmatrix}$, where α and β are positive integers to be found.

(b) (iii)

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

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

[6]

(iv) specific latent heat.

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}.

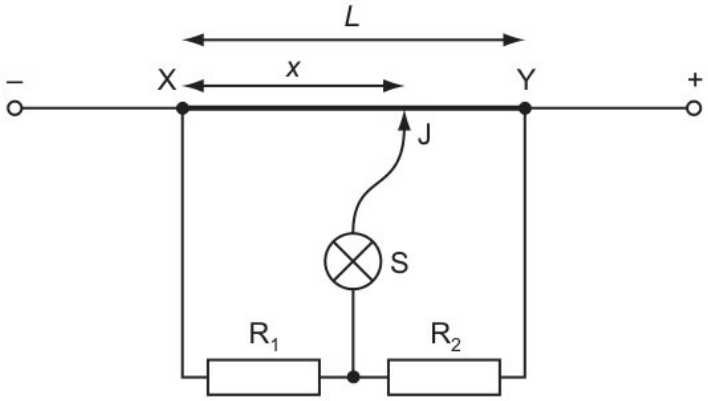
1.35 standard = ... hs **[5]**

(i) 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.

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 $\lambda\mu$.

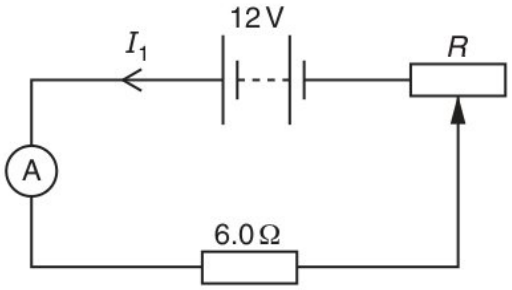
[5]

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



[12]

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



[6]

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

a, b and c are integers to be determined.

[3]

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

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

Saturday, 600 competitors took part. The times taken to complete the puzzle were normally distributed with mean 32.4 minutes and standard deviation 2.5 minutes.

[5]

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

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.

[6]

(ii)

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

It limits the range of values obtained in repeated measurements.

[3]

24 State one other feature of this orbit.

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

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

[2]

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

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

[15]

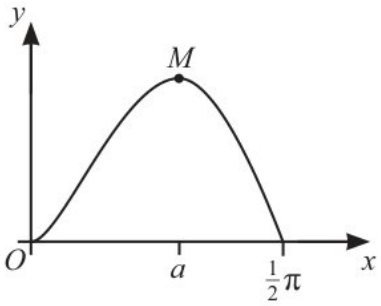
(ii) coil contains N turns of insulated copper wire wound on to a cylindrical iron core of diameter D. The copper wire has a diameter d. The resistivity of copper is ρ. Diameter D is much greater than diameter d.

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

Find the value of I_2.

[20]

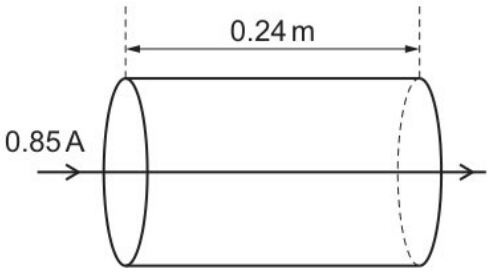
(d) (iii)



is now given that the true value of p is 0.05 .

[5]

(ii)



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

$$y = 0.46x + 1.62 \quad \text{and} \quad x = 0.93y + 8.24$$

[12]

(i) linear transformation $\text{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

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

[4]

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

only one of the following two alternatives.

[5]

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

Calculate the acute angle between the planes.

expression gives the value of $\frac{v}{u}$?

[4]

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

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

[6]

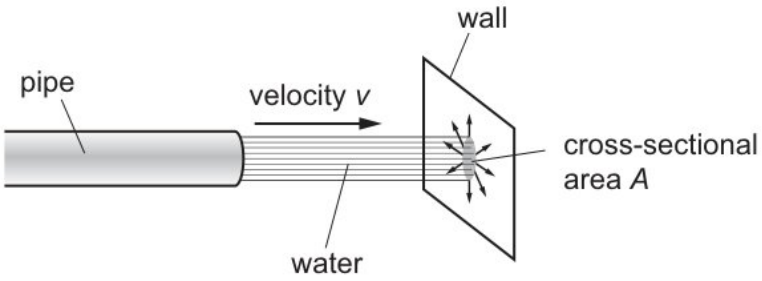
(a) (i) molecule of mass m travelling horizontally with velocity u hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.

Show how the expected value of 22.18 , for $x = 3$, is obtained and find the expected values for $x = 6$ and for $x \geqslant 7$.

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.

[8]

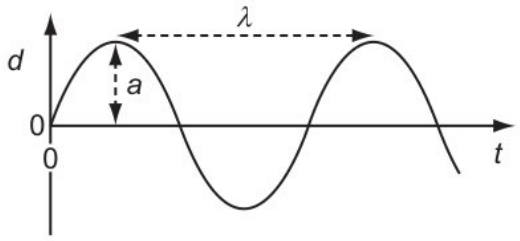
(vi)



Under 25 178 181 183 192 203 209 223 231

[1]

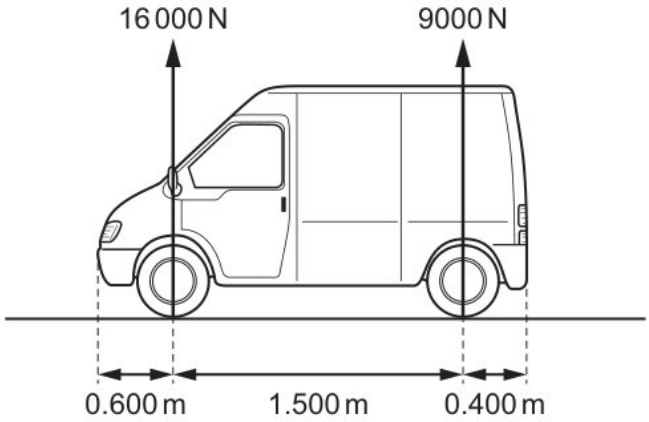
(ix)



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

[4]

(iv)



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.

Draw a fully labelled tree diagram to illustrate this situation.

[2]

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

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

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

[6]

(i) the coordinates of any stationary points on C

Calculate the speed of projection of P.

[5]

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

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

[1]

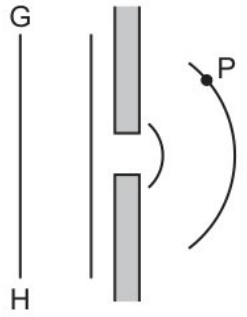
(d) (iii) the probability that fewer than 6 rolls of this dice are required to obtain an A .

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

[5]

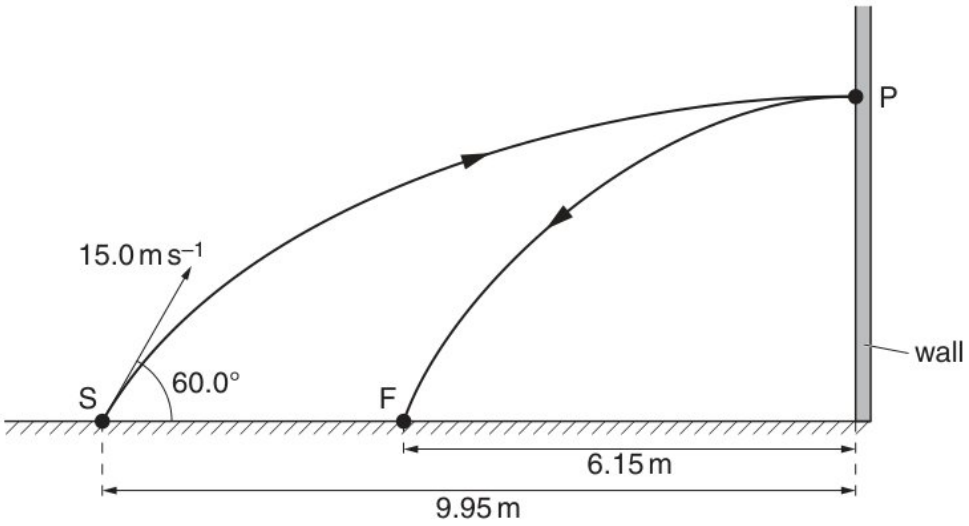
(ii) Find also the value of $\frac{1}{\alpha^2\beta^2} + \frac{1}{\beta^2\gamma^2} + \frac{1}{\gamma^2\alpha^2}$.

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.



[8]

(iv)



obtain the roots of the equation

[10]

(c) (iv) as shown in Fig. 2.1.

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

[6]

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

$$\mathbf{A} = \begin{pmatrix} \frac{3}{2} & 3 & 8 \\ 0 & 3 & 4 \\ 0 & 0 & -1 \end{pmatrix}.$$

[6]

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

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

[5]

(iii) the exact area of one loop of the curve.

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.

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

[6]

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

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

much energy is stored in the compressed column?

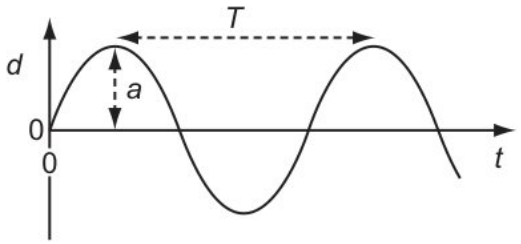
[5]

(v) the probability that a 3 is obtained for the second time before the 6th throw.

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

[4]

(b) (iii) Calculate the speed of the star relative to the Earth.



the exact value of a.

[5]

(i) the term isotope.

statement about the weight of the plank is correct?

wavelength of the wave and the width of the gap are both changed by a small amount.

[5]

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

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.

[6]

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

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

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

[1]

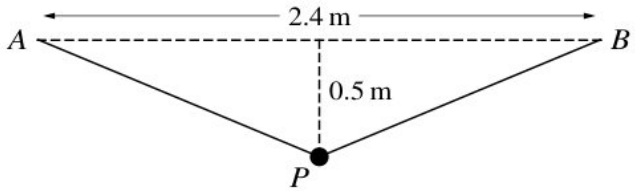
(iv) Use the trapezium rule with two intervals to find an approximation to the area of region A. Give your answer correct to 2 decimal places.

$$x^2 \sin y + \cos 3y = 4$$

the distribution function of X.

[10]

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



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

[20]

(c) (iv) activity of a radioactive sample.

waves are emitted from two sources.

[8]

(v) the acute angle between the directions of l_1 and l_2.

the equations of the asymptotes of C

[5]

(i) measurements to be taken,

the solution of the differential equation

[5]

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

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

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

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

[5]

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

diagram shows the curve $y = \sqrt{}\left(1 + x^3\right)$. 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 values of ωz_1 and ωz_2 Give your answers in the form $r\mathrm{e}^{\mathrm{i}\theta}$ where $r > 0$ and $-\pi < \theta \leqslant \pi$

[10]

(iii) coplanar forces of magnitudes 40 N, 30 N and X N act at a point in the directions shown in the diagram.

[10]

(ii) resistors of equal value are connected as shown.

Find the values of p and q such that

[5]

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

It limits the precision of the measured value.

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

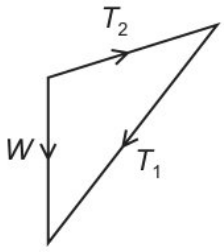
Find the coordinates of the point A on C at which $\frac{dy}{dx} = 0$ and $x \neq 0$.

[5]

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

[15]

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



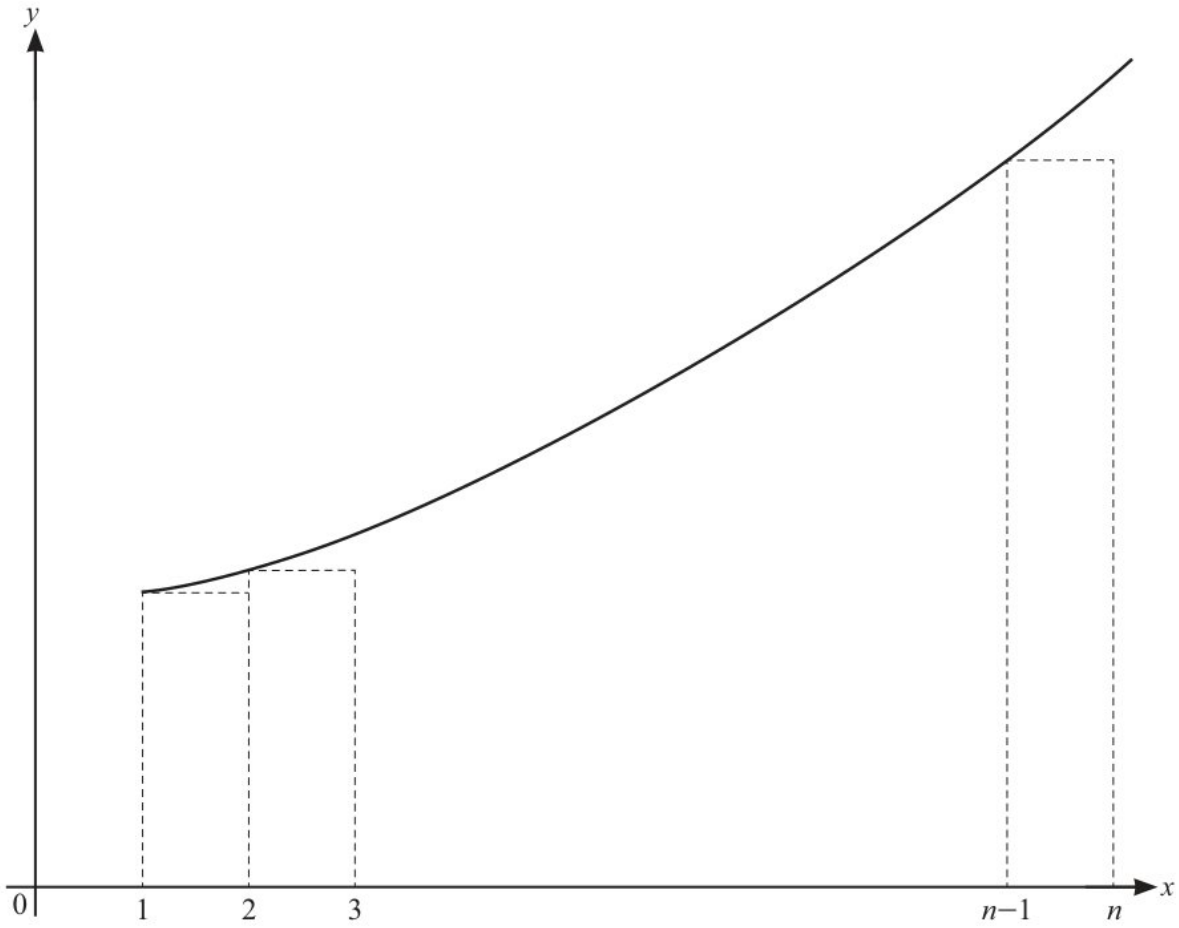
[10]

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

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?

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

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



[6]

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

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.

[5]

(ii) a positron and a neutrino

the vertical and horizontal components of velocity at time t.

[15]

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

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

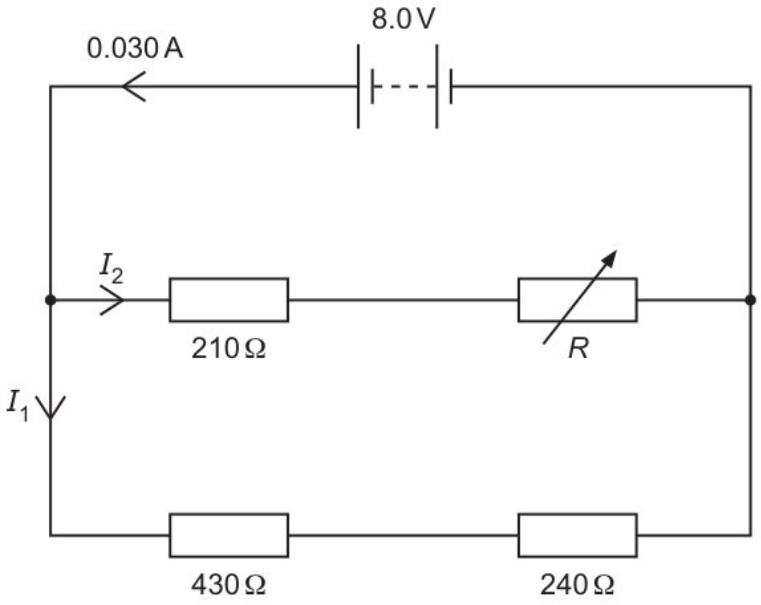
[3]

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

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

[5]

18 (c) Use the trapezium rule, with two intervals, to estimate the value of



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

[4]

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

[12]

(d) - falling freely with the parachute closed,

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

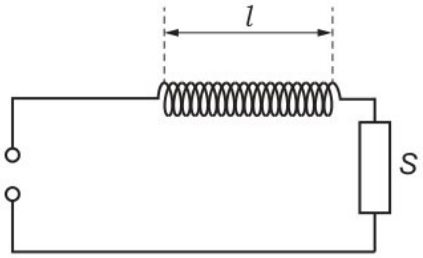
[6]

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

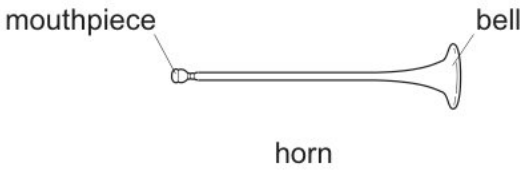
[8]

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

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



(d) (iii)



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

[4]

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

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 $\lambda\mu$.

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

[8]

(ii) is given that λ is an eigenvalue of the non-singular square matrix **A**, with corresponding eigenvector **e**.

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

[4]

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

diagram shows the curve $y = \sqrt{\left(1 + x^3\right)}$. 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 $y = 3$.

[5]

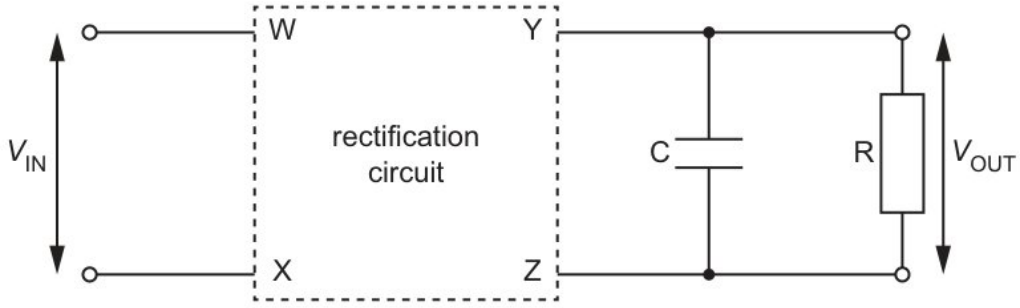
(i) that $y = 0$ when $x = 3$ Give your answer in an exact form

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.

State the equation of the other asymptote.

[15]

(ii)



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

[10]

(c) (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.

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

that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.

[5]

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

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

[10]

21 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.

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

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

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

(b) (ii) Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

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

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

[10]

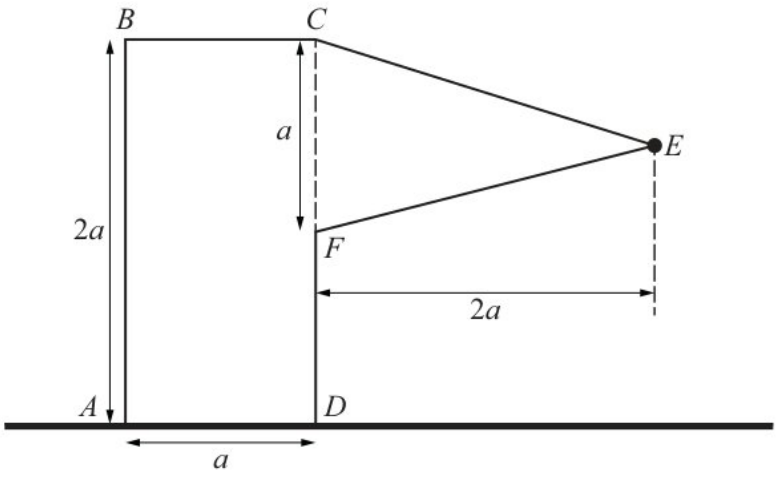
(iii) the nucleus of $^{238}_{92}$U absorbs a neutron, the nucleus decays, emitting an α-particle. State the proton number and nucleon number of the nucleus that is formed as a result of the emission of the α-particle.

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

$$T = \frac{\lambda}{l}(a - l).$$

[4]

(vi)



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.

[12]

(e) (iii) t time $t = 5.8$ s the speed of the car becomes constant

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

[2]

(v) sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

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

[5]

(c) (ii) point D is such that $ABCD$ is a parallelogram.

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

[10]

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

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

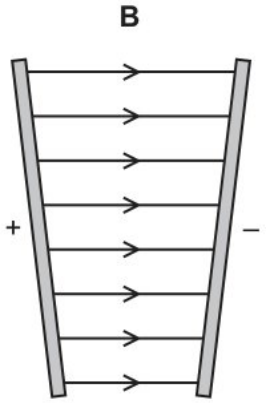
[4]

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

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

[6]

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



matrix **A** is given by

[3]

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

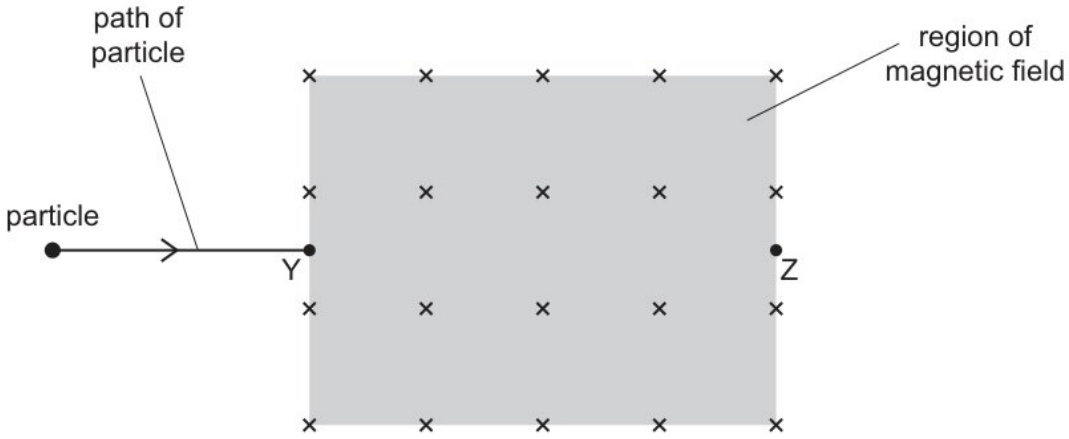
could M and N be?

[4]

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

circuit is set up as shown in Fig. 2.1.

(b) (vi) 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.



[2]

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

that l_1 and l_2 do not intersect.

[8]

(ix) car is accelerated by a constant resultant force of 300 N for 5.0 s .

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

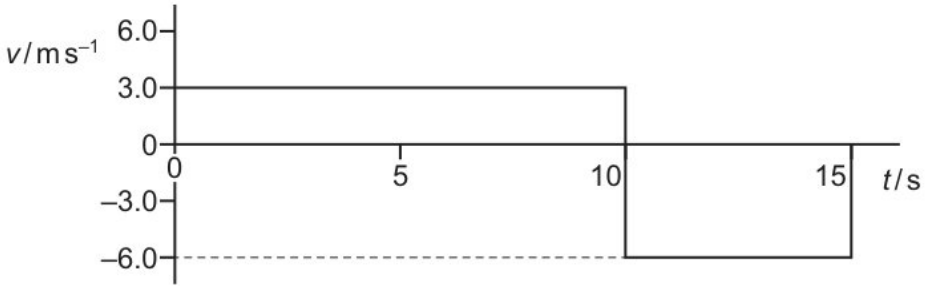
randomly = ... mq **[6]**

(c) (iv) spherical object falls through water at constant speed. Three forces act on the object.

the term interference.

[15]

(i)



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

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

[12]

(e) (iii) In some nuclear processes, mass-energy is not conserved.

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

[4]

(ii) the gradient of the curve

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

[4]

31 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.

are the amplitude and period of the wave?

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

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

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

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

[6]

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

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

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

[6]

(a) (ii) only one of the following two alternatives.

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

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

[3]

(iii) internal diameter of the beaker is 0.05 m ± 3%.

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

[12]

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

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

[3]

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

cubic polynomial p(x) is defined by

[10]

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

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

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

[3]

19 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 .

many images of the slit does he see?

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation

$\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

(a) (iv) Find the equations of the asymptotes of C.

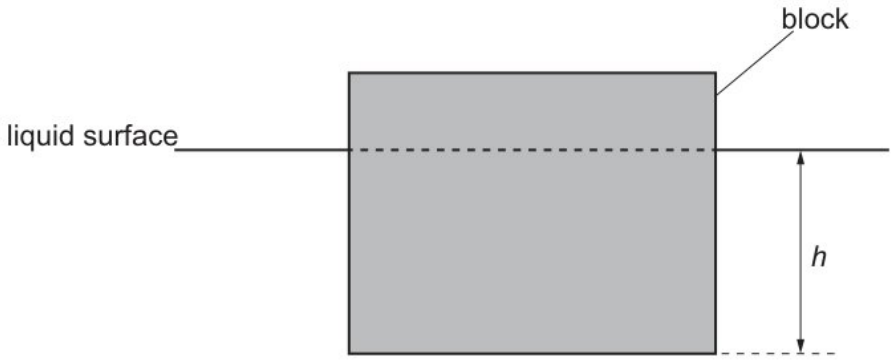
$$E_{\mathrm{K}} = \frac{1}{2}mv^2.$$

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

[4]

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

leptons are emitted from the sodium-21 nucleus during the decay?



[8]

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

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

[10]

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

sample contains a single radioactive isotope that decays to form a stable isotope.

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

[6]

(ii)

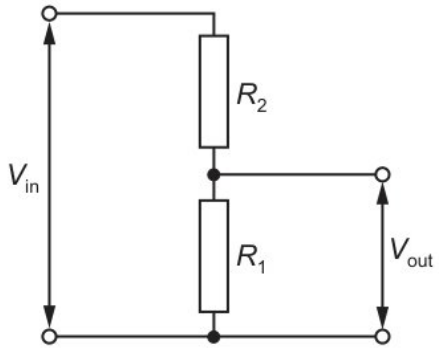
	momentum	kinetic energy
A	mv	$\frac{1}{4}mv^2$
B	mv	$\frac{1}{8}mv^2$
C	$2mv$	$\frac{1}{2}mv^2$
D	$2mv$	mv^2

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

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

[5]

(iii)



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]

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

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.

[5]

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

100 nm to 400 nm

[6]

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

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

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

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.

[5]

(iv) p and q are given real numbers, then

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

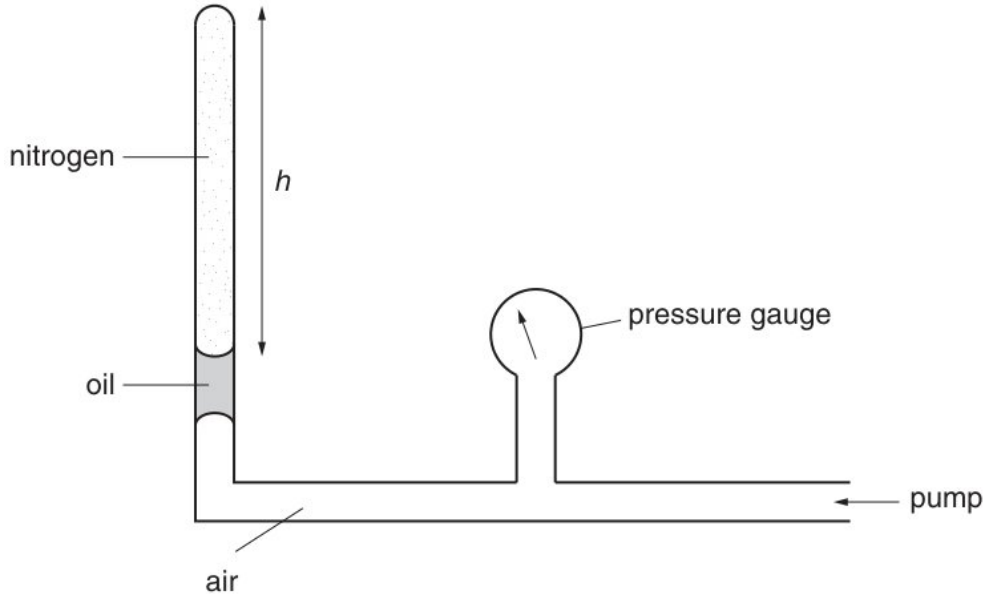
[12]

(f) (ii) Find the coordinates of any intersections with the coordinate axes.

statement about nuclei is correct?

[8]

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



[5]

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

the moment of a force about a point.

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

[3]

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

relationship is used in the derivation of the equation shown?

Find the x-coordinate of M.

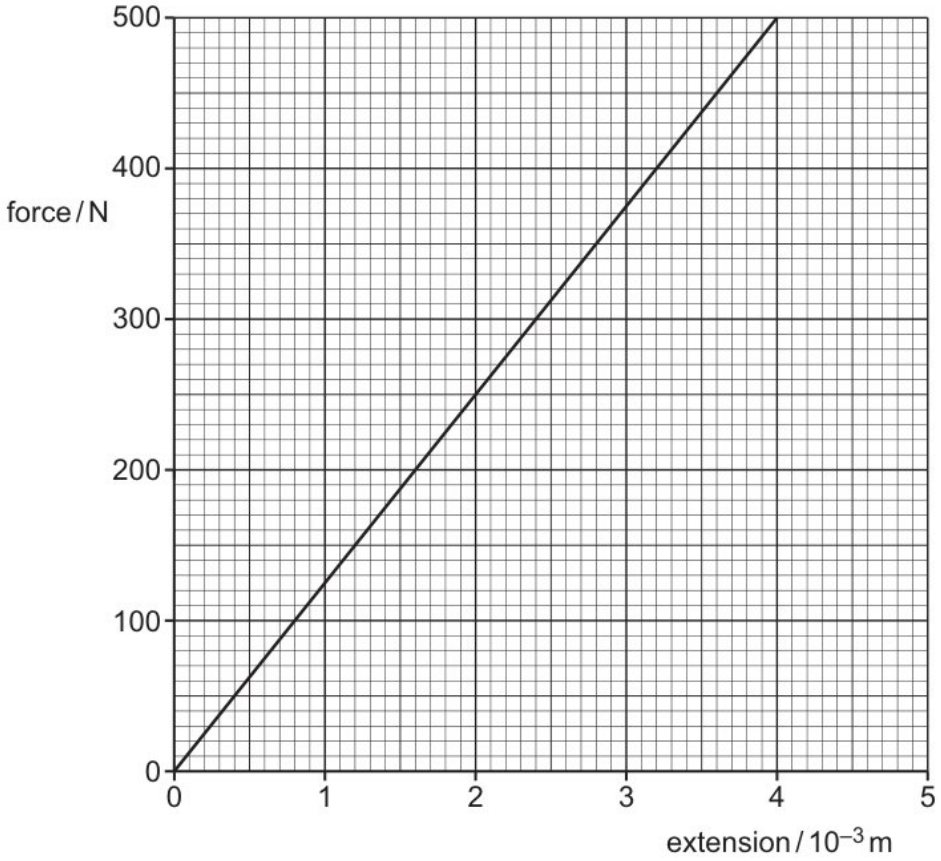
[2]

11 Show how the expected value of 22.18 , for $x = 3$, is obtained and find the expected values for $x = 6$ and for $x \geqslant 7$.

analysis of the data,

the distribution function of X.

(a) (v)



sample contains a single radioactive isotope that decays to form a stable isotope.

[5]

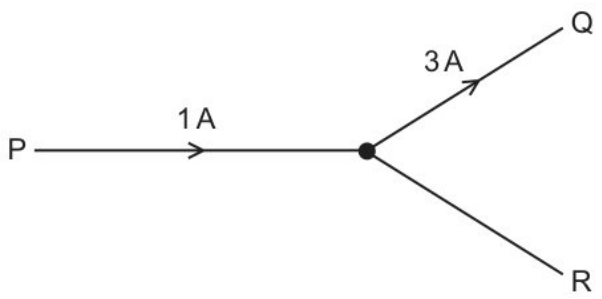
(iv) is the angle between the second-order maximum and the third-order maximum?

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

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

[2]

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



[8]

(d) (ii) what is meant by the de Broglie wavelength.

magnetic flux density.

is the minimum constant acceleration necessary for the aircraft?

[3]

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

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.

curve = ... *ii* **[6]**

(c) (ii) statement about light waves and sound waves is correct?

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

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

[5]

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

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.

[4]

12 variables x and y satisfy the differential equation

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

(b) (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 $\lambda\mu$.

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

[8]

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

only one of the following two alternatives.

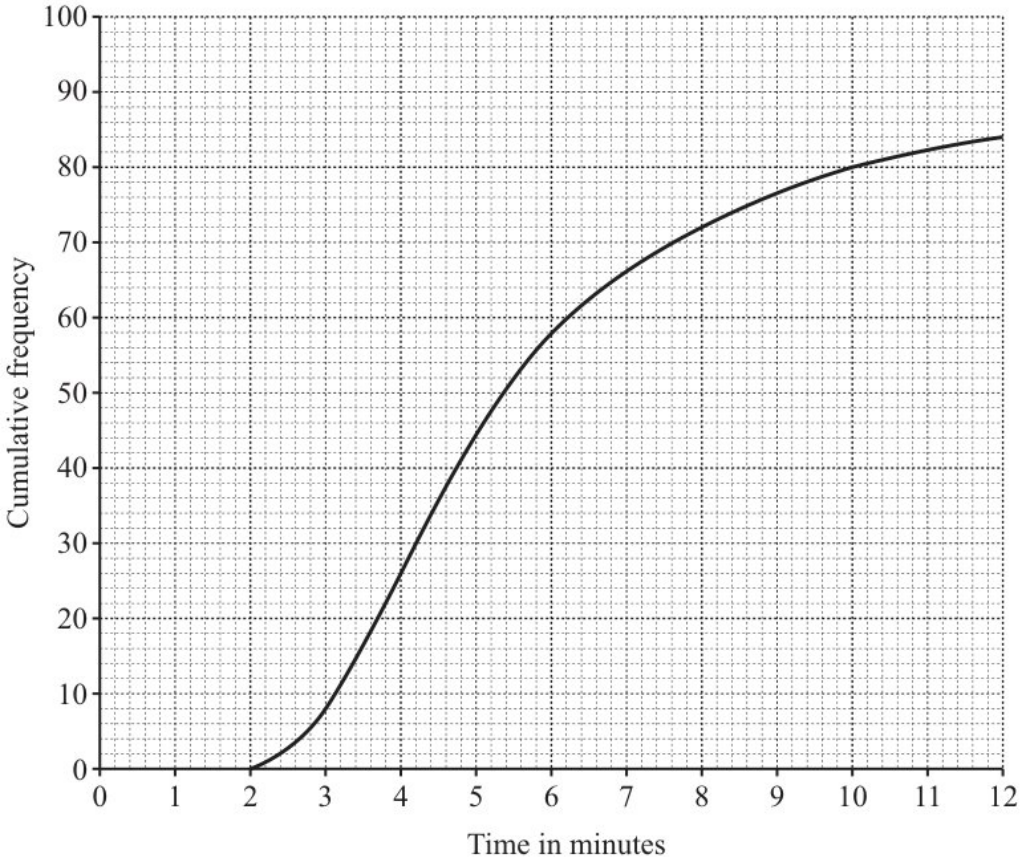
[3]

(d) (iii) Find the coordinates of A and M.

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

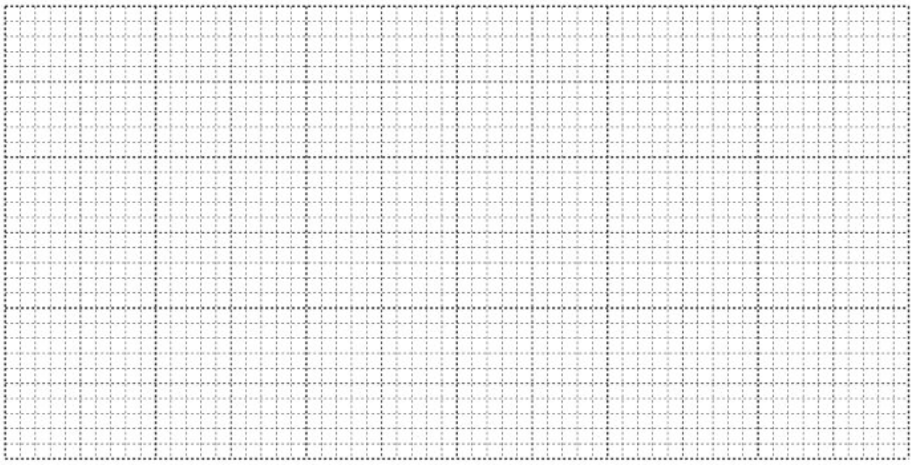
[8]

(ii) 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.



[3]

15 (c)



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

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

what is meant by the de Broglie wavelength.

[5]

(ii) parametric equations of a curve are

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

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]

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

[12]

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

(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.

[12]

(i) diagram, showing these three forces to scale, is correct?

[6]

(b) an unbiased estimate of $\mathrm{E}(T)$, and show that an unbiased estimate of $\mathrm{Var}(T)$ is 14.44.

(ii) only one of the following two alternatives.

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

Find the rate of working of the tension at this instant.

[3]

(i) a laboratory experiment to determine the absorption coefficient of glass. You should

[8]

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

(d) (ii) Find the equations of the asymptotes of C.

curve C has equation

box contains 6 identical-sized discs, of which 4 are blue and 2 are red. Discs are taken at random from the box in turn and not replaced. Let X be the number of discs taken, up to and including the first blue one.

[4]

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

is the grand-daughter product?

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

[5]

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

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

[8]

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

cable has tensions T_1 and T_2 as shown.

[6]

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

(b) (iii) safety precautions to be taken.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(\mathrm{e}^x \sin x\right) = 2^{\frac{1}{2}n}\mathrm{e}^x \sin\left(x + \frac{1}{4}n\pi\right)$$

[6]

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

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

[12]

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

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

[6]

(i) diagram shows two waves R and S.

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Observed frequency	4	9	18	26	20	16	7	0
Expected frequency	3.88	12.60	20.48	22.18	18.02	11.72		

[6]

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

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

[8]

(e) (iii) 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.

many electrons pass a point in the conductor in one minute?

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

[5]

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

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?

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

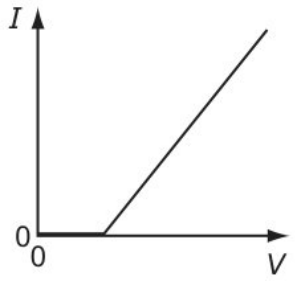
[15]

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

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

[4]

(ii) 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.



Find the standard deviation of x.

[2]

(vi) the expected value and variance of Y.

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

[10]

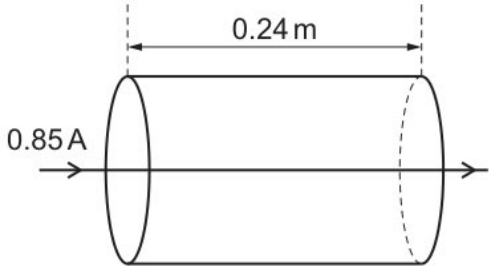
14 Determine the decay constant, in min^{-1}, of the radioactive isotope.

(b) (ii) the rank of the matrix

Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0° < \theta < 180°$.

[10]

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



[5]

(iii) 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'.

Find the mean age of all 19 people.

[10]

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

which direction does the droplet accelerate, and which change needs to be made to the separation of the plates in order to stop this acceleration?

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.

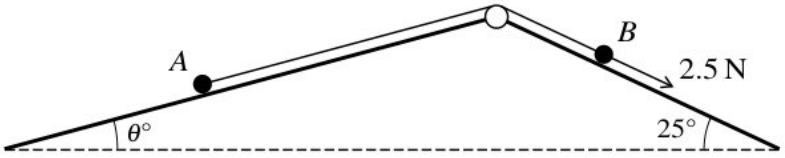
[10]

(v) marks of the pupils in a certain class in a History examination are as follows.

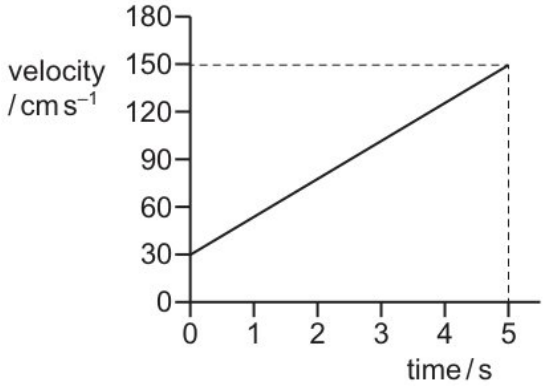
the other root and hence find the values of b and c.

[10]

(ii)



flows out of a pipe and hits a wall.



[5]

(d) (iii) has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.

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 $\lambda\mu$.

probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

[5]

(vi) Velocity is proportional to wavelength.

circuit is set up as shown in Fig. 2.1.

[4]

(i) is given that a is a positive constant such that

the gradient of the curve

[8]

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

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

(c) (iii) is given that $y = \frac{1}{12}\pi$ when $x = \frac{1}{2}\pi$.

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 $\lambda\mu$.

[6]

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

none of them

[12]

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

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

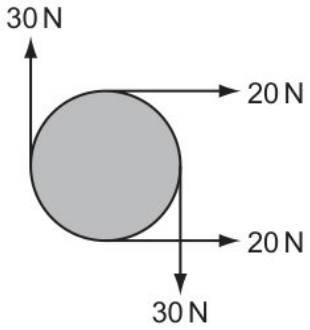
[5]

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

procedure to be followed,

[5]

(e) (ii)



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

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.

[3]

(iii) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

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

[6]

(d) (iv) When the tensile force is removed, the wire does not return to its original length.

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.

[8]

(i) When the tensile force is removed, the wire does not return to its original length.

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.

[4]

(a) (iii) 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.

Find the area of the triangle ABC.

[5]

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

the term elastic limit.

[4]

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

Find the rate of working of the tension at this instant.

[6]

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

Show that if

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

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.

[6]

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

Find the value of x.

[5]

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

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

[8]

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

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

[10]

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

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

Find the product moment correlation coefficient for the data.

[4]

(iii) 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.

Find the probability density function of Y.

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

[8]

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

V remains the same because the decrease of p.d. across r is balanced by the increase of p.d. across R.

[8]

(b) (vi) a laboratory experiment to determine the absorption coefficient of glass. You should

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

obtain the roots of the equation

[2]

(v) Find the modulus and argument of u.

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

[6]

9 Q hears a sound of decreasing frequency.

(a) (iv) 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.

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).

Show that the tension in the string is 10 N .

[12]

(i) Calculate the acute angle between the planes p and q.

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

[4]

(ii)

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

[4]

(b) (ii) 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.

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

[6]

(iv) 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.

Find the exact coordinates of this point.

a basis for the null space of T .

[6]

(v) the period of small oscillations,

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

[12]

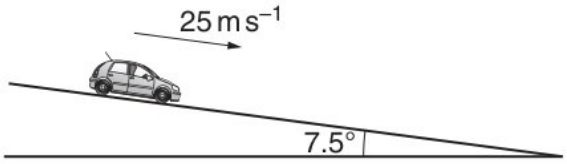
(c) (ii) sample of an ideal gas at thermodynamic temperature T has internal energy U.

is the minimum constant acceleration necessary for the aircraft?

the sum to infinity of the progression.

[3]

(iii)



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

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

[6]

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

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 $\lambda\mu$.

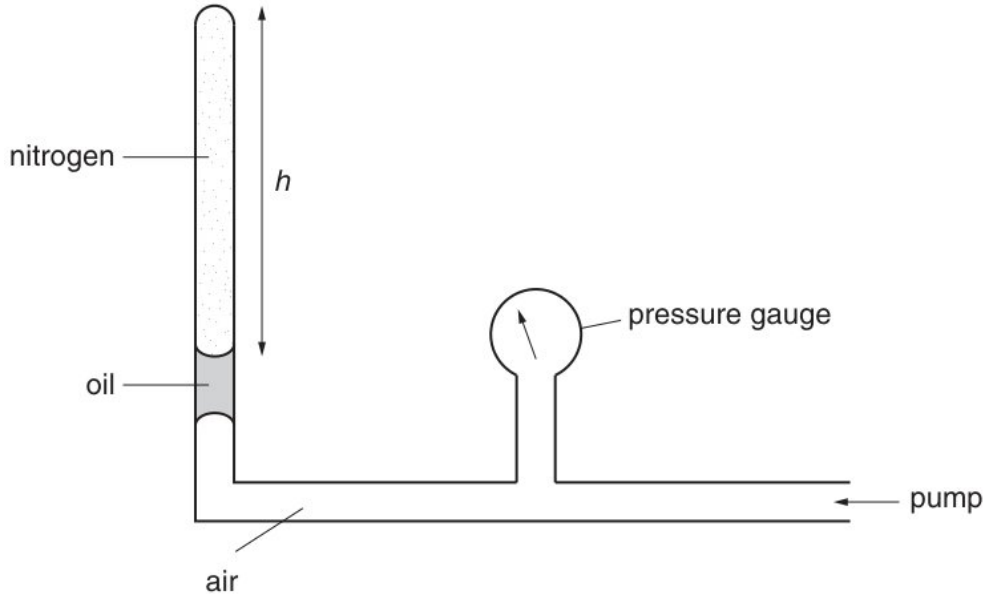
[10]

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

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.

[6]

(e) (ii)



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

[4]

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

Find the solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 7 \\ 18 \\ -7 \end{pmatrix}$ of the form $\mathbf{x} = \begin{pmatrix} 4 \\ 9 \\ \alpha \\ \beta \end{pmatrix}$, where α and β are positive integers to be found.

[4]

19 an expression for $\tan\theta$ in terms of e.

box contains 6 identical-sized discs, of which 4 are blue and 2 are red. Discs are taken at random from the box in turn and not replaced. Let X be the number of discs taken, up to and including the first blue one.

Q always hears a sound of higher frequency than person P .

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

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

[5]

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

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

[5]

(b) (iii) Find the acceleration of the particle during the first 5 seconds of motion.

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

[20]

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

Find the value of I_2.

[6]

(ii) Find the coordinates of the turning points of C.

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

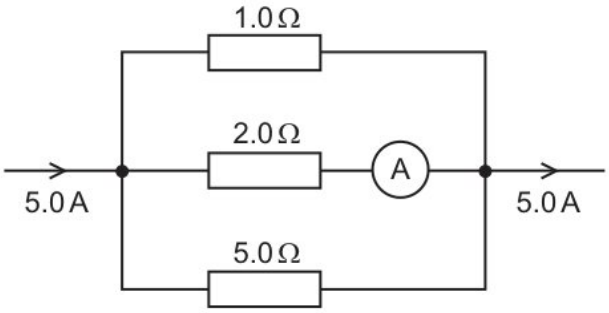
[2]

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

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

[6]

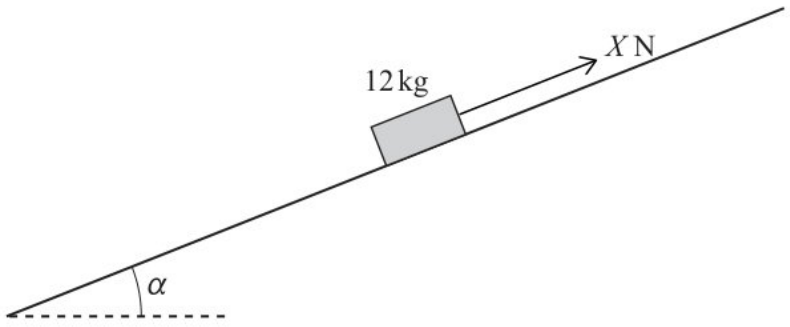
(d) (i)



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

[4]

(iii)



anywhere between point R and point S

[10]

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

$$g(t) = \begin{cases} \frac{1}{2}\cos t & -\frac{1}{2}\pi \leqslant t \leqslant \frac{1}{2}\pi \\ 0 & \text{otherwise} \end{cases}$$

[6]

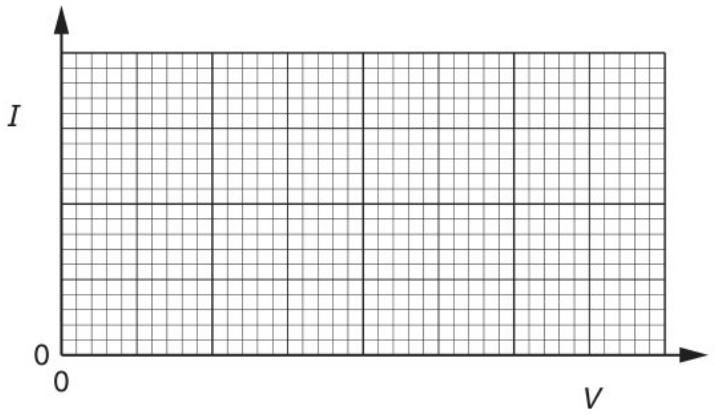
16 much energy is stored in the compressed column?

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

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]

(v)



that $k = 3$ and $p = 26$.

the average output power of the car during this time

[5]

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

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 .

[6]

(a) (ii) m.f. for $n = 0$.

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

[8]

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

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

[8]

18 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

Q always hears a sound of higher frequency than person P .

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

the period of small oscillations,

[5]

(ii)

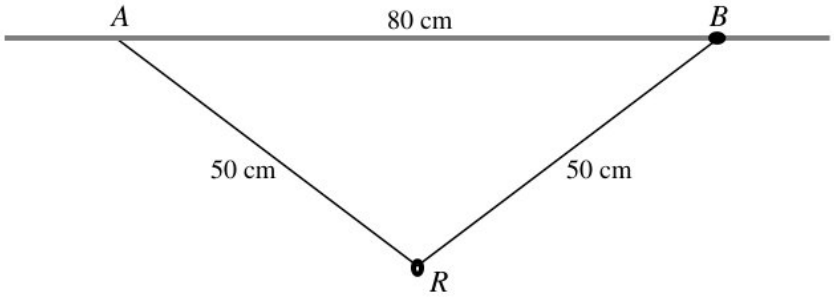
Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

diagram shows part of the curve $y = 4\sqrt{x} - x$. The curve has a maximum point at M and meets the x-axis at O and A.

curve C has equation

[12]

(e) (i)



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

value = ... ri **[6]**

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

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.

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

[5]

(iii) fair six-sided dice with faces labelled $1, 2, 3, 4, 5, 6$ is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X.

$$\begin{aligned} \frac{3}{2}x + 3y + 8z &= 1, \\ ax + 3y + 4z &= 2, \\ ay - z &= 3, \end{aligned}$$

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

[4]

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

$$x^3 + px^2 + qx + r = 0$$

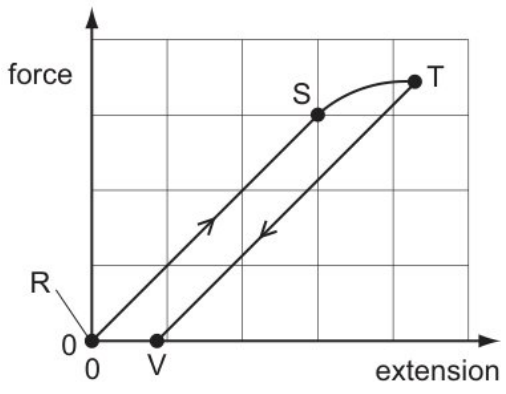
[5]

(i) displacement = velocity × time

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

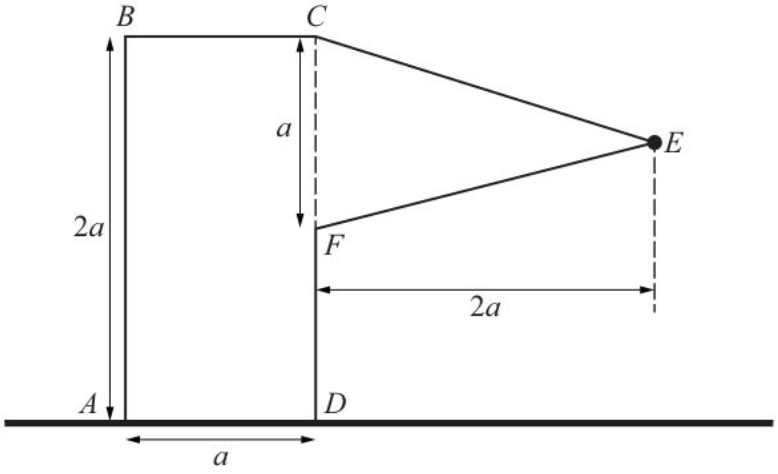
[2]

(f) (iii) the probability of a Type I error.



[8]

(i)



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

[3]

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

the term ultimate tensile stress.

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

The waves must not be polarised.

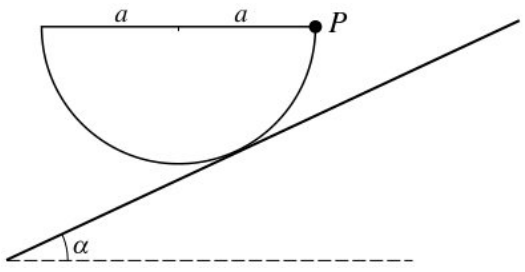
[4]

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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted

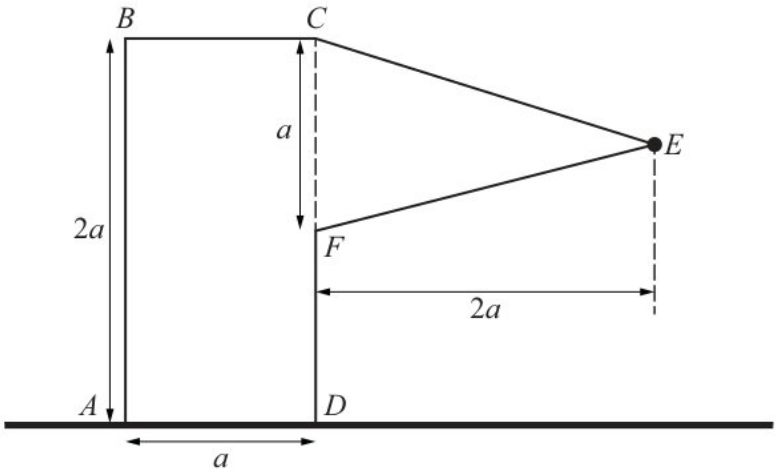
[4]

(i) if there are no restrictions,



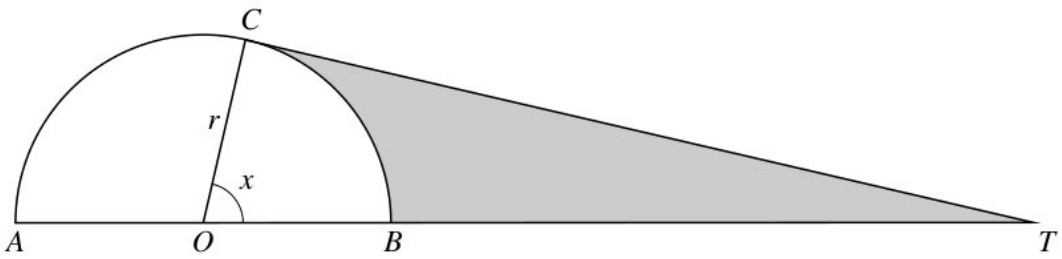
[6]

(c) (i) that $\tan\theta = \frac{4}{3}$, find ω in terms of a and g.



[6]

(iii)



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

[4]

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

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

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

[5]

21 that the forces are in equilibrium, find the values of θ and X.

lamina is freely suspended at A and hangs in equilibrium.

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

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

[4]

(ii)

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

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

[6]

(i) 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.

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.

sample contains a single radioactive isotope that decays to form a stable isotope.

[10]

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

- coming to rest instantaneously on hitting the ground.

[6]

(a) (iv) statement is correct?

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

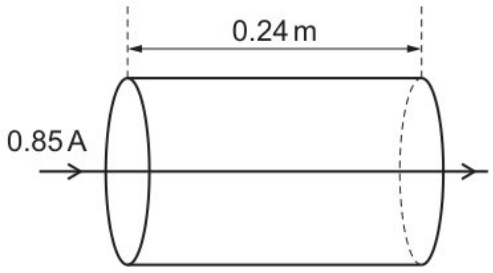
[10]

(v) moment of a force.

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

[1]

(e) (v)



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

[5]

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

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

[5]

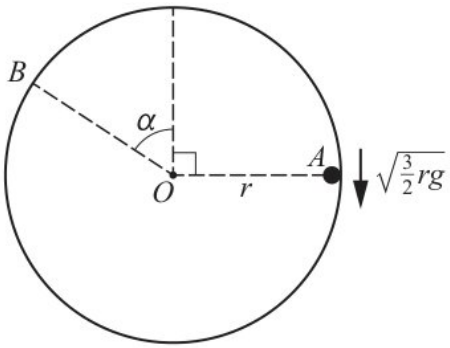
(b) (iv) Show that $\frac{\mathrm{d}s}{\mathrm{d}x} = \frac{1}{2}(\mathrm{e}^x + \mathrm{e}^{-x})$, where s denotes the arc length of C, and find the surface area generated when C is rotated through 2π radians about the x-axis.

is the force exerted on the wall by the water?

[12]

(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.

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}.



[8]

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

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

this compression, work W is done on the gas.

[6]

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

the value of n.

Hence solve the equation

[6]

(iii) 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.

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

[4]

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

(a) (i) is the efficiency of the process?

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

[5]

(iv) to the value α.

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

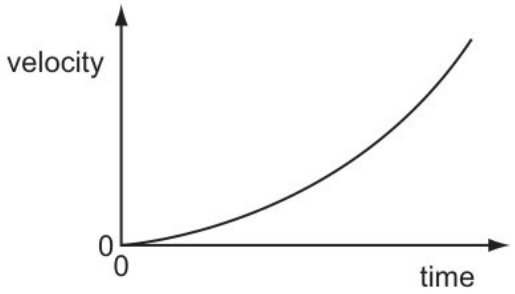
[4]

(ii) measuring instrument should be used?

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

[5]

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



[8]

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

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

[4]

(vi) projectile is thrown at an angle to the ground.

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

[3]

16 (e) is given that $\mu = 0.15$ and $X = 20$.

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

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

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

many images of the slit does he see?

[8]

(ii) Find the frictional and normal components of the contact force acting on B.

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

[3]

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

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

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

the moment of a force about a point.

through = ... pv **[6]**

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

arrive = ... ey **[3]**

(b) Find the values of p and q.

(i) the geometric effects of multiplying z_1 and z_2 by ω

[4]

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

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

[5]

23 supermarket is open 7 days a week.

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.

(a) (ii) 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.

statement about nuclei is correct?

the sum to infinity of the progression.

[10]

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

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

[3]

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

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

[12]

(i) lengths of 250 leaves of a certain type of plant are measured, correct to the nearest centimetre. The results are summarised in the table below.

It limits the precision of the measured value.

[8]

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

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

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

student is investigating how a volume of nitrogen gas is affected by the pressure exerted

[3]

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

In the case where $k = 2$,

wavelength of the wave and the width of the gap are both changed by a small amount.

[8]

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

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.

[8]

(b) (i) lamina is freely suspended at A and hangs in equilibrium.

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

[10]

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

only one of the following two alternatives.

[6]

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

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

[6]

(d) (i) state an eigenvector of the matrix $\mathbf{CD}$ and give the corresponding eigenvalue.

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

[10]

(iii) block is released from rest at the top of a slope inclined at an angle to the horizontal. The slope has length L as shown in the diagram.

$$T = \frac{\lambda}{l}(a - l).$$

[8]

22 striking the horizontal plane, P rebounds with speed w. The coefficient of restitution between P and the plane is $\frac{2}{3}$.

(a) (iii) a certain time, the projectile has a horizontal velocity of 23.0 ms^{-1} and a vertical velocity of -10.1 m s^{-1}.

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

[6]

(v) Potential difference is energy per unit current.

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).

[15]

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

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

[5]

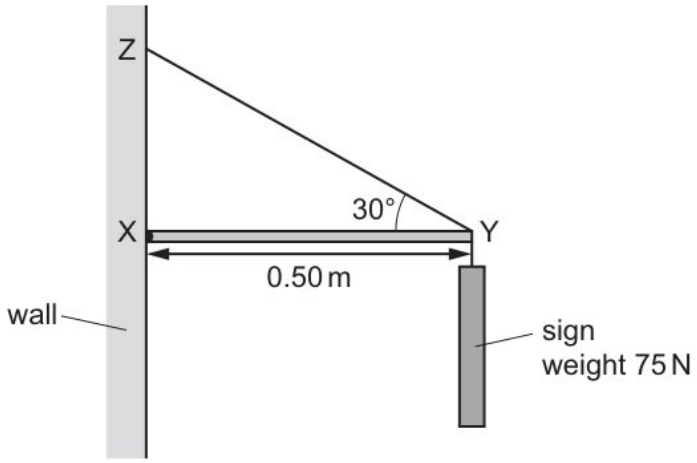
(iii) linear transformation $\text{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

the coordinates of any stationary points on C

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

[5]

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



[3]

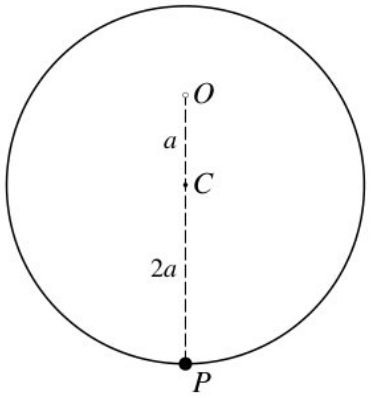
(b) (ii) Find the area of the triangle ABC.

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

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

[1]

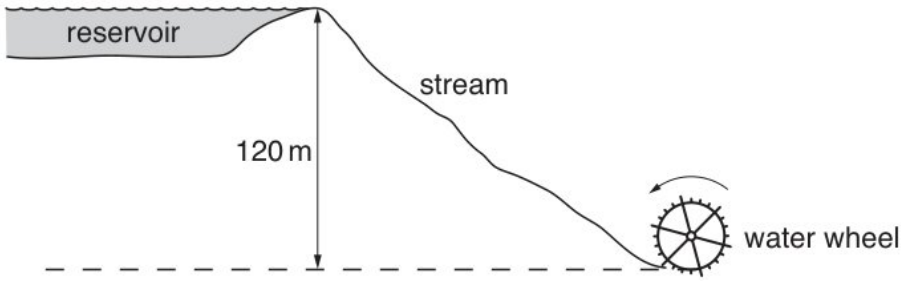
(iii)



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

[3]

(d) (iii) 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}.



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

[6]

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

lamina is freely suspended at A and hangs in equilibrium.

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]

(ii) waves are emitted from two sources.

the gradient of the curve

[8]

13 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 .

(a) (ii) 100 nm to 400 nm

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

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 .

[8]

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

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

[8]

(d) (iii) P and Q collide and stick together.

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

[4]

(iv)

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

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

[10]

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

diagram illustrates successive wavefronts.

[12]

(i) 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.

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

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

[8]

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

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.

[15]

(ii) the past, the population mean time was 62.4 seconds.

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

[4]

11 Find the modulus and argument of u.

points A, B, C have position vectors

(c) (i) your answer correct to 2 decimal places.

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

Find the value of x.

[4]

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

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

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

[12]

(b) (ii) Show that $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$.

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

[8]

(iii) a set of 40 values of x, it is found that

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

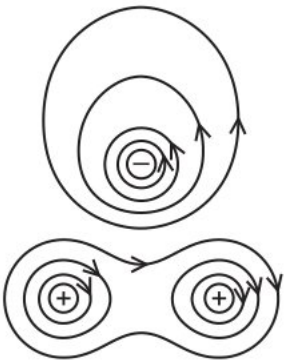
[8]

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

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

[4]

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



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

athlete coach = ... ka **[5]**

(i) diffraction grating with 500 lines per mm is used to observe diffraction of monochromatic light of wavelength 600 nm .

as shown in Fig. 2.1.

[4]

15 Show that if

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

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

block of mass 12 kg is placed on a rough plane inclined at an angle of α to the horizontal, where $\alpha = \tan^{-1} 0.5$. A force of X N is applied to the block, directly up the plane (see diagram). The coefficient of friction between the block and the plane is μ.

[5]

(vii) is suggested that the e.m.f. V is related to the number n of glass sheets by the equation

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?

parametric equations of a curve are

[4]

(i) only one of the following two alternatives.

	weight/N	mass/kg
A	9.85	1.00
B	9.85	6.00
C	58.9	1.00
D	58.9	6.00

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

[5]

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

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

[6]

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

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

[8]

11 only one of the following two alternatives.

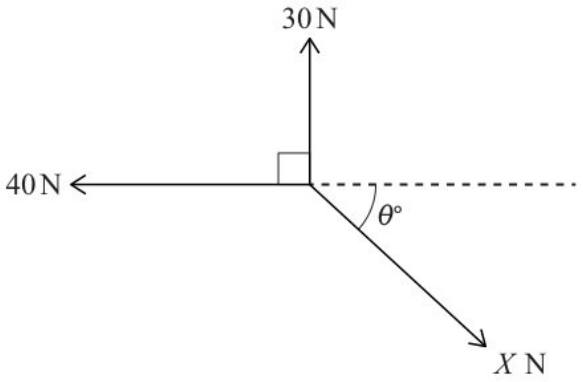
(d) (i) the solution of the differential equation

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

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

[4]

(ii)



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

[5]

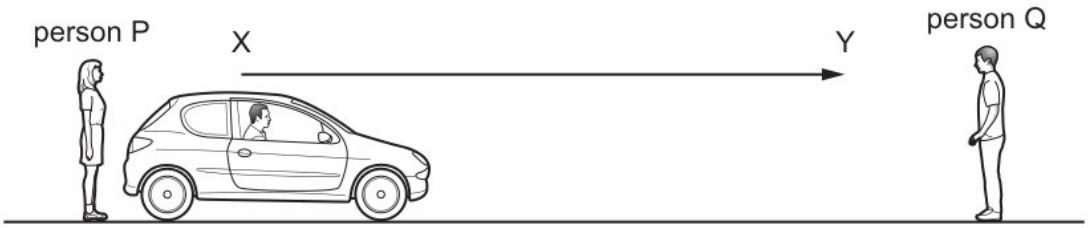
(iii) to the origin O, the position vectors of the points A, B and C are given by

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 .

[6]

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

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.



[5]

(a) (iii)

A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

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.

combination of changes must increase the amount of spreading due to diffraction?

[5]

(i) 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).

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

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

[5]

14 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.

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

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

[6]

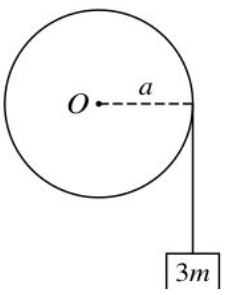
(d) the lowest note produced by a horn, a node is formed at the mouthpiece and the antinode is formed at the bell. The frequency of this note is 75 Hz .

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

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

[15]

(iii) (b) p and q are given real numbers, then



[12]

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

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

is the force on an electron when it is in the uniform electric field between the plates?

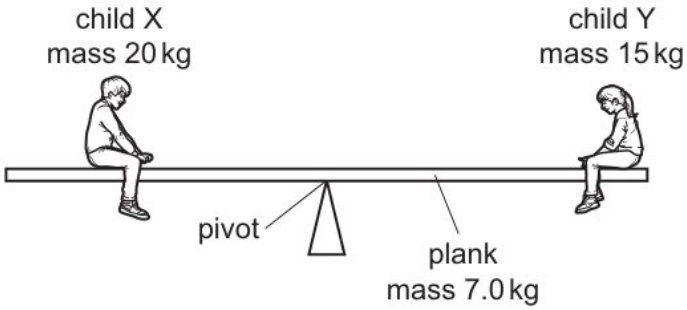
[8]

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

the torque of a couple.

[8]

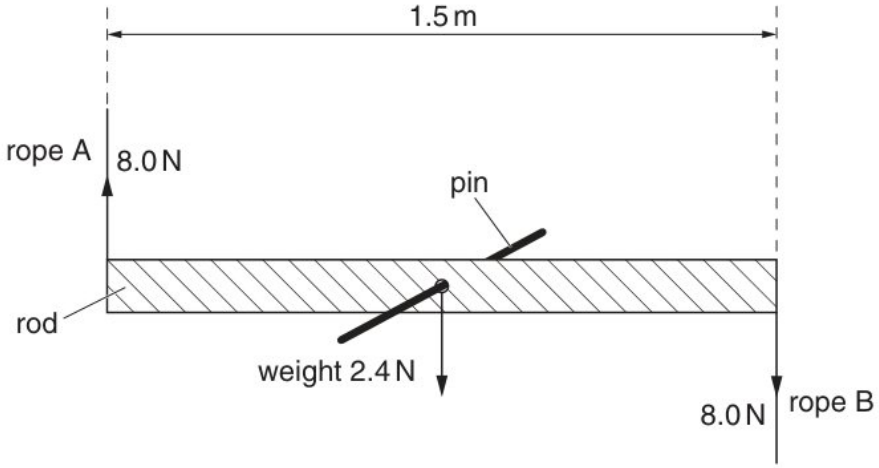
(i) (b)



by calculation that $0.9 < a < 0.95$.

[6]

(f)

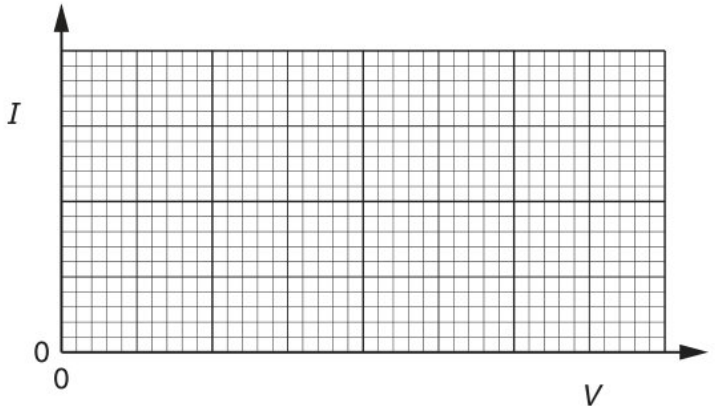


The same force is used to change the speed of the car from 30 ms^{-1} to 45 ms^{-1}. Explain why the distance moved is not the same as that calculated in (i).

[6]

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

(iv) The weight of the plank is causing an anticlockwise moment.

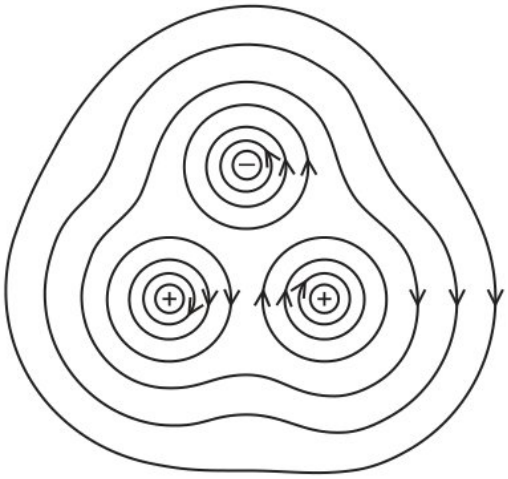


[6]

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

[3]

(d)



by calculation that a lies between 2 and 2.1.

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

[2]

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

[5]

(ii) Find the rate of working of the tension at this instant.

[4]

(b) Its speed decreases to a value greater than zero, then increases to a value greater than 20 ms^{-1}.

(ii) Find the perpendicular distance of the point A from the line BC.

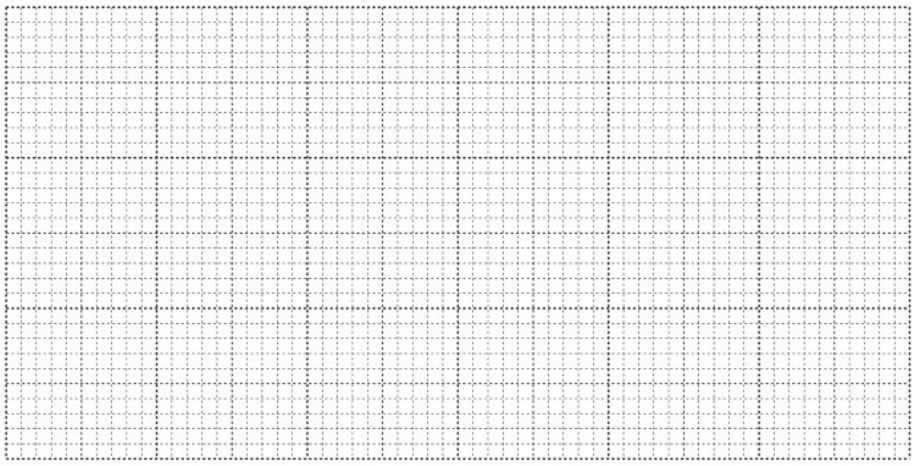
[5]

(iv) polarised beam of light with intensity I is incident normally on a polarising filter.

[8]

(c) the data to carry out a goodness of fit test at the 5% significance level to test the scientist's claim.

(iii) t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the
Find the area of the sector of C between $\theta = 0$ and $\theta = \frac{1}{3}\pi$.



[10]

(v) Show that $v\frac{\mathrm{d}v}{\mathrm{d}x} = 5 - 0.5v^2$.
amplitude $\propto \sqrt{\text{intensity}}$

[4]

29 how the pattern of interfering waves may be observed.
throws three coins at the same time.
Different isotopic nuclei have different proton numbers.

(c) (iii) shop sign weighing 75 N hangs from a frame attached to a vertical wall.
is the grand-daughter product?

[6]

(i) that the greatest height of B above the ground is 1.2 m , find the value of x.
is the speed of the projectile at this time?

[3]

(d) (v) measuring instrument should be used?

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.

Find the area of the region enclosed by C.

[4]

(iii) a group of 20 musicians, there are 9 guitarists, 6 pianists and 5 drummers.

Find the rank of **A** and a basis for the null space of T .

[8]

(i) is the value of the ratio $\frac{V_1}{V_2}$?

There will always be 9.0 V across the battery terminals.

[6]

(b) (i) random variable Z is the sum of the number of red balls and the number of different colours present in Kieran's selection. Kieran claims that the probability generating function of Z is equal to $\mathrm{G}_X(t) \times \mathrm{G}_Y(t)$.

Show that the deceleration of the car with the brakes applied is 4.1 m s^{-2}.

your graph to find an estimate for k.

[5]

(vi) object is fully submerged in a liquid.

Find the interquartile range of X.

[12]

(iii) by mathematical induction that, for all positive integers n,

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}.

[6]

13 sample of an ideal gas at thermodynamic temperature T has internal energy U.

thermistor is connected to a cell with negligible internal resistance.

(b) (iv) The power to X will increase and the powers to Y and Z will remain unaltered.

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.

[5]

(iii) a, b and c are constants, has two asymptotes. It is given that $y = 2x - 5$ is one of these asymptotes.

the exact value of $\mathrm{cosec}^2 15° - \sec^2 15°$.

gravitational potential at a point.

[4]

(a) (v) uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

the distribution function of X.

Speed is distance travelled per second.

[2]

(i) 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.

$$I_3 = \frac{3}{1024}\pi + \frac{1}{128}$$

students are selected at random from the students who study Science.

[10]

(d) (i) your answer correct to 2 decimal places.

the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

the general solution of the differential equation

[3]

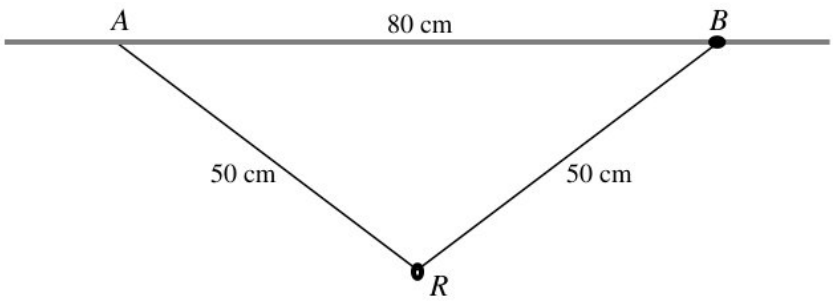
(ii) uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

[1]

(iii) It results in the measured value being different from the correct value.

Given also that C has a turning point when $x = 2$, find the value of c.



[15]

(iv) gas is then cooled at constant volume so that its temperature decreases to $2T$.

with a reason, whether you agree with Nikki's friend.

[6]

16 tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

(a) (ii) random sample of twelve pairs of values of x and y is taken from a bivariate distribution. The equations of the regression lines of y on x and of x on y are respectively

diagram shows part of the curve

the acute angle between the directions of l_1 and l_2.

[6]

(i) the surface area generated when C is rotated through 2π radians about the x-axis.

the probability density function of Y,

[6]

(iii) 191.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3}.

$I_n = \int_0^1 x^n(1-x)^{\frac{1}{2}}\,\mathrm{d}x$, for $n \geqslant 0$. Show that, for $n \geqslant 1$,

[4]

(b) (iii) a value, to three significant figures, for the specific latent heat of fusion of water.

Show that x satisfies the equation

Find the least tension in the string during the motion.

each = ... re **[12]**

(vii) a cartesian equation of the plane Π containing l_1 and l_2.

the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

[6]

(iv) has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.

Show that $\frac{\mathrm{d}^{n+1}}{\mathrm{d}x^{n+1}}\left(x^{n+1}\ln x\right) = \frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n + (n+1)x^n \ln x\right)$.

[8]

(c)(vii)

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave **x** = not a property of an electromagnetic wave
A	✓	χ	✓	
B	✓	χ	×	
C	×	✓	✓	
D	×	✓	×	

researcher records the time, T seconds, taken by adults to complete a questionnaire.

[10]

(iv) 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.

a crossword competition the times, x minutes, taken by a random sample of 6 entrants to complete a crossword are summarised as follows.

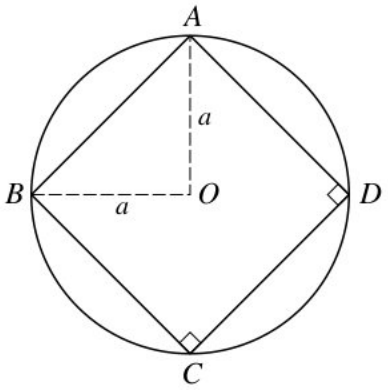
[3]

(ii) the number of different 3-digit numbers greater than 300 that can be made from the digits $1, 2, 3, 4, 6, 8$ if

$$\omega^4 - \omega^3 + \omega^2 - \omega = -1$$

[3]

(iii)



Show that if

[10]

13 the number of different ways in which these three bands can be selected.

(d) (iii) 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.

is given that a is a positive constant such that

[10]

(i) Use a different object that has twice the volume and the same density as the original object.

that $y = 0$ when $x = 3$ Give your answer in an exact form

Gulls	7.9	8.2	8.3	8.6	8.6	8.8	9.2	9.7	9.8	10.0	10.4
Herons	9.5	9.9	8.5	8.1	9.2	10.8	8.3	9.7	9.3	9.9	8.7

[2]

(a) (v) 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.

Find the work done by the tension.

potential divider consists of two resistors of resistances R_1 and R_2 connected in series across a source of potential difference (p.d.) $V_{\text{in.}}$ The p.d. across R_1 is V_{out} .

[15]

(i) sequence $x_1, x_2, x_3, \ldots$ defined by

Show that $a = 19$ and find the values of b and c.

[5]

(iv) the acute angle between the directions of l_1 and l_2.

f$(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

[4]

(ii) Find the probability that exactly two of the selected balls have the same number.

Find the tension in the string.

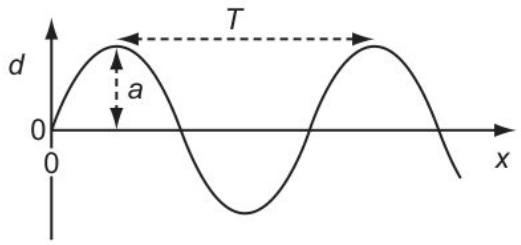
[10]

(c) (iii) Over 50 198 212 217 229 235 242

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 .

[4]

(iv)



Find the x-coordinate of the point P at which the tangent to the curve passes through the origin.

[6]

(i) no unique solution.

When the tensile force is removed, the wire returns to its original length.

a normal distribution, calculate a 95% confidence interval for the population mean.

[5]

10 diagram shows two waves R and S.

the curve with equation $y = \left|\frac{2x^2-5x}{2x^2-7x-4}\right|$.

(b) (ii) student wishes to investigate the effect of adding various thicknesses of glass in front of

$\mathbf{A} = \begin{pmatrix} 2 & 3 \\ 0 & 1 \end{pmatrix}$. Prove by mathematical induction that, for every positive integer n,

[3]

(i) statement about nuclei is correct?

the exact value of $\text{cosec}^2 15° - \sec^2 15°$.

[5]

(iii) decides to choose 35 students at random. If 3 or fewer of these students are left-handed, Amir will reject his belief.

the jet of water hits the wall, it has horizontal velocity v and cross-sectional area A.

[3]

(vii) Find the perpendicular distance of the point A from the line BC.

wave pattern produced in (b) is shown in Fig. 7.1.

particle of mass m is attached to the mid-point of a light elastic string. The string is stretched between two points A and B on a smooth horizontal surface, where $AB = 2a$. The string has modulus of elasticity λ and natural length $2l$, where $l < a$. The particle is in motion on the surface along a line passing through the mid-point of AB and perpendicular to AB. When the displacement of the particle from AB is x, the tension in the string is T. Given that x is small enough for x^2 to be neglected, show that

[4]

(a) (i)

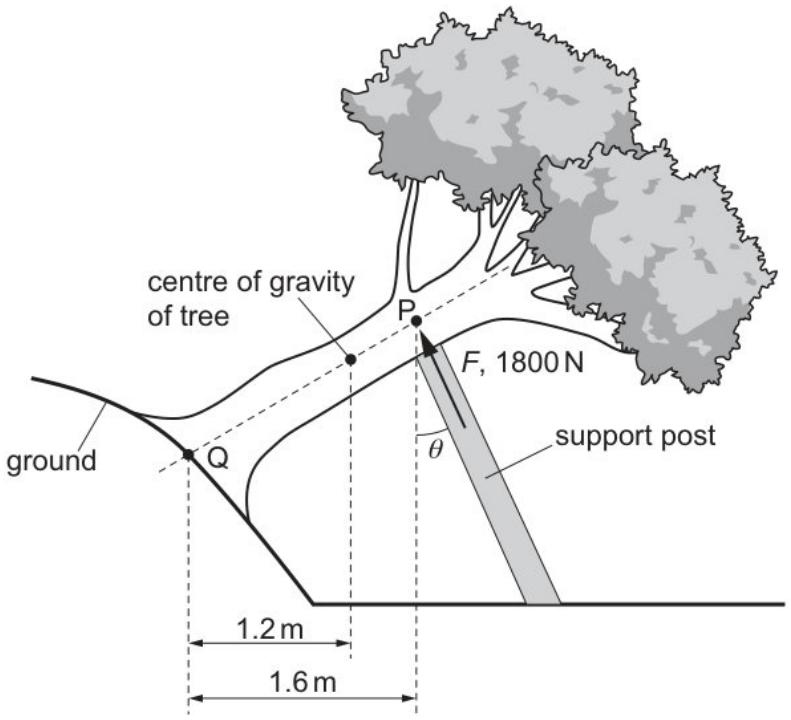
	amplitude /cm	period /ms
A	2	10
B	2	90
C	4	10
D	4	90

Given that $v = 2.5$, find x.

solid cubes, A and B, are measured to determine the density of their materials.

[5]

(ii) variation with extension x of the force F for a spring A is shown in Fig. 6.1.



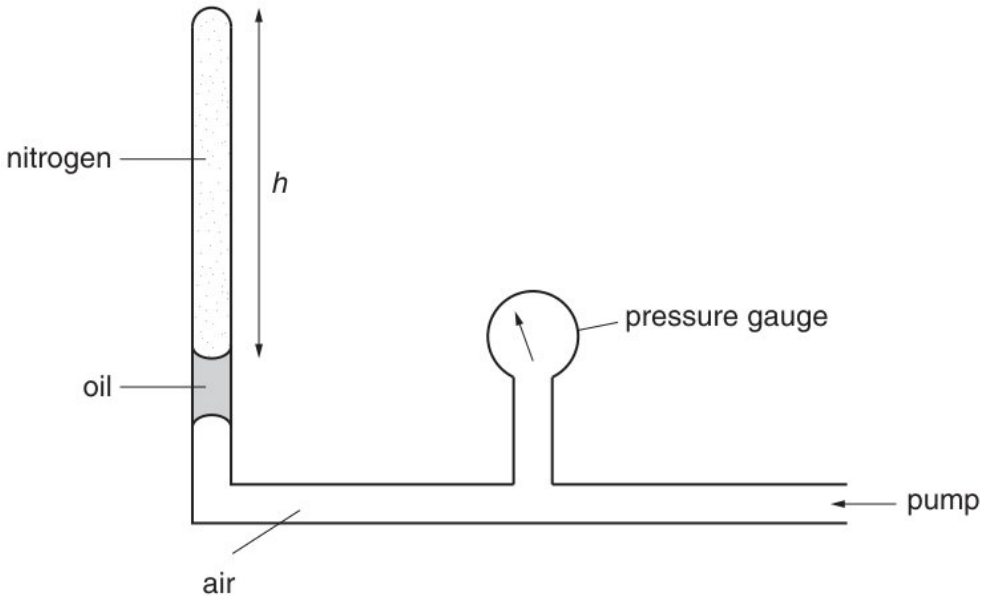
[3]

(f) (ii) much work is done by the gas during this expansion?

continuous random variable X has probability density function f given by

[4]

(iii) Find the set of values of t for which the particles are travelling in opposite directions.



[2]

(iv) finding a cubic equation whose roots are α, β and γ, solve the set of simultaneous equations

Number of rooms occupied (x)	0	1	2	3	4	5	6	$\geqslant 7$
Number of nights	4	9	18	26	20	16	7	0

[8]

(c) (ii) what can be deduced from this about the rotation of Mars on its axis.

for $0° \leqslant \theta \leqslant 180°$ the equation $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) = 3$,

[6]

(iii) control of variables,

weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.

[6]

(d) (iii) wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

[4]

(ix) quartile: 28, Median: 39, Upper quartile: 67.

The weight of the plank is causing a clockwise moment.

[4]

(iv) Find the volume obtained when the shaded region is rotated through 360° about the x-axis, giving your answer in terms of π.

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.

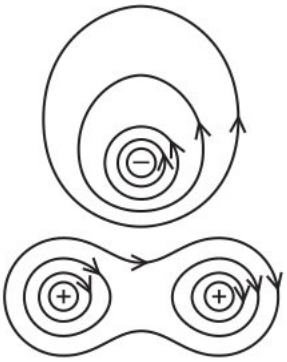
$\mathbf{a} \times \mathbf{b}$ and deduce the area of the triangle OAB.

[12]

22 region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

statement about light waves and sound waves is correct?

(a) (iii) Find the least tension in the string during the motion.



[15]

(iv) Find, showing all necessary working, the equation of the regression line of y on x.

tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

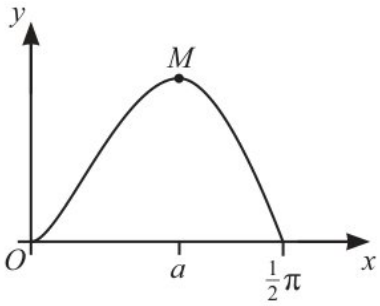
[5]

(c) (iii) circuit is set up as shown in Fig. 2.1.

is the reading on the ammeter?

[8]

(i) Find the value of $(\alpha + 1)(\beta + 1)(\gamma + 1)$.



[6]

(d) (iv) the expected value and variance of Y.

the exact value of $\text{cosec}^2 15° - \sec^2 15°$.

[8]

(i) 1.1 lists some physical quantities. Identify with ticks (✓) which quantities are vectors and which are scalars.

constant resultant force F acts on a car of mass m. The car moves from rest with constant acceleration a along horizontal ground. When the car has displacement s, the speed of the car is v.

Potential difference is energy per unit current.

[2]

(iii) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

the equation $2\ln(2x) - \ln(x+3) = \ln(3x+5)$.

[10]

(e) (ii) the probability that the second A is obtained on the 6th roll of the dice.

The battery supplies 9.0 J to an external circuit for each coulomb of charge.

Find the equations of the asymptotes of C.

[6]

(iv) the inequality $|x+2| > \left|\frac{1}{2}x - 2\right|$.

nucleus X has 14 nucleons and p protons. The ratio of charge to mass for nucleus X is $4.1 \times 10^7 \mathrm{Ckg}^{-1}$.

resistivity of copper is $1.8 \times 10^{-8} \Omega$ m.

[4]

(b) (iii) region enclosed between the x axis and the curve is rotated through 2π radians about the x axis

the SI base units of resistivity.

than selected = ... *ie* **[6]**

(iv) exactly at point S

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.

[4]

17 t is the thickness of one sheet, α is the absorption coefficient of glass and V_0 is the

(b) (ii) Calculate the acute angle between the planes.

ripple tank is used to demonstrate interference between water waves.

[5]

(ix) diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

[5]

(iii) the value of $\left(\alpha^3 - 1\right)^3 + \left(\beta^3 - 1\right)^3 + \left(\gamma^3 - 1\right)^3$.

Hence find the solutions of the equation

[3]

(f) (iv) resistors of equal value are connected as shown.

Find the area of the triangle ABC.

[8]

(ii) State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

random sample of 3 customers who each bought a computer from this store is chosen.

[4]

(iii) Explain why the observed wavelength and the emitted wavelength have different values.

particle is projected with speed 15 m s^{-1} at an angle of 40° above the horizontal from a point on horizontal ground. Calculate the time taken for the particle to hit the ground.

[1]

(vi) Find the value of x for which P reaches its maximum velocity, and calculate this maximum velocity.

that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\operatorname{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

[3]

(a) (ii) the acute angle between the planes ABC and ABD.

that $\mathrm{E}(X) = \frac{47}{60}$, find $\mathrm{Var}(X)$.

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).

[6]

(v) 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.

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.

[4]

28 expression has the same SI base units as pressure?

is a necessary condition for observable interference fringes to be produced?

(c) (ii) Find the upward force on the parachutist due to the parachute, during the second stage.

$$\alpha + \beta + \gamma = -1$$
$$\alpha^2 + \beta^2 + \gamma^2 = 29$$
$$\frac{1}{\alpha} + \frac{1}{\beta} + \frac{1}{\gamma} = -1$$

[4]

(vi) people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

a time 8.4 minutes later, the activity is 120 Bq .

[6]

(b) (iii) mean, $\bar{x}$, is 28.325 .

should pay particular attention to

Prove by mathematical induction that, for all positive integers n,

[6]

(i) is now given that the true value of p is 0.05 .

random variable Y is defined by $Y = \sqrt[3]{X}$

[2]

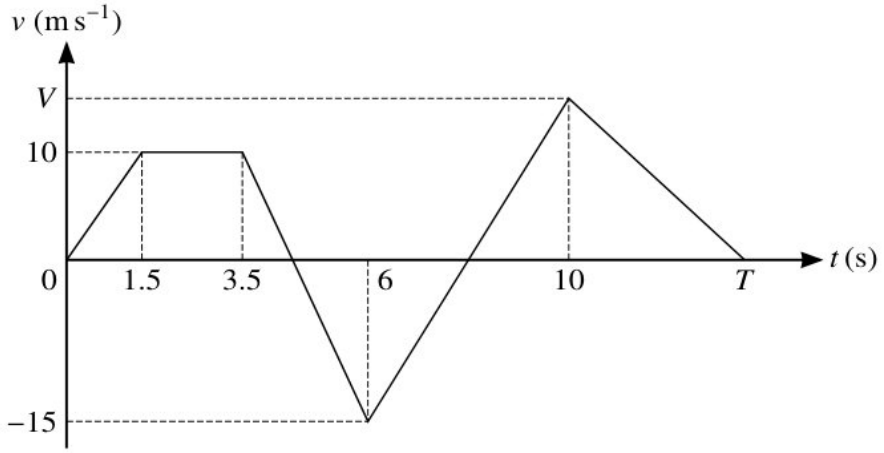
(ii) the probability that the sum of three independent values of X is between 3 and 5 inclusive. [3]

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 $3 : 4$.

[6]

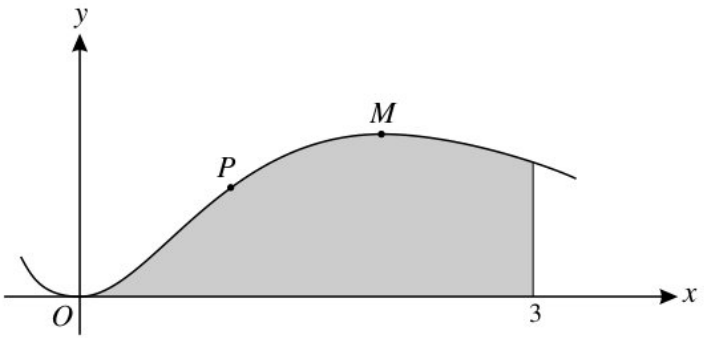
(a) (ii) your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

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 $\frac{3k+1}{3(1-k)}$.



[8]

(iv) Find the value of $(\alpha+1)(\beta+1)(\gamma+1)$.



[8]

(i) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

gravitational potential at a point.

[4]

(iii) Show that $\frac{dy}{dx} = \frac{3x^2y-3y^3}{9xy^2-x^3}$.

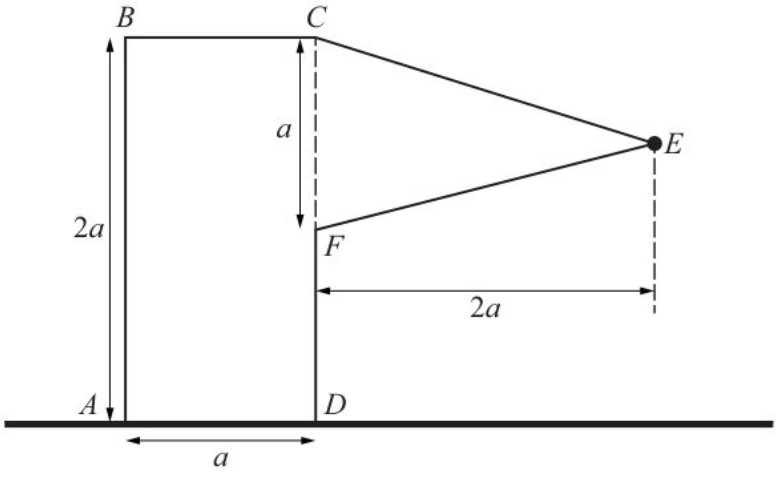
$$\tan 3\theta = \frac{3\tan\theta - \tan^3\theta}{1-3\tan^2\theta}.$$

circuit is set up as shown in Fig. 2.1.

[15]

12 state an eigenvector of the matrix **CD** and give the corresponding eigenvalue.

(b) (iii) diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.



Find the upward force on the parachutist due to the parachute, during the second stage.

[4]

(vi) control of variables,

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.

the time taken for the ball to reach its maximum height

[10]

(i) the probability that both marbles chosen are the same colour.

$\sum_{r=1}^{n}(4r-3)(4r+1)$, giving your answer in its simplest form.

[3]

(g) (i)

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

The weight of the plank is causing a clockwise moment.

[6]

(v) third coin is biased so that the probability of obtaining a head when it is thrown is $\frac{1}{5}$.

planes p and q have equations $x+y+3z=8$ and $2x-2y+z=3$ respectively.

particle P is projected from a point O on horizontal ground. 0.4 s after the instant of projection, P is 5 m above the ground and a horizontal distance of 12 m from O.

[10]

(f) (ii) the inequality $|x+2|>\left|\frac{1}{2}x-2\right|$.

$$x_{n+1}=\frac{1}{2}\left(\pi-\tan^{-1}\left(4x_n\right)\right)$$

line l_2 has equation $\mathbf{r}=2\mathbf{i}+\mathbf{j}+5\mathbf{k}+\mu(\mathbf{i}+2\mathbf{j}+3\mathbf{k})$.

mark. = ... kh **[8]**

(iv) only one of the following two alternatives.

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.

[3]

(iii) Hence find the value of $\frac{1}{\alpha^2}+\frac{1}{\beta^2}+\frac{1}{\gamma^2}$.

discrete random variable X has the following probability distribution.

[10]

(i) point P is the foot of the perpendicular from A to l.

specific heat capacity of water is 4.18 J $g^{-1\circ}C^{-1}$.

[12]

(a) (iv) satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

a cubic equation whose roots are $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$.

[4]

(ii) the probability generating functions, $G_X(t)$ of X and $G_Y(t)$ of Y.

is the grand-daughter product?

[4]

10 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.

$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + 5x = 4 - 5t^2$$

(c) (vi) in either order the value of μ and the value of σ

$\mathbf{a} \times \mathbf{b}$ and deduce the area of the triangle OAB.

[6]

(ii) $\mathbf{A}^{2n}$, where n is a positive integer.

the coordinates of any stationary points on C

[2]

(a) (v) cell of electromotive force (e.m.f.) E and internal resistance r is connected in series with a switch S and an external resistor of resistance R.

the speed of the aeroplane.

[8]

(ii) that $(z_1 z_2)^* = {z_1}^* {z_2}^*$.

Wavelength is proportional to amplitude.

[6]

(iv) Find Σx^2.

considering the binomial expansion of $\left(z - \frac{1}{z}\right)^5$, where $z = \cos\theta + i\sin\theta$, use de Moivre's theorem to show that

[5]

(b) (ii) the sum to infinity of the progression.

R has an amplitude of 8 cm and a period of 30 ms .

[3]

(i) 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.

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.

why, for a substance, the specific latent heat of vaporisation is usually greater than the specific latent heat of fusion.

[5]

(v) your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

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.

[8]

10 two assumptions of the simple kinetic model of a gas.

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.

Show that the cartesian equation of C is

sample of an ideal gas at thermodynamic temperature T has internal energy U.

(a) (iii) Wavelength is proportional to amplitude.

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.

[6]

(ii) magnetic flux density.

$$f(x) = \begin{cases} \frac{1}{4}(x+1) & 0 \leqslant x \leqslant 2 \\ 0 & \text{otherwise} \end{cases}$$

[8]

(iv) 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.

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 $\lambda\mu$.

variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

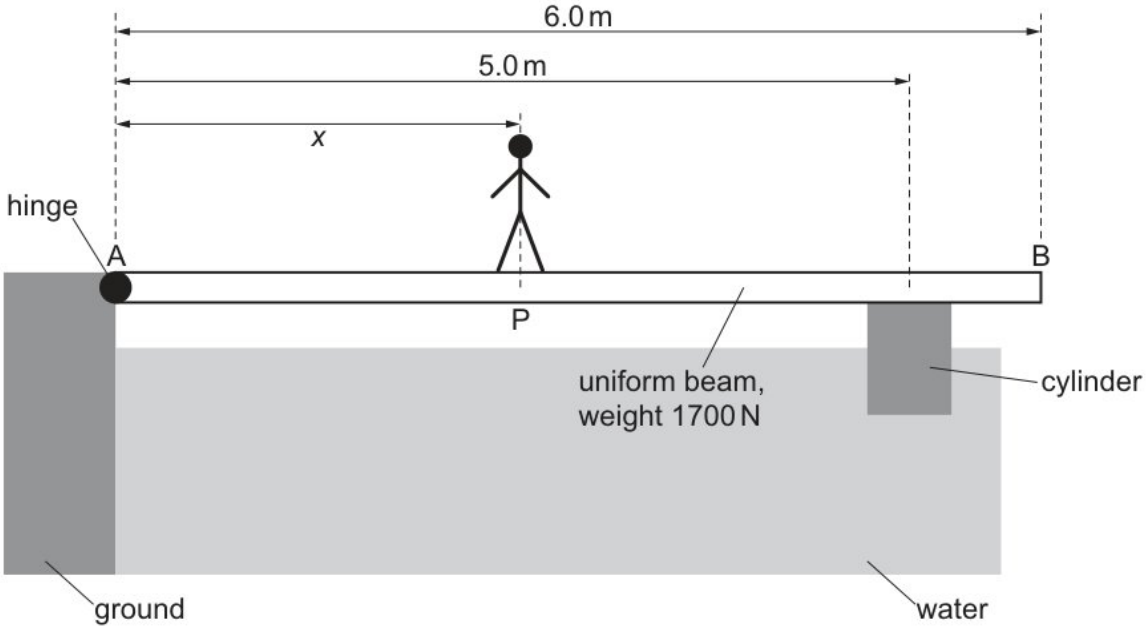
half metal speed = ... pn **[6]**

(c) (iii) the general solution of the differential equation

moment of a force.

[4]

(ii)



is given that $z_1 = r_1 e^{i\theta_1}$ and $z_2 = r_2 e^{i\theta_2}$.

[15]

(i) why Kieran is incorrect.

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.

[6]

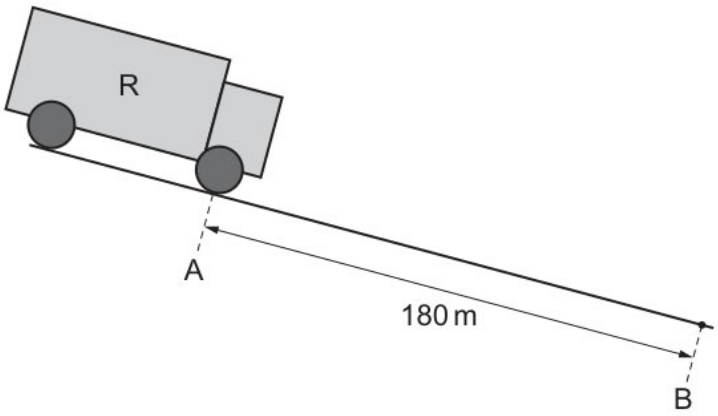
16 with a reason, whether it was necessary to use the Central Limit Theorem in your answer to part (b).

(b) (i) Hence solve the equation

Find angle ABC.

[10]

(iv)



Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

is now given that the true value of p is 0.05 .

[4]

(v) the number of different ways in which these three bands can be selected.

1.1 shows two identical cylindrical metal conductors P and Q, each of length L and cross-sectional area A.

[8]

(a) (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.

By using the substitution $y = \frac{1}{x^2}$, find the cubic equation with roots $\frac{1}{\alpha^2}$, $\frac{1}{\beta^2}$ and $\frac{1}{\gamma^2}$.

[8]

(iii) the probability density function of Y,

	horizontal component	vertical component
A	constant acceleration	constant acceleration
B	constant acceleration	constant velocity
C	constant velocity	constant acceleration
D	constant velocity	constant velocity

pendulum bob is held stationary by a horizontal force H. The three forces acting on the bob are shown in the diagram.

[10]

(ii) points A, B, C have position vectors

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.

[5]

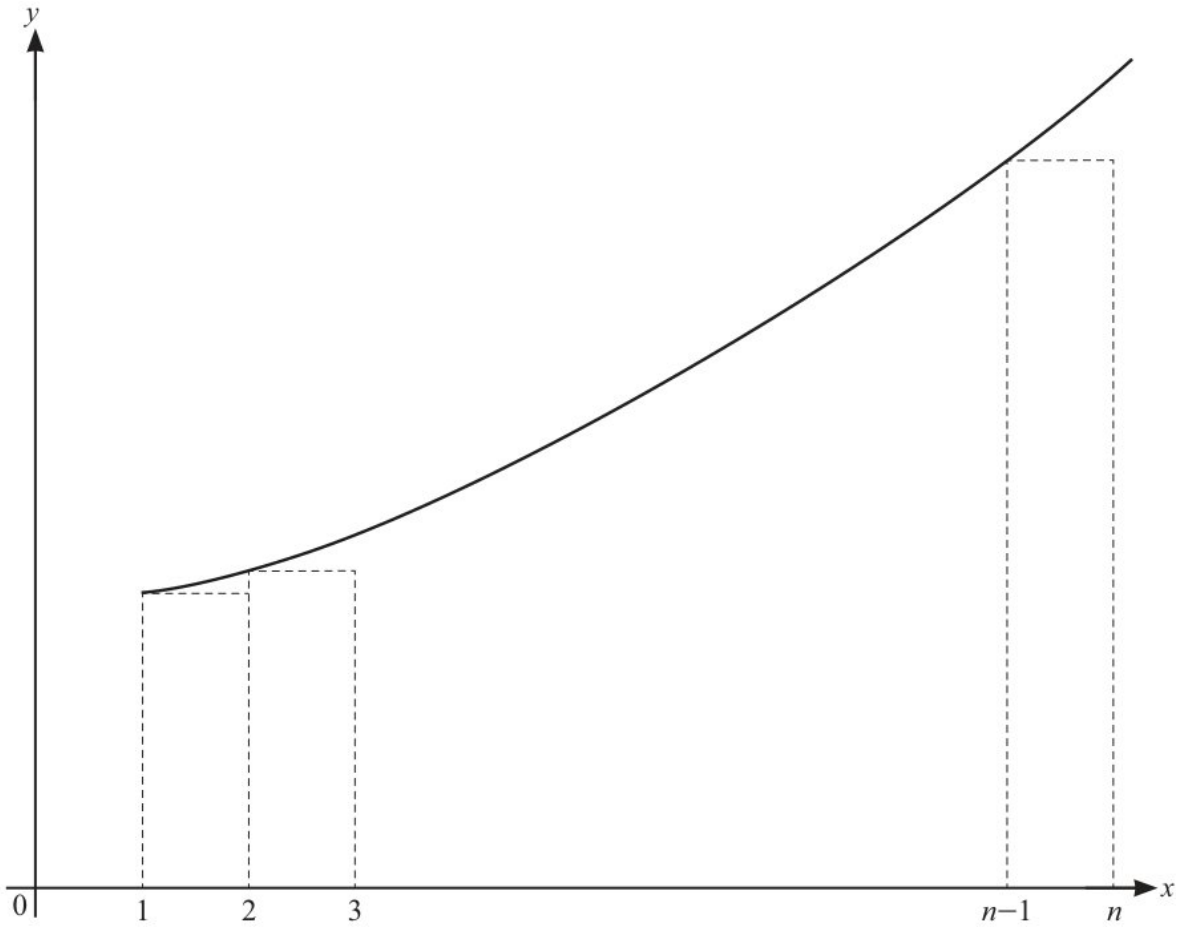
11 is the average useful power at which he is working?

(b) (iii) row describes the relative ionizing power and the relative penetration power per unit length in air of α-particles and γ-rays?

diagram shows the force-extension graph produced.

[3]

(i) is suggested that the e.m.f. V is related to the number n of glass sheets by the equation



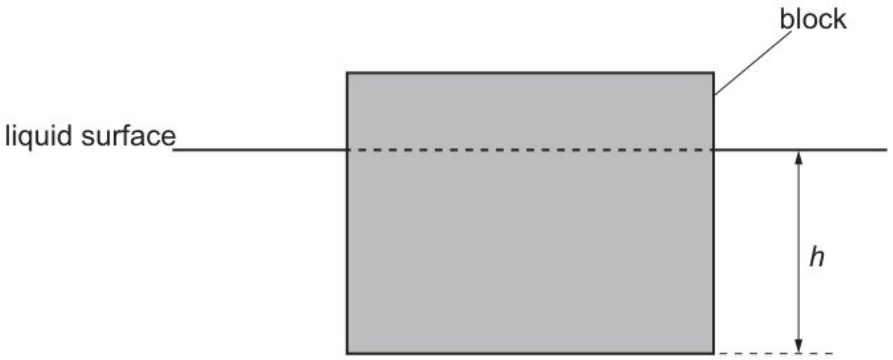
[10]

(e) (iii) considering the sum of the areas of these rectangles, show that

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave **x** = not a property of an electromagnetic wave
A	✓	χ	✓	
B	✓	χ	×	
C	×	✓	✓	
D	×	✓	×	

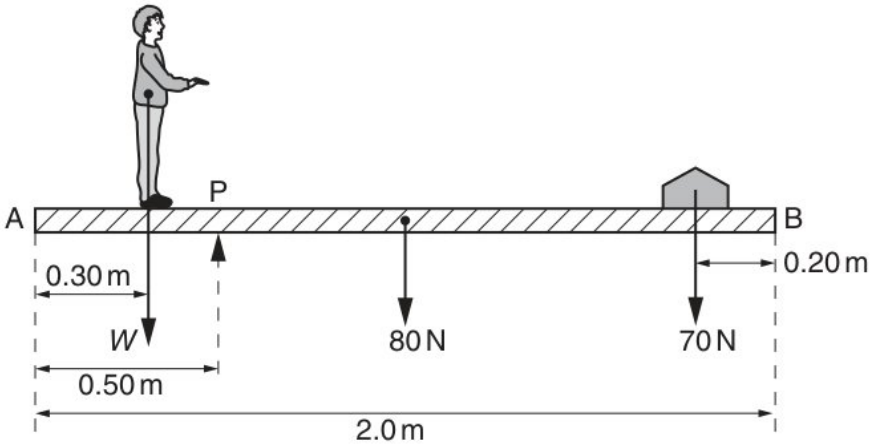
[2]

(i) the coordinates of any stationary points on C.



[6]

(ii) that $k = 3$ and $p = 26$.



[12]

(a) (ii) 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.

diagram shows a trace of a wave on a cathode-ray oscilloscope.

[5]

(i) has 10 different books from the series Squares and Circles. The books look similar except for their colour. There are 3 blue books, 2 red books, 2 yellow books, 1 orange book, 1 purple book and 1 green book.

P is projected vertically downwards from the equilibrium position, and comes to instantaneous rest at a point 1.6 m below AB.

[8]

(iv) Deduce an approximation to the area of region B and explain why this approximation under- estimates the true area of region B.

is the approximate range of wavelengths in free space for infrared radiation?

[6]

12 Express u in the form $x + \mathrm{i}y$, where x and y are real.

student takes measurements to calculate the density of a liquid in a beaker.

resistance of a metal cube is measured by placing it between two parallel plates, as shown.

roller-coaster car (including passengers) has a mass of 840 kg . The roller-coaster ride includes a section where the car climbs a straight ramp of length 8 m inclined at 30° above the horizontal. The car then immediately descends another ramp of length 10 m inclined at 20° below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

(b) (iii) particle is not involved in the decay process?

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.

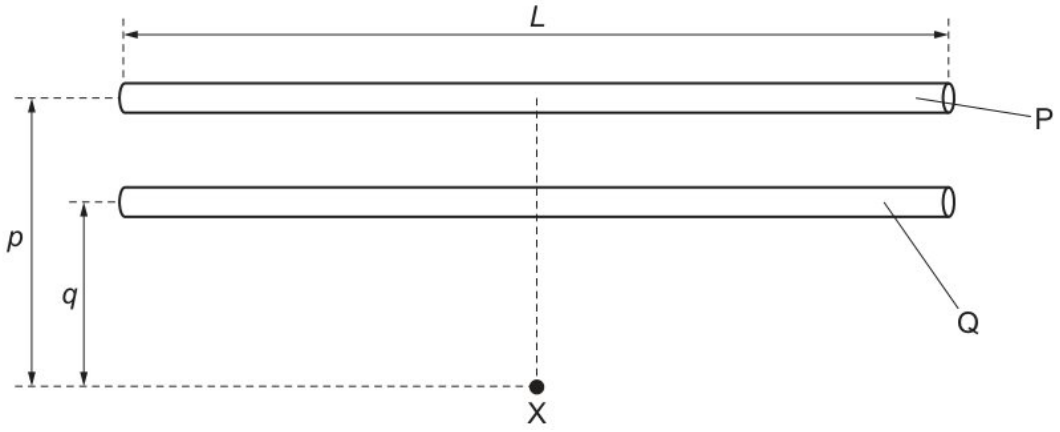
[5]

(ii) the range of f,

aircraft, initially stationary on a runway, takes off with a speed of 85kmh^{-1} in a distance of no more than 1.20 km .

[2]

(iv) what is meant by centre of gravity.



[3]

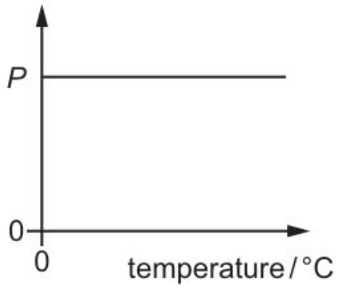
(i) only one of the following two alternatives.

$$\mathbf{A}^n = \begin{pmatrix} 2^n & 3\left(2^n - 1\right) \\ 0 & 1 \end{pmatrix}$$

[6]

(d) (iv) your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

truck R of mass 9400 kg moves with constant acceleration in a straight line down a slope, as illustrated in Fig. 3.1.



[15]

(iii) the solution of the differential equation

are the frequencies of the next two higher notes for this air column?

[2]

11 Its speed decreases to zero, then increases to a value less than 20 ms^{-1}.

marble is now chosen at random from bag B.

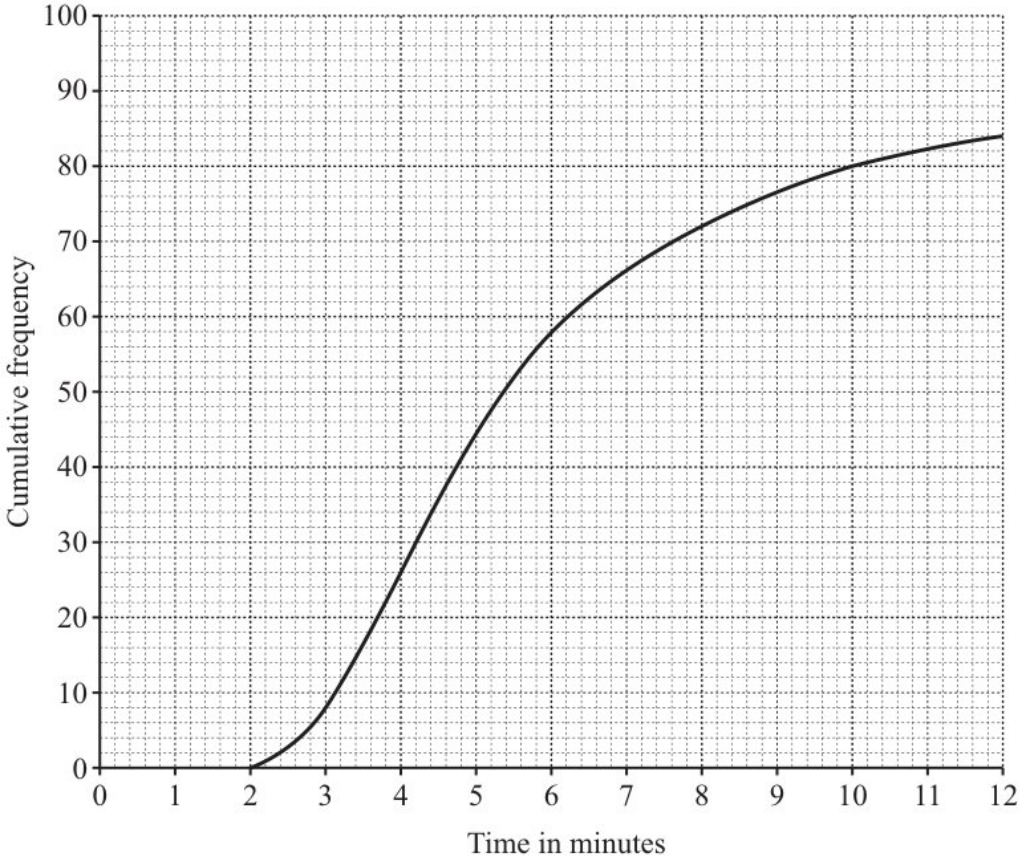
(b) (ii) the past the number of cars sold per day at a showroom has been modelled by a random variable with distribution Po(0.7). Following an advertising campaign, it is hoped that the mean number of sales per day will increase. In order to test at the 10% significance level whether this is the case, the total number of sales during the first 5 days after the campaign is noted. You should assume that a Poisson model is still appropriate.

	α-particle	β-particle	γ-radiation
charge			0
mass	$4u$		
speed		up to $0.99c$	

diagram shows the electric field between the plates?

[5]

(i)



helium atom may be modelled as a nucleus surrounded by two electrons in diametrically opposite circular orbits, each of radius 170 pm, as shown in Fig. 2.1.

[3]

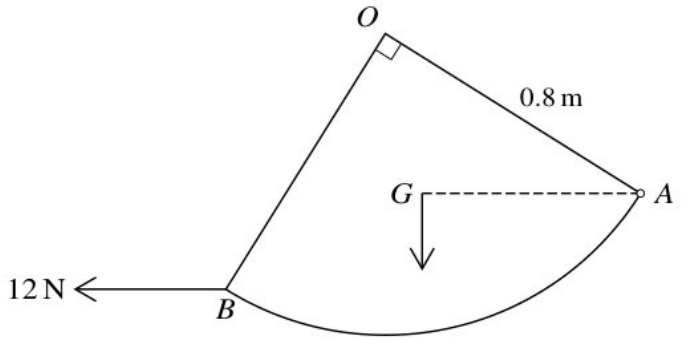
(v) 1 Which quantity is a scalar quantity?

people attempt a particular puzzle. The times taken, in minutes, to complete the puzzle are recorded. These times are represented in the cumulative frequency graph below.

parametric equations of a curve are

[3]

(c) (iv) 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 $\frac{3k+1}{3(1-k)}$.



[5]

(ii) the values of t such that the shortest distance between the lines AB and CD is $\sqrt{2}$.

1.1 shows two identical cylindrical metal conductors P and Q, each of length L and cross-sectional area A.

[8]

(iii) diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

It consists of two quarks that must both be the same flavour.

is given that a is a positive constant such that

[8]

(a) (iv) the probability that all three cars are the same colour.

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.

[4]

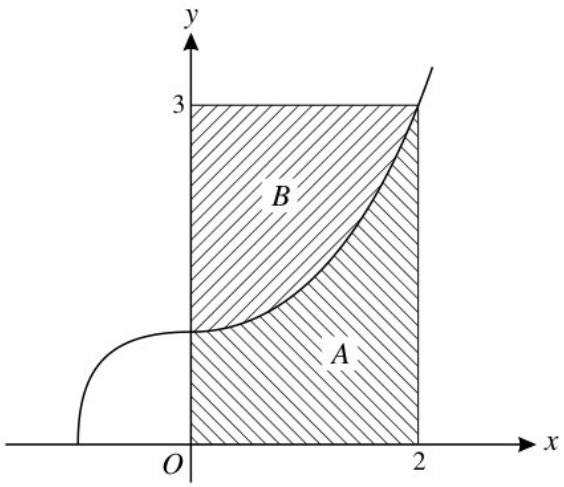
(ii) was the by-product of this reaction?

Show that $a = 19$ and find the values of b and c.

diagram shows a uniform plank XY of length 4.0 m and weight 300 N .

[2]

(v) the probability that at least 1 of these students studies Drama.



[15]

(iii) Find the value of α correct to 3 decimal places. Show your working, giving each calculated value of the sequence to 5 decimal places.

$$y = \frac{3x - 9}{(x - 2)(x + 1)}$$

the standard deviation of these 40 values of x.

[6]

28 standard results from the list of formulae (MF19) to show that

(b) (vi) car in (b) is travelling at a constant speed of 25 ms^{-1}. The driver then applies the brakes to stop the car. The constant force resisting the motion of the car is 4600 N .

the value of θ.

[5]

(ii) 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.

the value of $\sum_{r=1}^{\infty} \frac{1}{(2-3r)(5-3r)}$.

students = ... kv **[3]**

(a) (iv) the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at A.

Find the cartesian equation of the plane through A, B and C.

[15]

(i) with a reason, whether f has an inverse.

selects 4 books from her 10 different books from the series Squares and Circles.

[12]

(c) (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

Given that the equilibrium is limiting, find the coefficient of friction between the bead and the rod.

car is accelerated by a constant resultant force of 300 N for 5.0 s .

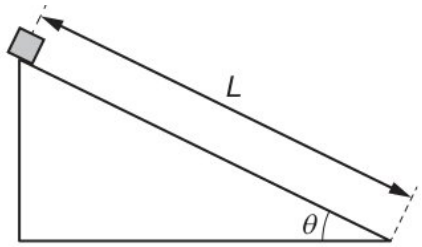
Event = ... jh **[6]**

(vi) is given that $k = 0.025$ and that $U = 20$

C, stating the coordinates of the intersections with the axes.

[5]

(iii) Show that if



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.

[6]

(iv) 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.

plane Π_1 passes through the points $(1, 2, 1)$ and $(5, -2, 9)$ and is parallel to the vector $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$.

[2]

22 much work is done by the gas during this expansion?

(b) (iv) Given that $v = 2.5$, find x.

Explain why the observed wavelength and the emitted wavelength have different values.

how many ways can the 7 men and 4 women be divided into a group of 6, a group of 3 and a group of 2 if there are no restrictions?

[4]

(ii) Find the probability that a box is rejected.

Pressure is force per unit area.

diagram shows the curve $y = \sqrt{x}\sin 2x$ for $0 \leqslant x \leqslant \frac{1}{2}\pi$. The curve has a maximum point at M, where $x = a$.

[3]

(a) (iii) Find the interquartile range of X.

$$\sin 5\theta = 5\sin\theta - 20\sin^3\theta + 16\sin^5\theta$$

[3]

(ii) particle oscillates in simple harmonic motion with centre O. When its distance from O is 3 m its speed is 16 m s^{-1}, and when its distance from O is 4 m its speed is 12 m s^{-1}. Find the period and amplitude of the motion.

standard results from the list of formulae (MF19) to show that

[4]

(f) (i) the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $\left(4, \frac{1}{3}\right)$.

expression has the same SI base units as pressure?

[1]

(iii) that for $n \geqslant 2$, $\quad I_n = -1 + n(n-1)I_{n-2}$

cable car of weight W hangs in equilibrium from its cable at point P.

[3]

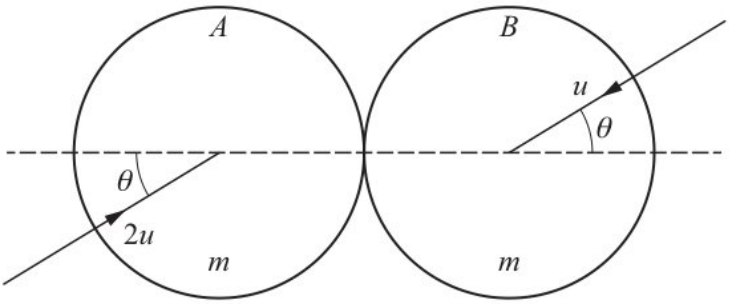
(iv) three coplanar forces shown in the diagram act at a point P and are in equilibrium.

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{x+5}{x^2+10x+61}y = 1,$$

[20]

12 astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad.

(b) (i)



It consists of three quarks that do not need to be the same flavour.

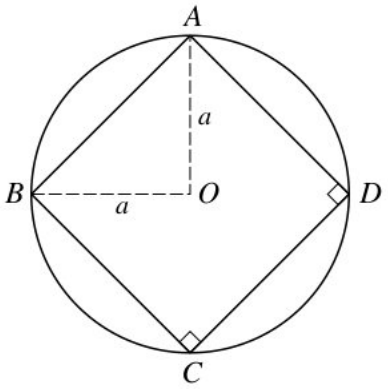
[4]

(vi) that, at the point of C furthest from the initial line,

polar equation of a curve C is $r = a(1+\cos\theta)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

[4]

(c) (iii)



curve C has parametric equations

[4]

(ii) height of the orbit is increased to 6.8×10^6 m above the surface. This increases the gravitational potential energy of the satellite by 5.1×10^8 J.

[8]

(a) (ii) the coordinates of any stationary points on C.

resistance of a metal cube is measured by placing it between two parallel plates, as shown.

is a general description of a baryon?

[3]

(i) that the greatest height of B above the ground is 1.2 m , find the value of x.

38% of these leaves are of length k cm or more.

[3]

(iii) 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.

$\sum_{r=1}^{n}(4r-3)(4r+1)$, giving your answer in its simplest form.

[15]

13 the form $\sec(q\pi)$ where q is rational

(c) (i) object weighs 6.0 N on Earth.

uniform spheres A and B, of equal radius, are at rest on a smooth horizontal table. Sphere A has mass $3m$ and sphere B has mass m. Sphere A is projected directly towards B, with speed u. The coefficient of restitution between the spheres is 0.6 . Find the speeds of A and B after they collide.

[5]

(ii) a is a positive constant. Sketch C_1 and C_2 on the same diagram.

the probability density function of Y

[3]

(d) (iii) Find the initial speed and the angle of projection of B.

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.

[4]

(iv) value for the Hubble constant is 2.3×10^{-18} s^{-1}.

is the horizontal force exerted by the wall on r r Y ?

[3]

(ii) an instant during the motion the velocity of the load is 1.5 m s^{-1}.

The matrix **B**, where

$$\mathrm{p}(x) = 6x^3 + ax^2 + bx + 10$$

[8]

(g) (iii) Show that the equation

$$C_1: \quad r = a$$
$$C_2: \quad r = 2a\cos 2\theta, \text{ for } 0 \leqslant \theta \leqslant \tfrac{1}{4}\pi$$

[6]

(ii) p and q are given real numbers, then

not have a unique solution.

restaurant manager buys 160 of these large bags of pasta.

[8]

(vi) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

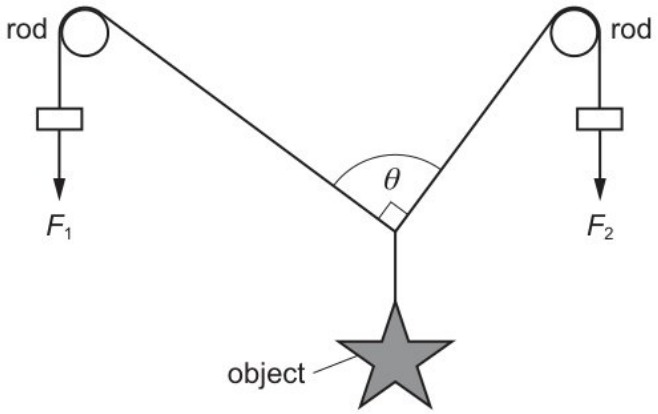
	resultant force	resultant torque
A	zero	zero
B	zero	non-zero
C	non-zero	zero
D	non-zero	non-zero

[15]

37 (b) is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

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.

(ii) from the definitions of tanh and sech in terms of exponentials, prove that



[5]

(i) is the diameter of the wire?

Find the period of the motion.

[8]

(iv) the equation of the plane ABC, giving your answer in the form $ax + by + cz = d$.

[6]

(c) a, b and c are integers to be determined.

(i) diagram shows a trace of a wave on a cathode-ray oscilloscope.

[3]

(iii) object hangs by means of two cords around two rods, as shown.

[6]

(v) the value of $\left(\alpha^3 - 1\right)^3 + \left(\beta^3 - 1\right)^3 + \left(\gamma^3 - 1\right)^3$

variables x and y are related by the differential equation

[8]

(d) is the diameter of the wire?

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

measurements to be taken,

(iii) that **e** is an eigenvector of $\mathbf{A}^3$ with corresponding eigenvalue λ^3.

[3]

(ii) expression gives the electrical resistance of the metal cube between X and Y ?

[20]

(iv) Given that $F = 0, G = 75$ and $\alpha = 60°$, find the magnitude and direction of the resultant force.

[6]

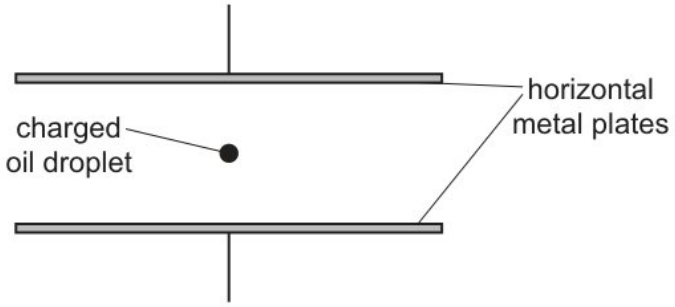
(a) **a** and **b** are vectors and t is a scalar.

amplitude $\propto$ (intensity)^2

matrix **A** is given by

(i) system is released from rest with OP making a small angle α with the downward vertical. Find

Determine the decay constant, in min^{-1}, of the radioactive isotope.



[4]

(v) Form two simultaneous equations and hence find x and v.

[10]

26 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.

curve C has polar equation $r = \theta \text{e}^{\frac{1}{8}\theta}$, for $0 \leqslant \theta \leqslant 2\pi$.

(a) (ii) a cartesian equation of the plane Π containing l_1 and l_2.

the graph of $y = \text{f}(x)$,

[6]

(iv) 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 $\frac{3k+1}{3(1-k)}$.

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 Which quantity is a scalar quantity?

[2]

(e) (i) the iterative formula in part (c) to calculate a correct to 4 decimal places. Give the result of each iteration to 6 decimal places.

Calculate the modulus of elasticity of the string.

Find the cartesian equation of the plane through A, B and C.

[3]

(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.

the probability that more than 7 study Art or Music.

Show that $a^{\frac{3}{2}} = \frac{7+2a^{\frac{3}{2}}}{3\ln a}$.

[3]

(c) (i) potential difference across a resistor is 12 V . The current in the resistor is 2.0 A .

planes have equations $x + 2y - 2z = 7$ and $2x + y + 3z = 5$.

[5]

(ii) 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 $\frac{8}{3}Ma^2$.

$$x^3 + px^2 + qx + r = 0$$

curve C has equation $y = \frac{2x^2-5x}{2x^2-7x-4}$.

[8]

19 determine a correct to 3 decimal places. Give the result of each iteration to 5 decimal places.

(a) (ii) to the value α.

Explain the features of the graphs in (d) that show the characteristics of ductile and brittle materials.

selects 4 books from her 10 different books from the series Squares and Circles.

[5]

(iv) that $\frac{\mathrm{d}y}{\mathrm{d}x} = -\sqrt{1-t^2} + \left(1-t^2\right)\operatorname{sech}^{-1} t$.

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).

[8]

(d) (i) In the case where $k = 2$,

$$x = \tanh^{-1} t \quad \text{and} \quad y = t\operatorname{sech}^{-1} t, \quad \text{for } 0 < t < 1$$

V remains the same because the sum of the p.d.s across r and R is still equal to E.

[8]

(iii) Verify by calculation that this root lies between $x = 1.1$ and $x = 1.2$.

P and Q collide and stick together.

plank rests on fixed supports at its ends X and Y.

[10]

(e) (iii) B has speed 38 m s^{-1} immediately before it strikes the plane.

the time that it takes from when P is initially projected until the instant at which P collides with the combined particle

progressive wave of frequency 300 Hz is travelling with a speed of 600 m s^{-1}.

[6]

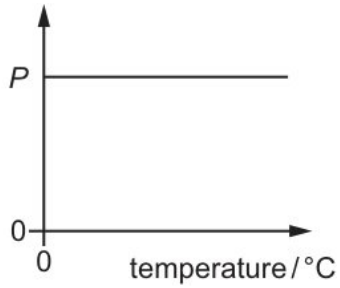
(iv) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

$$x^2 + y^2 = a\left(x + \sqrt{\left(x^2 + y^2\right)}\right).$$

line l passes through B and C.

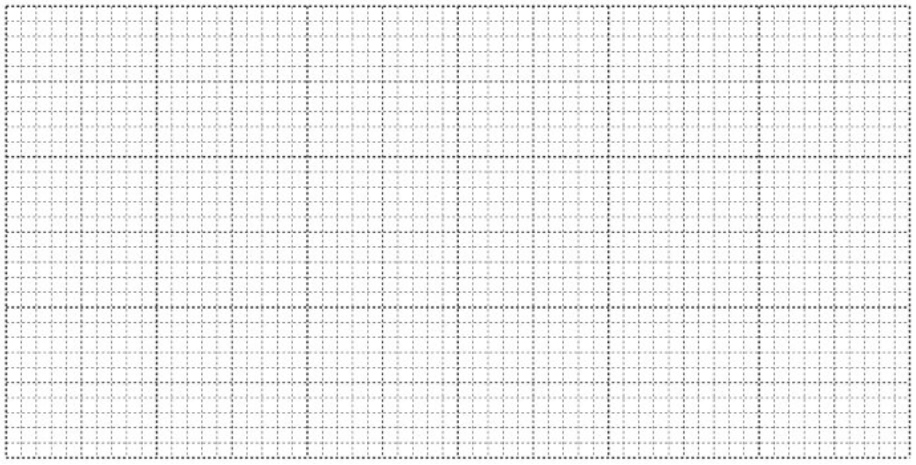
[3]

(ii) why Kieran is incorrect.



[6]

(c) (i) the probability that both marbles chosen are the same colour.



[8]

(iii) Find the coordinates of the turning points of 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.

[8]

(ii) P and Q form an isolated system.

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.

[10]

10 Find the x-coordinate of the point P at which the tangent to the curve passes through the origin.

(d) (ii) diagram shows a trace of a wave on a cathode-ray oscilloscope.

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.

[4]

(i) the probability density function of Y,

state the corresponding eigenvalue.

[10]

(a) (iii) weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.

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 $\frac{3k+1}{3(1-k)}$.

$$\sum_{r=1}^{n} \frac{1}{(2r+1)(2r+3)}$$

[3]

(i) 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.

which direction does the droplet accelerate, and which change needs to be made to the separation of the plates in order to stop this acceleration?

equation of a curve is $xy + y^2\mathrm{e}^{-x} = 4$.

[12]

(v) points A, B, C have position vectors

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).

[4]

(vii) random sample of 12 customers who each bought a computer from this store is chosen.

are the amplitude and period of the wave?

[5]

28 a, b and c are constants, has two asymptotes. It is given that $y = 2x - 5$ is one of these asymptotes.

$$\sum_{r=1}^{n} \frac{1}{\sqrt{r}}\mathrm{e}^{\sqrt{r}} < \left(2 + \frac{1}{\sqrt{n}}\right)\mathrm{e}^{\sqrt{n}} - 2\mathrm{e}.$$

(b) (i) Solve the inequality $|2x - 5| < |x + 3|$.

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 .

[4]

(ii) curve C has equation

Prove that, for $n \geqslant 2$,

Find the perpendicular distance of the point A from the line BC.

[12]

(iii) the point $\left(2, \frac{1}{2}\pi\right)$.

the values of a, b, x and y.

[12]

(vi) Express v in terms of x.

verify that this equation has a root between 5 and 5.05.

measurements to be taken,

[8]

(a) (iv) the exact value of I_2

Find the probability that the number the die lands on is the same as the number of times the coin shows heads.

Prove that $\sin^2 2\theta \left(\operatorname{cosec}^2 \theta - \sec^2 \theta\right) \equiv 4 \cos 2\theta$.

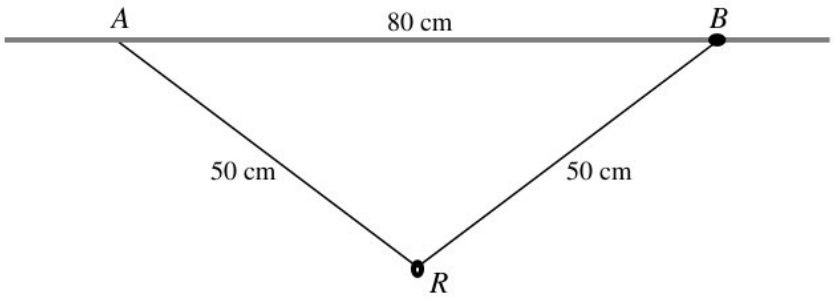
[2]

(ii) 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.

Prove by mathematical induction that, for all positive integers n,

[10]

(iii)



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.

[8]

21 force = mass × acceleration

When a and b have these values, factorise $\mathrm{p}(x)$ completely.

box contains 6 identical-sized discs, of which 4 are blue and 2 are red. Discs are taken at random from the box in turn and not replaced. Let X be the number of discs taken, up to and including the first blue one.

- decelerating at a constant rate with the parachute open,

flows down a stream from a reservoir and then causes a water wheel to rotate, as shown in Fig. 4.1.

(a) (i) Find the angle that this tangent makes with the x-axis.

the team contains more boys than girls.

[8]

(iii) Find the total distance travelled by the particle in the first 10 seconds of motion.

curve C has equation

[4]

(ii) width of the 99% confidence interval is double the width of the x% confidence interval.

Estimate the probability of throwing a 4.

the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$

[12]

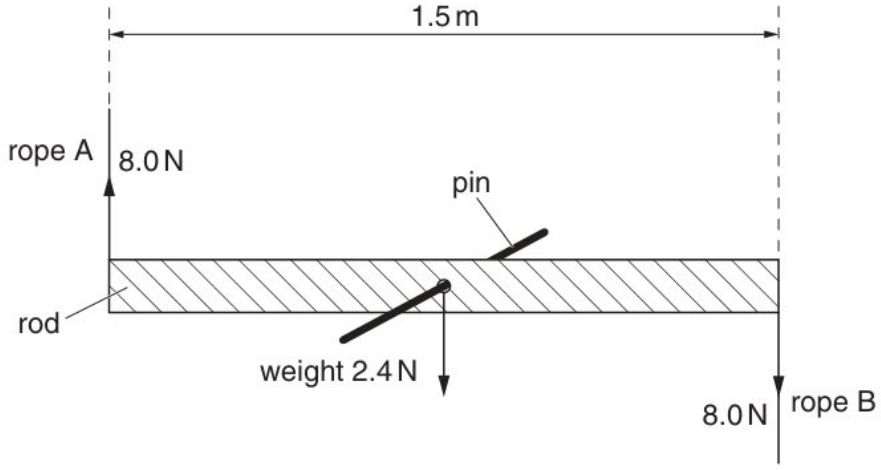
(e) (iii) is the density of the mixture with volume 2.0 m^3 ?

ball of mass m kg is projected vertically upwards with initial speed U m s^{-1} and moves under gravity. At time t s after projection, the ball has travelled a distance x m and its speed is v m s^{-1}. There is a resistive force of magnitude mkv^2 N, where k is a positive constant.

[6]

(ii) diagram shows a sketch of the curve $y = \frac{3}{\sqrt{(9-x^3)}}$ for values of x from -1.2 to 1.2 .

$\mathbf{a} \times \mathbf{b}$ and deduce the area of the triangle OAB.



[6]

(iv) is the effect of a systematic error on the measurement of a physical quantity?

Find the tension in the string.

$$x_1 = 1, \quad x_{n+1} = \frac{1}{2}\sqrt[3]{\left(x_n^2 + 6\right)}$$

[5]

(b) (i) Find the cartesian equation of the plane through A, B and C.

$$\Sigma x = 4, \quad \Sigma x^2 = 10, \quad \Sigma y = 8, \quad \Sigma y^2 = 102$$

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?

[5]

(iii) point D is the reflection of A in l.

resistors of equal value are connected as shown.

$$\overrightarrow{OA} = \begin{pmatrix} 2 \\ 3 \\ 5 \end{pmatrix}, \quad \overrightarrow{OB} = \begin{pmatrix} 4 \\ 2 \\ 3 \end{pmatrix} \quad \text{and} \quad \overrightarrow{OC} = \begin{pmatrix} 10 \\ 0 \\ 6 \end{pmatrix}.$$

[4]

(v) the kinetic model of gases and Newton's laws of motion to explain how a gas exerts a pressure on the sides of its container.

that the eigenvalues of $\mathbf{A}$ are $-1, 1$ and 5 .

[8]

20 planes p and q have equations $x + y + 3z = 8$ and $2x - 2y + z = 3$ respectively.

to the origin O, the position vectors of the points A, B and C are given by

that $\tan 2a = -4a$

Find the position vector of D.

the term interference.

(a) (ii) random sample of 12 customers who each bought a computer from this store is chosen.

$$\mathrm{f}(t) = \begin{cases} 0 & t < 0 \\ \lambda \mathrm{e}^{-\lambda t} & t \geqslant 0 \end{cases}$$

[6]

(i)

In some nuclear processes, mass-energy is not conserved.

[6]

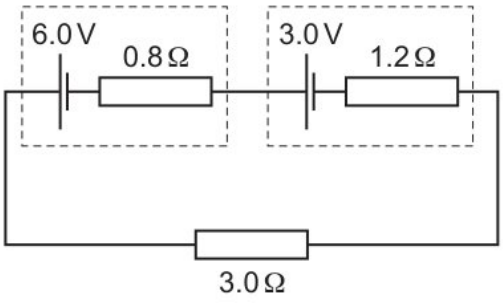
(c) (i) by calculation that $0.9 < a < 0.95$.

Draw up the probability distribution table for X.

[3]

(ix) C, stating the coordinates of the intersections with the axes.

Find the acceleration of the particle during the first 5 seconds of motion.



[6]

(iv) that $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$ is an eigenvector of the matrix **D**, where

statement describes the speed of the object after it is fired until immediately before it reaches the ground again?

[5]

(b) (v) 1,2 and 3

counts the number of emails, x, he receives each day and notes that, over a period of n days, $\Sigma(x-10) = 27$ and the mean number of emails is 11.5 . Find the value of n.

[5]

(iv) 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.

is the ratio $\frac{\text{stress at } Y}{\text{stress at } X}$?

[4]

(i) Show that the kinetic energy of the electron before the collision is 1.1×10^{-15} J.

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.

[4]

(ii) continuous random variable X takes values in the interval $0 \leqslant x \leqslant 3$ only. For $0 \leqslant x \leqslant 3$ the graph of its probability density function f consists of two straight line segments meeting at the point $(1, k)$, as shown in the diagram. Find k and hence show that the distribution function F is given by

$$C_1: \quad r = a$$
$$C_2: \quad r = 2a\cos 2\theta, \text{ for } 0 \leqslant \theta \leqslant \tfrac{1}{4}\pi$$

[6]

14 (iv) 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) equation gives v in terms of A and u ?

Using $\alpha = 3$, find the shortest distance of the point D from the line AC, giving your answer correct to 3 significant figures.

[5]

(d) 6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

is the effect of a systematic error on the measurement of a physical quantity?

is the mass of the car?

[10]

(a) a vector equation for l.

diagram, showing these three forces to scale, is correct?

[8]

(iii) p and q are given real numbers, then

(e) mean, $\bar{x}$, is 28.325 .

[2]

(c) the roots of the equation $z^3 = 27 - 27\mathrm{i}$, giving your answers in the form $r\mathrm{e}^{\mathrm{i}\theta}$, where $r > 0$ and $-\pi \leqslant \theta < \pi$.

Each seconds = ... ij **[4]**

(i) metal electrical conductor has a resistance of 5.6kΩ. A potential difference (p.d.) of 9.0 V is applied across its ends.

diagram shows a car travelling at a constant speed in a straight line between person P and person Q from point X to point Y .

object hangs by means of two cords around two rods, as shown.

(c) 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]

(a) the probability generating functions, $\mathrm{G}_X(t)$ of X and $\mathrm{G}_Y(t)$ of Y.

[8]

(b) a, b and c are integers to be determined.

[6]

(ii) the inequality $|x + 2| > \left|\frac{1}{2}x - 2\right|$.

(c) the surface area generated when C is rotated through 2π radians about the x-axis.

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{x+5}{x^2+10x+61}y = 1,$$

Use a different object that has twice the density and the same volume as the original object.

[12]

(b) safety precautions to be taken.

Show that the length of the arc of C from the pole to the point furthest from the pole is given by

[12]

(vi) radio-controlled toy car travels along a straight line for a time of 15 s .

safety precautions to be taken.

(c) Find the frictional and normal components of the contact force acting on B.

[6]

(d) the exact solutions of the equation $\mathrm{f}(x) = 1$.

[6]

(b) mid-day temperature, $x°$C, and the amount of sunshine, y hours, were recorded at a winter holiday resort on each of 12 days, chosen at random during the winter season. The results are summarised as follows.

[5]

(h) was the by-product of this reaction?

The wavelength of maximum intensity of emission is used to determine a value for the surface temperature of the star.

[5]

26 of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

Find the equations of the asymptotes of C.

(b) (i) exactly at point S

Find a 99% confidence interval for μ, giving your answer correct to 2 decimal places.

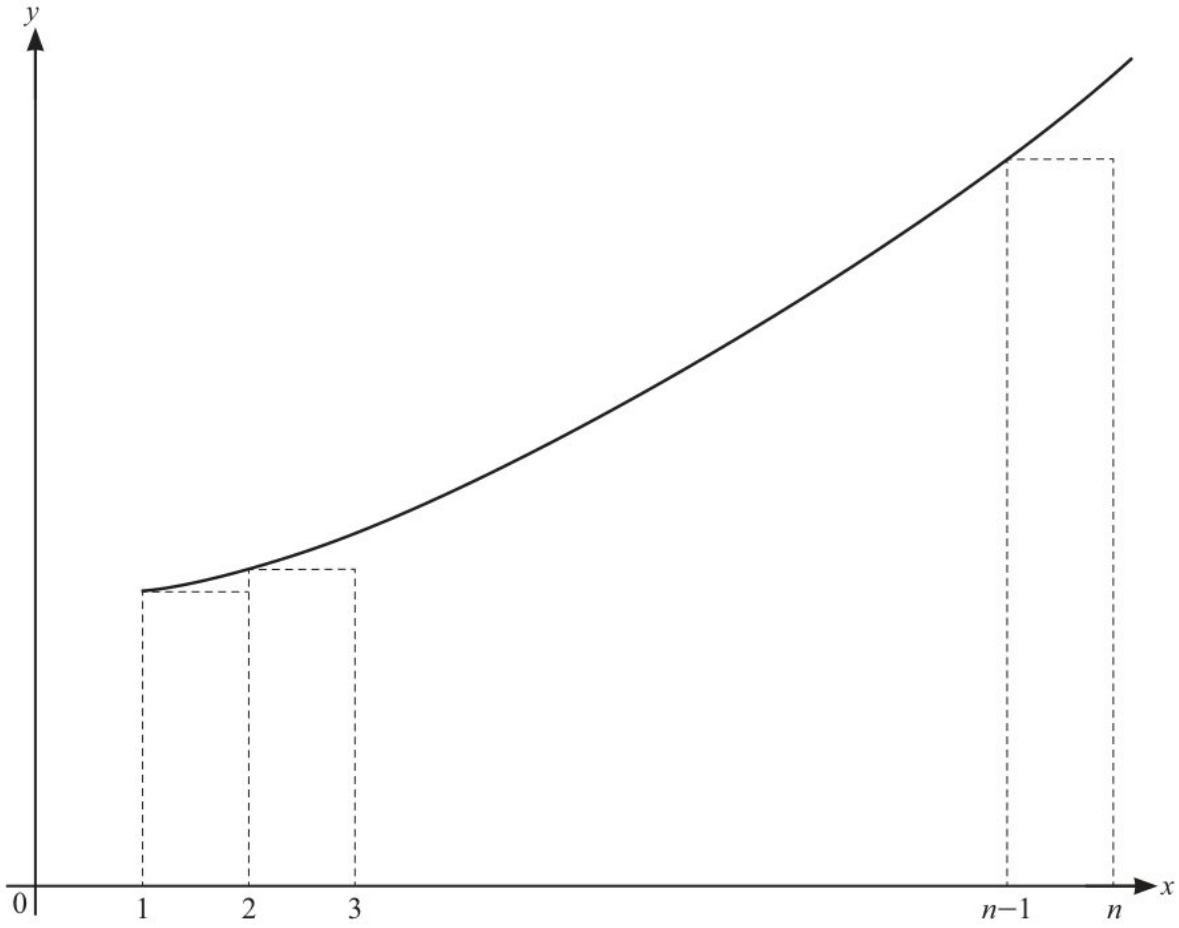
[3]

(ii) value for the Hubble constant is 2.3×10^{-18} s^{-1}.

skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

[4]

(a) (iv) amplitude $\propto$ (intensity $)^2$



[10]

(i) the value of σ.

the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

Find the magnitude and direction of the force exerted by the surface on the lamina at A.

[12]

10 the exact value of $\int_{\frac{1}{5}\pi}^{\frac{1}{4}\pi} 3\cos^2 5x \, \mathrm{d}x$

light is passed through a narrow slit and the grating is placed so that its lines are parallel to the slit. Light passes through the slit and then the grating.

(f) (iii) the value of $\sum y^2$, correct to 1 decimal place.

satellite in (b) is moved to an orbit in which the satellite remains at the same point above the surface of Mars.

support at end X exerts a force F vertically upwards on the plank.

[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 .

single change would double the value of this ratio?

[4]

(c) (vi) Derive an expression for v in terms of B and the electric field strength E.

Find also the exact value of the surface area generated when C is rotated through 2π radians about the x-axis.

[4]

(iii) up the probability distribution table for X.

Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

[8]

(a) (vi) cylindrical copper wire P of length 0.24 m is shown in Fig. 6.1.

a value, to three significant figures, for the specific latent heat of fusion of water.

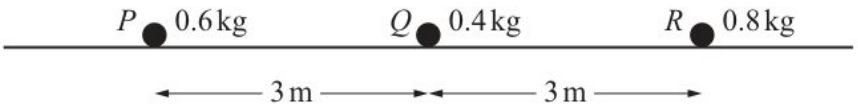
[8]

(iii) State the number of roots of the equation $\mathrm{p}\left(2^{y}\right)=0$, justifying your answer.

Find the value of t when the particle is instantaneously at rest.

[3]

(iv) arrangement that can be used to determine the speed of sound in air is shown in Fig. 6.1.



[8]

(ii) and explain whether the nuclei in the sample are undergoing α-decay, β^{+}decay or β^{-}decay.

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Observed frequency	1	3	15	31	59	107

[2]

(i) Find the modulus and argument of u.

curves C_1 and C_2 have polar equations

[5]

21 that $\mathrm{E}(X)=3.05$, find the values of p and q.

(c) (ii) random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.

Find the value of a.

diagram shows a charged particle as it approaches a pair of charged parallel plates in a vacuum.

[8]

(iv) the term isotope.

system is released from rest with OP making a small angle α with the downward vertical. Find

[8]

(b) (i) diagram shows the force-extension graph produced.

$$f(x) = \begin{cases} kx^2 & 0 \leqslant x < 6 \\ 0 & \text{otherwise} \end{cases}$$

[5]

(iii) How many possible arrangements are there of seating Mary, Ahmad, Wayne, Elsie and John assuming there are no restrictions?

variables x and y satisfy the differential equation

[2]

(a) (vi) By using the substitution $y = \frac{1}{x^2}$, find the cubic equation with roots $\frac{1}{\alpha^2}$, $\frac{1}{\beta^2}$ and $\frac{1}{\gamma^2}$.

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.

uniform metre rule of mass 100 g is supported by a pivot at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.

[3]

(i) Find the value of x.

the expected value and variance of Y.

[8]

(ii) mass of the liquid is 0.36 kg $\pm$ 10%.

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

[2]

(e) (iii) The extension of the wire is proportional to the tensile force.

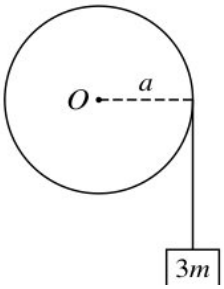
wave pattern produced in (b) is shown in Fig. 7.1.

It consists of two quarks that do not need to be the same flavour.

[12]

(v) 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.

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.



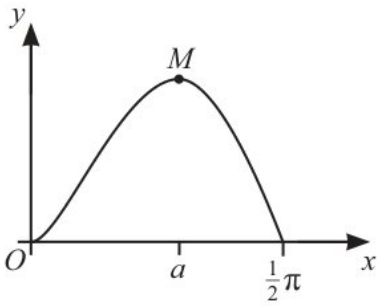
[12]

12 8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, dx$ for $n > 0$.

polarised beam of light with intensity I is incident normally on a polarising filter.

car is accelerated by a constant resultant force of 300 N for 5.0 s .

(c) (ii)



Given that $\cos\alpha = \frac{1}{6}$, find the greatest speed achieved by the centre of the sphere in the subsequent motion.

a period of time Julian finds that on long-distance flights he flies economy class on 82% of flights. On the rest of the flights he flies first class. When he flies economy class, the probability that he gets a good night's sleep is x. When he flies first class, the probability that he gets a good night's sleep is 0.9 .

[4]

(iv) the period of small oscillations,

row compares the number of charge carriers per unit time passing through X and through Y and compares the average drift speed of the charge carriers in X and in Y ?

are selected from these 20 to perform at a concert.

[5]

(d) (iii) progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

force is caused only by a pressure difference?

[6]

(iv) 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

X and Y are connected in series to a cell.

$$\mathrm{f}(t) = \begin{cases} 0 & t < 0 \\ \lambda \mathrm{e}^{-\lambda t} & t \geqslant 0 \end{cases}$$

[10]

11 planes p and q have equations $x + y + 3z = 8$ and $2x - 2y + z = 3$ respectively.

Find the equation of the tangent to the curve at the point where $x = 0$.

(c) (iii) variables x and y are related by the differential equation

the Young modulus.

suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.

[4]

(vi) The power to X will increase and the powers to Y and Z will decrease.

$$\mathrm{f}(t) = \begin{cases} 0 & t < 0 \\ \lambda \mathrm{e}^{-\lambda t} & t \geqslant 0 \end{cases}$$

Calculate the distance moved by the car during this acceleration.

[5]

(i) the acute angle between the planes ABC and ABD.

uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

[15]

(ii)

the apparatus used to produce two sources of coherent waves that have circular wavefronts,

flights = ... *ci* **[6]**

(a) (i) State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

$$\mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \lambda(\mathbf{i} - 2\mathbf{j} - \mathbf{k}) \quad \text{and} \quad \mathbf{r} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k} + \mu(2\mathbf{i} + 3\mathbf{j} - \mathbf{k}).$$

[6]

(v) 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?

particle P is projected from a point O with speed U at an angle $45°$ above the horizontal and moves freely under gravity.

[4]

11 is the speed of the block at the bottom of the slope?

(a) (ii) V increases because there is a p.d. across R.

Given that $\mu = 0.36$ and that both P and Q move in the same horizontal circle of radius 0.5 m , calculate the greatest possible value of ω and the corresponding tension in the string.

[4]

(iv) Show that the possible values of α are 3 and 5 .

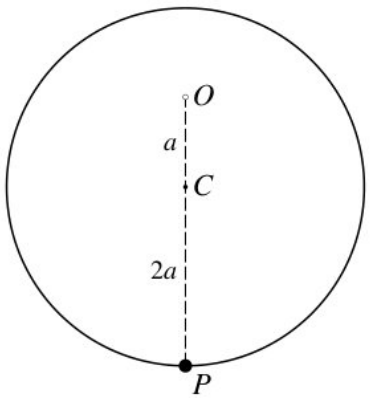
Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

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.

[6]

(iii) wavelength of the wave and the width of the gap are both changed by a small amount.

Show that $v^2 = u^2 + \frac{14}{5}ag$.



[3]

(i) for a wire,

Show that the equation

[4]

(c) (vi) that $y = 0$ when $x = 0$. Give your answer in an exact form.

Find the value of the product moment correlation coefficient for this sample.

[6]

(ii) particle is not involved in the decay process?

Calculate the modulus of elasticity of the string.

[10]

(iii) is given that $\sum x = 175.0$ and that the mean of y is 8.4 .

Find the modulus and argument of u.

[8]

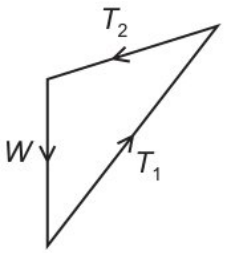
(f) (i) Find the mean age of all 19 people.

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.

basic principle of note production in a horn is to set up a stationary wave in an air column.

[6]

(iii) student investigates the cooling of a liquid in a beaker.



[6]

24 bands will be selected from the original group of 20 musicians. Each band will consist of 3 guitarists, 1 pianist and 1 drummer. No musician can be in more than one band. The first band selected will play at a concert in France, the second band selected will play in Italy and the third band selected will play in Spain.

(a) (iii) point P is the foot of the perpendicular from A to l.

$a =$ ……..

$b =$ ……..

$x =$ ……..

$y =$ ……..……..

[3]

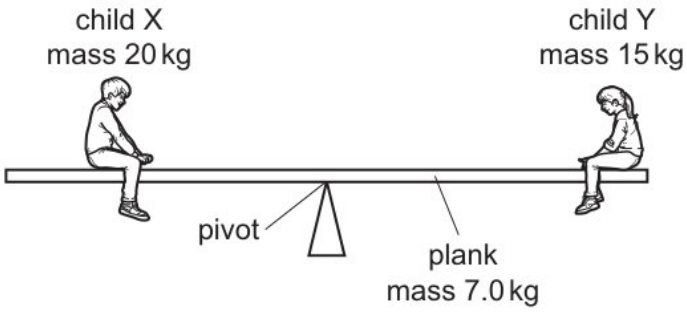
[6]

(v) row describes the momentum and kinetic energy of the two bodies after the collision?

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

[6]

(iv) Show that $u^3 + 8 = 0$.



[10]

(i) 8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, \mathrm{d}x$ for $n > 0$.

is suggested that these results are consistent with a distribution having probability density function f given by

[6]

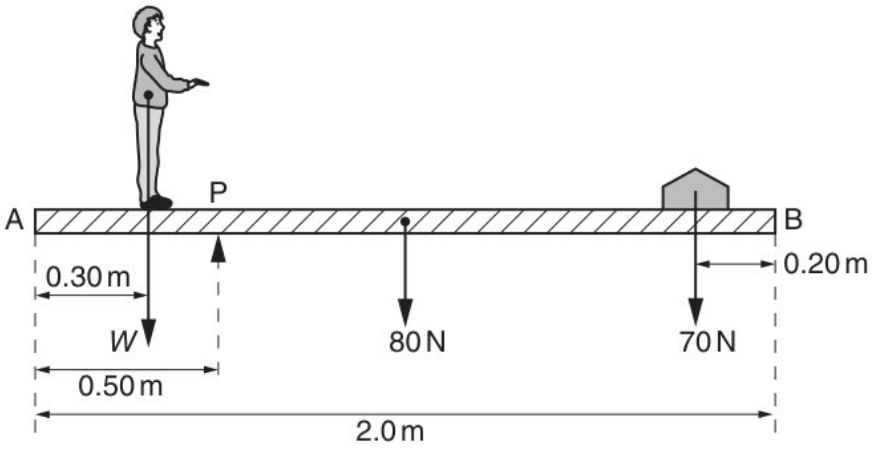
(c) (i) now that the standard deviation of the population is known to be 5.6 minutes. Find the smallest sample size that would lead to a 95% confidence interval for μ of width at most 5 minutes.

car is travelling along a road that has a uniform downhill gradient, as shown in Fig. 2.1.

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

[8]

(iv)



$\frac{\text{mass}}{\text{length} \times (\text{ time })^2}$

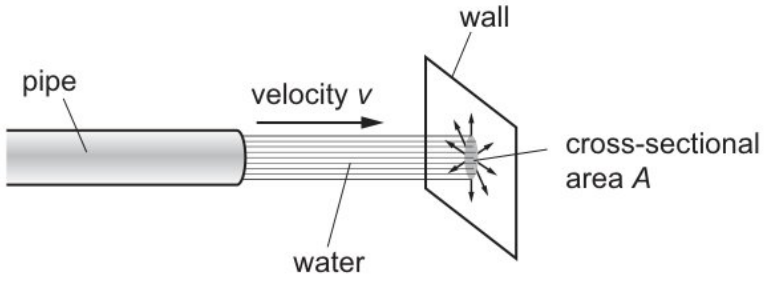
[6]

(h) (i) 1,2 and 3

discrete random variable X has the following probability distribution.

[1]

(ii)



The matrix **B**, where

[4]

17 (b) the probability that, when the 3 cars are selected, at least one car is white and at least one car is black.

random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

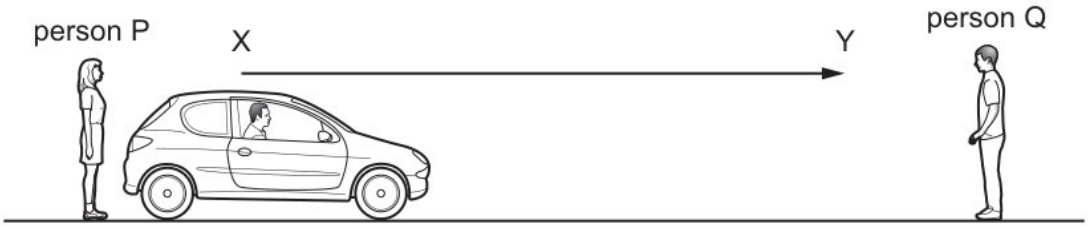
that $\frac{\mathrm{d}}{\mathrm{d}t}\left(\operatorname{sech}^{-1} t\right) = -\frac{1}{t\sqrt{1-t^2}}$.

(iii) State what is meant by the internal energy of a system.

what can be deduced from this about the rotation of Mars on its axis.

[4]

(iv) Find the values of p and q such that



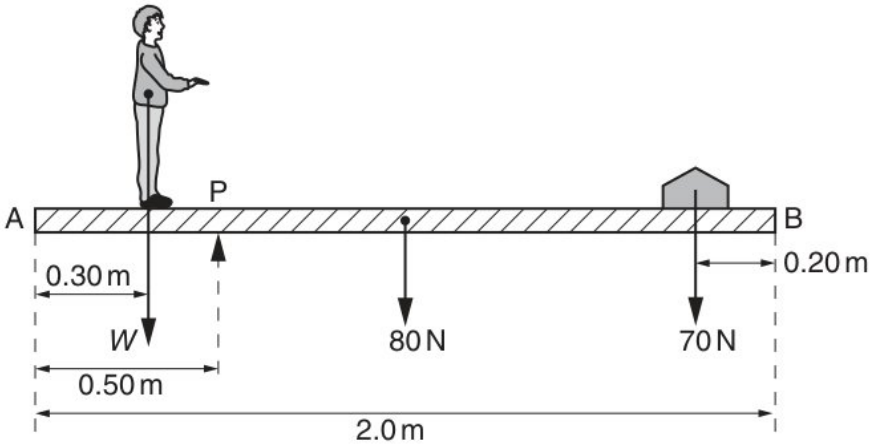
V remains the same because the sum of the p.d.s across r and R is still equal to E.

[5]

(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.

[5]

(c) 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.



would this object weigh on Pluto?

(iii) is the force on an electron when it is in the uniform electric field between the plates?

Show that the possible values of α are 3 and 5 .

[4]

(v) point D has position vector $\mathbf{i} + t\mathbf{k}$, where $t \neq -2$.

expression gives the electrical resistance of the metal cube between X and Y ?

[2]

(a) polar equation of a curve C is $r = a(1 + \cos\theta)$ for $0 \leqslant \theta < 2\pi$, where a is a positive constant.

(iii) diagram shows a car travelling at a constant speed in a straight line between person P and person Q from point X to point Y .

adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

[5]

(ii) leptons are emitted from the sodium-21 nucleus during the decay?

rods rods = ... *di* **[15]**

(i) Draw a sketch of C for the case $\lambda > 3$.

[5]

11 Velocity is proportional to wavelength.

will the powers to the resistors change when resistor W is removed?

V remains the same because the decrease of p.d. across r is balanced by the increase of p.d. across R.

curve C has equation $y = \frac{1}{2}(\mathrm{e}^{x} + \mathrm{e}^{-x})$ for $0 \leqslant x \leqslant 4$.

(a) (ii) time-base setting on the oscilloscope should be used?

Show that the cartesian equation of C is

[4]

(i) car then travels up a slope at 2° to the horizontal, maintaining the same constant speed.

has 10 different books from the series Squares and Circles. The books look similar except for their colour. There are 3 blue books, 2 red books, 2 yellow books, 1 orange book, 1 purple book and 1 green book.

[3]

(vi) State the gradient of the curve at the point $(-1, 2)$ and sketch the curve.

is the useful power output of the power station?

many different colour arrangements are there of the 10 books in which the 3 blue books are together, but the 2 yellow books are not next to each other?

[3]

(iv)

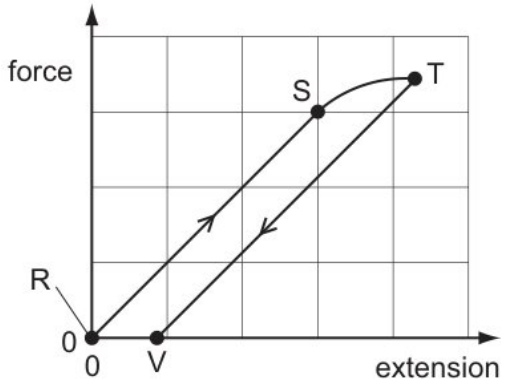
Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Expected frequency	1	7	a	b	c	91

is the charge, in terms of the elementary charge e, on a charm quark?

Find the greatest height that P reaches above the level of O.

[2]

(c) (iii)



Find the eigenvalues and corresponding eigenvectors of the matrix **A**, where

[6]

(iv) Find the values of a and b.

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?

[8]

(ii) The weight of the plank can be considered to be acting at its midpoint.

Show that the tension in the string is 10 N .

[6]

20 the general solution of the differential equation

(a) (i) eigenvalues $1, -1$ and -2 .

the value of c such that $\mathrm{P}(-c < t < c) = \frac{1}{2}$.

verify that this equation has a root between 5 and 5.05.

[5]

(ii)

Gulls	7.9	8.2	8.3	8.6	8.6	8.8	9.2	9.7	9.8	10.0	10.4
Herons	9.5	9.9	8.5	8.1	9.2	10.8	8.3	9.7	9.3	9.9	8.7

a is a positive constant. Sketch C_1 and C_2 on the same diagram.

[3]

(b) (ii) a 95% confidence interval for the difference between the mean number of beech trees in regions of this size in country A and in country B.

to the value α.

[20]

(iv) statement is correct when S is changed from open to closed?

aeroplane is flying at a constant speed.

potential difference (p.d.) between P and Q is V.

[6]

(c) (i) a similar method to find a lower bound for $\sum_{r=1}^{n} \frac{n}{n^2+r^2}$. Give your answer in terms of n and π.

$$\mathbf{A} = \begin{pmatrix} -1 & 3 & 4 \\ 0 & 1 & 0 \\ 0 & -2 & 5 \end{pmatrix}$$

[6]

(ii) position vectors of the points A, B, C, D are

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.

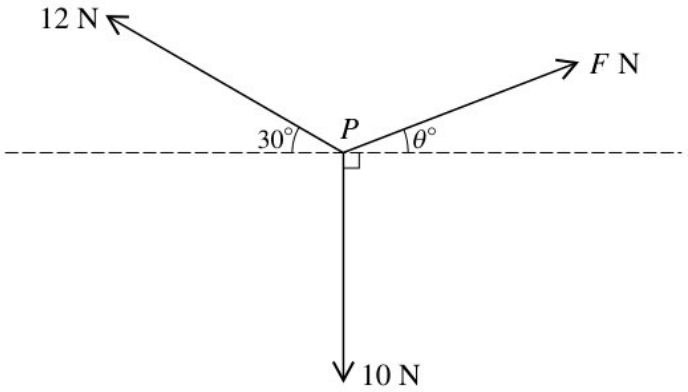
[12]

(v) Find the x-coordinate of the point P at which the tangent to the curve passes through the origin.

is given that $\int_1^a x^{\frac{1}{2}} \ln x \, \mathrm{d}x = 2$, where $a > 1$.

balls = ... *bk* **[12]**

21 the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.



(b) (v) 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.

Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

Find the frictional and normal components of the contact force acting on B.

[4]

(iii) Find the magnitude and direction of the force exerted by the surface on the lamina at A.

that $\begin{pmatrix} 1 \\ 6 \\ 3 \end{pmatrix}$ is an eigenvector of the matrix $\mathbf{D}$, where

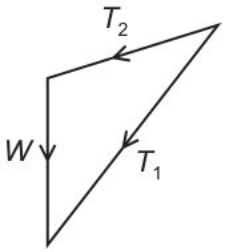
[6]

(ii) Hence show that there are only two points on the curve at which the tangent is parallel to the x-axis and find the coordinates of these points.

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.

[8]

(c) (i)



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.

row compares the number of charge carriers per unit time passing through X and through Y and compares the average drift speed of the charge carriers in X and in Y ?

[5]

(v) $\frac{\text{force}}{\text{length} \times \text{speed}}$

force is caused only by a pressure difference?

[1]

12 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.

point D is such that $ABCD$ is a parallelogram.

(v) (f) weight of the parachutist is 850 N .

V remains the same because the sum of the p.d.s across r and R is still equal to E.

[5]

(b) combined resistance is 66kΩ.

525 520 522 524 518 520 519 525 527 516

by induction that $u_n = 6^n - 1$ for all positive integers n.

[8]

(d) 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 $(x - 2)$.

525 520 522 524 518 520 519 525 527 516

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 $\frac{8}{3}Ma^2$.

[10]

(ii) (b) V remains the same because the sum of the p.d.s across r and R is still equal to E.

is now given that the true value of p is 0.05 .

graphs show possible current-voltage $(I - V)$ relationships for a filament lamp and for a semiconductor diode.

[12]

(g) a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A} - 2\mathbf{I} = \mathbf{PDP}^{-1}$.

Explain why the internal energy of an ideal gas is directly proportional to the thermodynamic temperature of the gas.

[6]

(d) flows out of a pipe and hits a wall.

the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

[4]

21 The matrix $\mathbf{B}$, where

combined resistance is 66kΩ.

(c) (i) Find the values of p and q.

roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

[20]

(iii) 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.

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 $3 : 4$.

[15]

(iv) that $\mathrm{E}(X) = 3.05$, find the values of p and q.

that $\mathbf{B} = \mathbf{A}^{-1}$, use the characteristic equation of $\mathbf{A}$ to show that $\mathbf{B}^2 = p\mathbf{I} + q\mathbf{A}$, where p and q are constants to be determined.

[5]

(ii) the value of $\left(\alpha^3 - 1\right)^2 + \left(\beta^3 - 1\right)^2 + \left(\gamma^3 - 1\right)^2$.

the complex numbers z for which $\frac{z+5\mathrm{i}}{z-5}$ is real and $|z| = \sqrt{17}$ Give your answers in the form $z = x + \mathrm{i}y$ where x and y are real

[5]

(a) (iv) The waves must be coherent.

line l_2 has equation $\mathbf{r} = 2\mathbf{i} + \mathbf{j} + 5\mathbf{k} + \mu(\mathbf{i} + 2\mathbf{j} + 3\mathbf{k})$.

[12]

(i) find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

$$\frac{\mathrm{d}^n}{\mathrm{d}x^n}\left(x^n \ln x\right) = n!\left(\ln x + 1 + \frac{1}{2} + \ldots + \frac{1}{n}\right).$$

[6]

(iii) random sample of residents in a town took part in a survey. They were asked whether they would prefer the local council to spend money on improving the local bus service or on improving the quality of road surfaces. The responses are shown in the following table, classified according to the area of the town in which the residents live.

a and **b** are vectors and t is a scalar.

Use your answer in (i) and an equation of motion to show that kinetic energy of a mass can be given by the expression

[8]

(b) (iii) what is meant by centre of gravity.

diagram correctly represents the forces acting at point P ?

[15]

(iv) a value, to three significant figures, for the specific latent heat of fusion of water.

Find the perpendicular distance of the point A from the line BC.

[2]

(ii) light is passed through a narrow slit and the grating is placed so that its lines are parallel to the slit. Light passes through the slit and then the grating.

diagram shows four forces applied to a circular object.

[15]

(f) (ii) roots of the cubic equation $x^3 + 2x^2 - 3 = 0$ are α, β and γ.

continuous random variable X has probability density function f given by

[8]

(i) 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'.

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 $t = 2$.

[5]

(iv) linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

is the average velocity of the toy car for the journey shown by the graph?

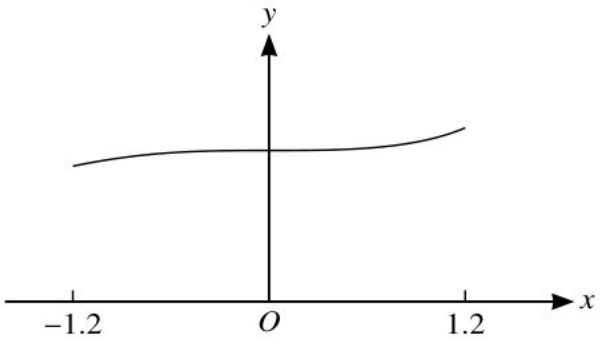
[5]

(v) 38% of these leaves are of length k cm or more.

find the position vectors of P and Q.

rest = ... *er* **[12]**

11 quantities would be measured in order to determine E ?



Its speed decreases to zero, then increases to 20 m s^{-1}.

(a) (i) $I_n = \int_0^1 (1-x)^n \sinh x \, \mathrm{d}x$, where n is a non-negative integer.

525 520 522 524 518 520 519 525 527 516

[10]

(iii) Derive an expression for v in terms of B and the electric field strength E.

$$\mathbf{A} = \begin{pmatrix} -1 & 3 & 4 \\ 0 & 1 & 0 \\ 0 & -2 & 5 \end{pmatrix}$$

[2]

(iv) C in the case $p = -1$. Your sketch should indicate the coordinates of any intersections with the axes, but need not show the coordinates of any turning points.

curve C has polar equation $r = \theta e^{\frac{1}{8}\theta}$, for $0 \leqslant \theta \leqslant 2\pi$.

diagram best represents the electric field surrounding the charges?

[5]

(d) (iii) Find the terms in x^2 and x^3 in the expansion of $\left(1 - \frac{3}{2}x\right)^6$.

The orbit has a period of 25 hours.

[5]

(ii)

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

specific latent heat.

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.

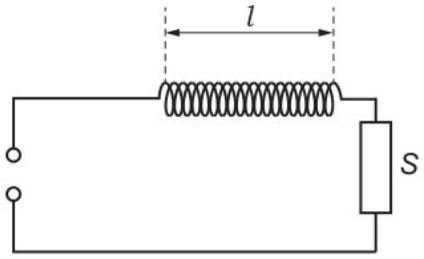
[5]

(i) 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.

- decelerating at a constant rate with the parachute open,

[6]

27 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.



Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

(e) (v) the differential equation to obtain an expression for y^2 in terms of x.

are the frequencies of the next two higher notes for this air column?

[8]

(iii) temperature θ_R of the laboratory is measured using a thermometer.

Express f(x) in partial fractions.

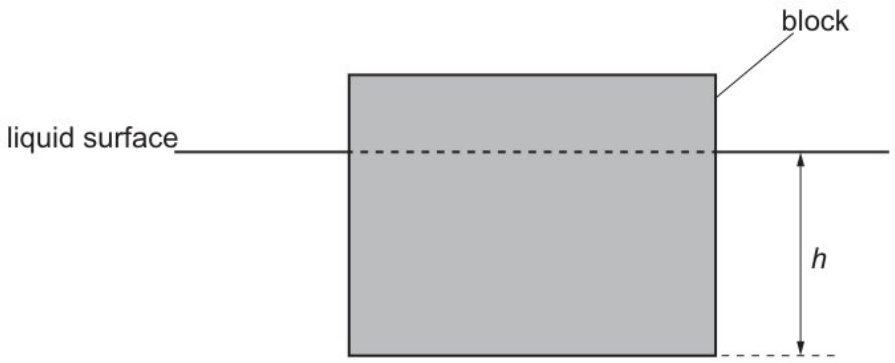
[8]

(b) (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 $-\pi \leqslant \theta < \pi$.

procedure to be followed,

[8]

(ii)



linear transformation $\mathrm{T} : \mathbb{R}^4 \to \mathbb{R}^4$ is represented by the matrix $\mathbf{A}$, where

[6]

(iv) Find $\sum_{r=n+1}^{2n} u_r$.

$$\mathbf{A} = \begin{pmatrix} 0 & 1 & 3 \\ 3 & 2 & -3 \\ 1 & 1 & 2 \end{pmatrix}.$$

Show that $\frac{\mathrm{d}s}{\mathrm{d}x} = \frac{1}{2}(\mathrm{e}^{x} + \mathrm{e}^{-x})$, where s denotes the arc length of C, and find the surface area generated when C is rotated through 2π radians about the x-axis.

[4]

(v) Express u in the form $x + \mathrm{i}y$, where x and y are real.

the probability density function of Y,

[12]

(a) (i) progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

is a planet that may be considered to be an isolated uniform sphere of radius 3.4×10^6 m.

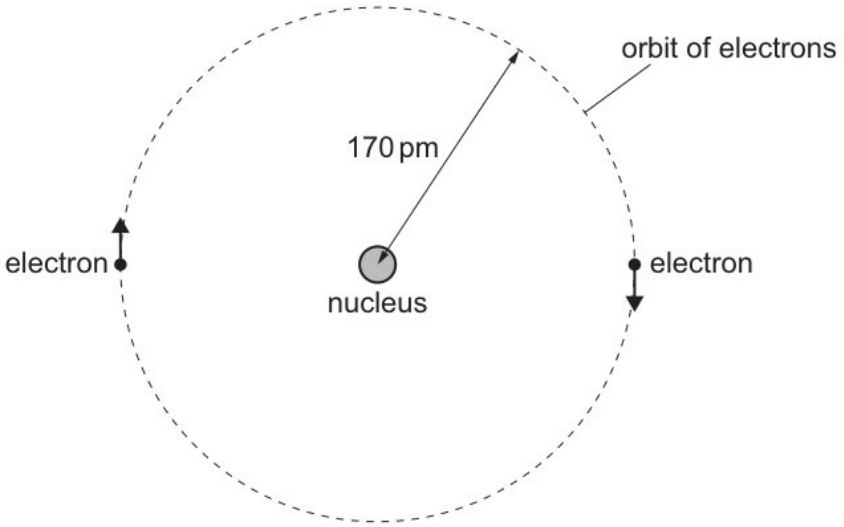
[5]

(ii) de Moivre's theorem to show that

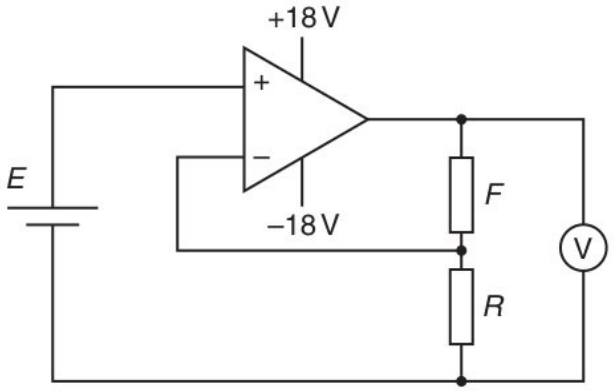
experiment consists of throwing a biased die 30 times and noting the number of 4 s obtained. This experiment was repeated many times and the average number of 4 s obtained in 30 throws was found to be 6.21.

[2]

(iii)



Use the information in (d)(iv) to determine, to three significant figures, the wavelength associated with the gamma radiation emitted in the collision.



[8]

15 is a statement of the principle of conservation of momentum for a system?

(d) (iv) a matrix $\mathbf{P}$ and a diagonal matrix $\mathbf{D}$ such that $\mathbf{A}^{-1} = \mathbf{PDP}^{-1}$.

lifetime, in hours, of a 'Trulite' light bulb is a random variable T. The probability density function f of T is given by

[6]

(ii) $\mathrm{f}(x) = \frac{3a-5x}{(3a+2x)(2a-x)}$ where a is a positive constant

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.

[10]

(c) (iii) find corresponding eigenvectors.

Hence find the largest integer y satisfying the inequality $|2\ln y - 5| < |\ln y + 3|$.

[5]

(iv) 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.

the equations of the asymptotes of C.

[5]

(b) (i) the principle of moments.

Show that the area of the shaded region bounded by the curve, the x-axis and the line $x = 3$ is equal to $2 - \frac{17}{e^3}$.

[4]

(iii) C, stating the coordinates of the intersections with the axes.

sample contains a single radioactive isotope that decays to form a stable isotope.

[2]

(iv) a, b and c are integers to be determined.

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.

[5]

24 momentum = mass × velocity

(b) (i) in terms of m and g, the magnitude of the frictional force in this position.

Given that $\mathrm{E}(X) = \frac{5}{2}$, calculate $\mathrm{Var}(X)$.

[2]

(ii) Hence explain why the roots of the equation $16x^4 - 20x^2 + 5 = 0$ are $x = \pm\sin\frac{1}{5}\pi$ and $x = \pm\sin\frac{2}{5}\pi$.

points A, B, C have position vectors

deviation = ... kh **[8]**

(vi) the differential equation to obtain an expression for y^2 in terms of x.

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

is meant by elastic deformation?

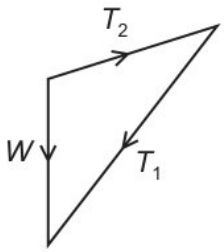
[4]

(iv) 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.

Find the tension in the string in terms of W.

town quality = ... ky **[2]**

(d) (iv) Find $\frac{\mathrm{d}}{\mathrm{d}x}\left(x\left(4+x^2\right)^{-n}\right)$ and hence show that



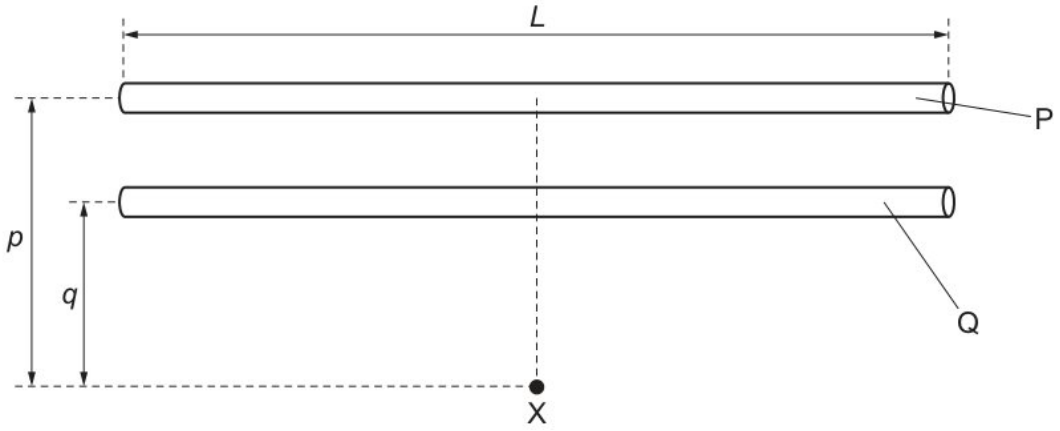
[3]

(ii) load on the lower end is increased from zero and then decreased again back to zero.

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]

(i) Potential difference is energy per unit current.



Express f(x) in partial fractions.

[12]

(iii) system is released from rest with OP making a small angle α with the downward vertical. Find

The waves must be coherent.

[6]

(a) (i) the ductile material,

mean, $\bar{x}$, is 28.325 .

[6]

(iv) none of them

cell of electromotive force (e.m.f.) E and internal resistance r is connected in series with a switch S and an external resistor of resistance R.

[4]

(ii) Find the coordinates of any intersections with the coordinate axes.

is given that $y = 2$ when $x = 2$.

mass = ... fa **[3]**

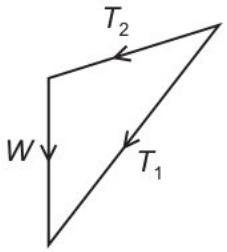
(iii) circuit symbol does not represent an electric component that is designed to emit sound waves?

diagram shows part of the curve $y = 4\sqrt{x} - x$. The curve has a maximum point at M and meets the x-axis at O and A.

[10]

22 the term interference.

(a) (i)



chooses an appropriate random sample of 60 students. She finds that 45 of these students think that the sports facilities are good.

[6]

(iii) the method of differences to find $\sum_{r=1}^{n} \frac{1}{(2-3r)(5-3r)}$ in terms of n.

a vector equation for the line l_1.

are the frequencies of the next two higher notes for this air column?

[4]

(iv) that, at the point $A(-1, 1)$ on C, $\frac{\mathrm{d}y}{\mathrm{d}x} = -4$.

now that the standard deviation of the population is known to be 5.6 minutes. Find the smallest sample size that would lead to a 95% confidence interval for μ of width at most 5 minutes.

[1]

(v) 6.1 shows a circuit that rectifies an alternating input voltage V_{IN} and produces an output voltage V_{OUT} across a resistor R.

of these springs is placed in each corner of a horizontal square plate. The axis of each spring is in a vertical direction. These four springs support a total load of 160 N .

[12]

(b) (i) with a reason, whether you agree with Nikki's friend.

procedure to be followed,

[6]

(iii) water is added to an insulated beaker, as shown in Fig. 2.1.

curves C_1 and C_2 have polar equations

[6]

16 find $1^2 - 2^2 + 3^2 - 4^2 + \ldots - (2n)^2$, simplifying your answer.

(i) (e) Show that $\cos\theta = \frac{2}{3}$.

continuous random variable X takes values in the interval $0 \leqslant x \leqslant 3$ only. For $0 \leqslant x \leqslant 3$ the graph of its probability density function f consists of two straight line segments meeting at the point $(1, k)$, as shown in the diagram. Find k and hence show that the distribution function F is given by

to the value α.

[6]

(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}.

battery is marked 9.0 V .

[8]

(ii) (c) Derive an expression for v in terms of B and the electric field strength E.

waves are emitted from two sources.

three coplanar forces shown in the diagram act at a point P and are in equilibrium.

[10]

(b) Find the area of the region enclosed by C.

$$1 - \tanh^2 u = \operatorname{sech}^2 u.$$

[2]

(a) time T, particle P is moving at an angle of $60°$ below the horizontal.

tractor of mass 3700 kg is travelling along a straight horizontal road at a constant speed of 12 m s^{-1}. The total resistance to motion is 1150 N .

the coordinates of any stationary points on C.

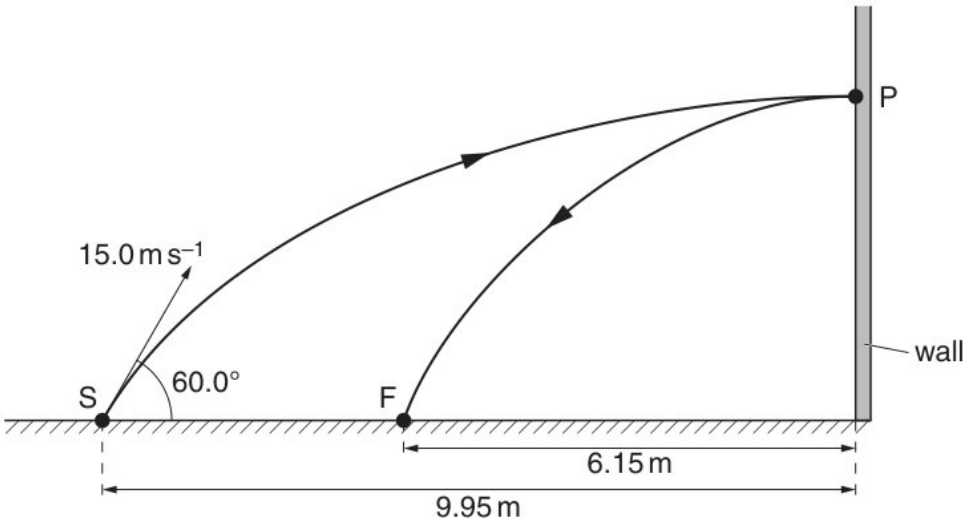
[5]

(iv) (a) the particular solution of the differential equation

lifetime, in hours, of a 'Trulite' light bulb is a random variable T. The probability density function f of T is given by

[8]

(c) random sample of 12 customers who each bought a computer from this store is chosen.



[5]

(b) matrix **A** is given by

diagram shows part of the curve $y = 4\sqrt{x} - x$. The curve has a maximum point at M and meets the x-axis at O and A.

[5]

(iii) (b) has 16 toy cars, of which 8 are white, 5 are black and 3 are silver. He places all the cars in a bag and selects three of them at random, without replacement.

525 520 522 524 518 520 519 525 527 516

[2]

(a) random sample of five metal rods produced by a machine is taken. Each rod is tested for hardness. The results, in suitable units, are as follows.

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 $\frac{3k+1}{3(1-k)}$.

Stating your hypotheses, test at the 1% significance level whether there is a non-zero correlation between mid-day temperature and amount of sunshine.

[12]

(c) number, x, of beech trees was counted in each of 50 randomly chosen regions of equal size in beech forests in country A. The number, y, of beech trees was counted in each of 40 randomly chosen regions of the same equal size in beech forests in country B. The results are summarised as follows.

object is fully submerged in a liquid.

[8]

9 the de Broglie wavelength of an electron moving at a speed of 4.9×10^7 m s^{-1}.

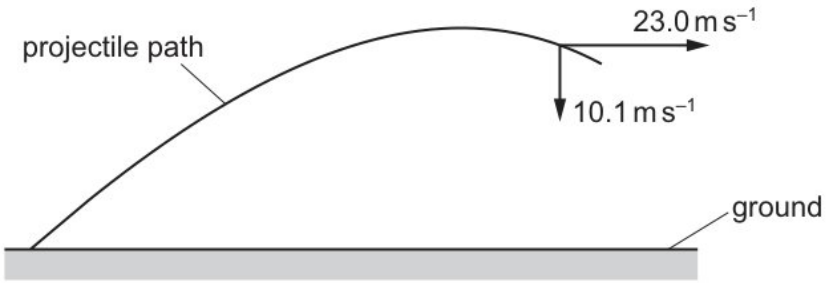
(b) (ii) the number of different ways in which the 6 musicians can be selected if there must be at least 3 guitarists, at most 2 pianists and exactly 1 drummer.

State one other feature of this orbit.

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 $\lambda\mu$.

[6]

(i) Young modulus E can be determined from measurements made when a wire is stretched.

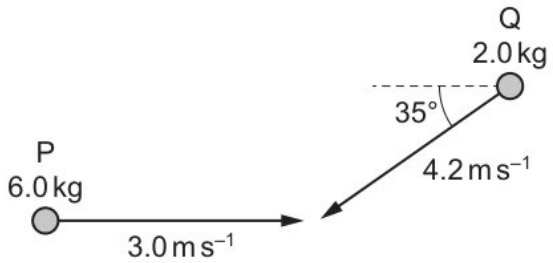


row correctly identifies the properties of all electromagnetic waves?

[4]

(iv) the solution of the differential equation

many electrons pass through a given cross-section of the wire in one second?



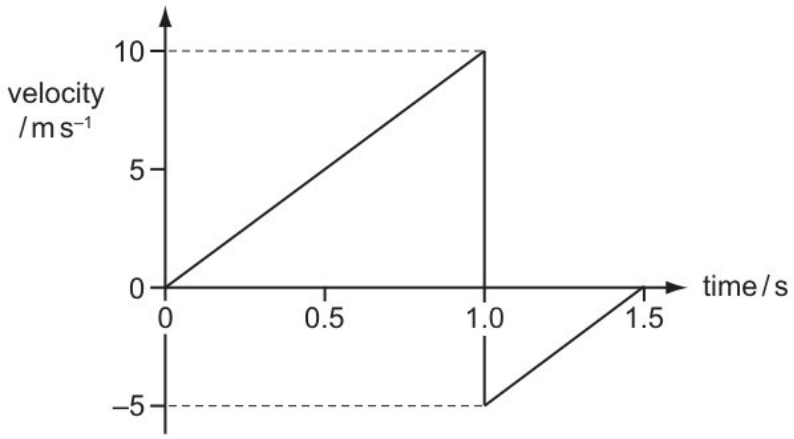
[4]

(a) (iv) a t test at the 5% significance level to find the range of values of k for which the result of the test is to reject the null hypothesis

fair six-sided dice with faces labelled $1, 2, 3, 4, 5, 6$ is thrown repeatedly until a 3 is obtained. The number of throws taken is denoted by the random variable X.

[6]

(ii)



191.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3}.

[6]

12 The speed of the car at the bottom of the first ramp is 14 m s^{-1}. Use an energy method to find the speed of the car when it reaches the bottom of the second ramp.

Find the x-coordinate of the maximum point M on the curve.

(a) (ii) that the mean of these 40 values is 124.0 , find the value of k.

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.

[15]

(i) ripple tank is used to demonstrate interference between water waves.

the quotient and remainder when $x^3 + 5x^2 - 2x - 15$ is divided by $x^2 - 3$.

[6]

(iii) Draw up the probability distribution table for X.

$\mathbf{A}^{2n}$, where n is a positive integer.

[5]

(d) (ii) the eigenvalues of the matrix $\mathbf{C}$, where

weight of 120 kN is placed on top of a metal column. The length of the column is compressed by 0.25 mm . The column obeys Hooke's law when compressed.

[5]

(iii) Amplitude is inversely proportional to velocity.

the iterative formula in part (c) to calculate a correct to 4 decimal places. Give the result of each iteration to 6 decimal places.

the average power of the aeroplane's engines.

[8]

(c) (iii) plane Π_1 passes through the points $(1, 2, 1)$ and $(5, -2, 9)$ and is parallel to the vector $\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$.

with a reason, whether it was necessary to use the Central Limit Theorem in your answer to part (b).

[6]

(ii) variable resistor in (b) is fitted with a scale so that its resistance can be accurately determined.

uniform solid sphere with centre C, radius $2a$ and mass $3M$, is pivoted about a smooth horizontal axis and hangs at rest. The point O on the axis is vertically above C and $OC = a$. A particle P of mass M is attached to the sphere at its lowest point (see diagram). Show that the moment of inertia of the system about the axis through O is $\frac{84}{5}Ma^2$.

[5]

(b) (iii) Show that $u^3 + 8 = 0$.

Explain the features of the graphs in (d) that show the characteristics of ductile and brittle materials.

[12]

(i) diagram shows a car travelling at a constant speed in a straight line between person P and person Q from point X to point Y .

Explain why the observed wavelength and the emitted wavelength have different values.

curve C has equation

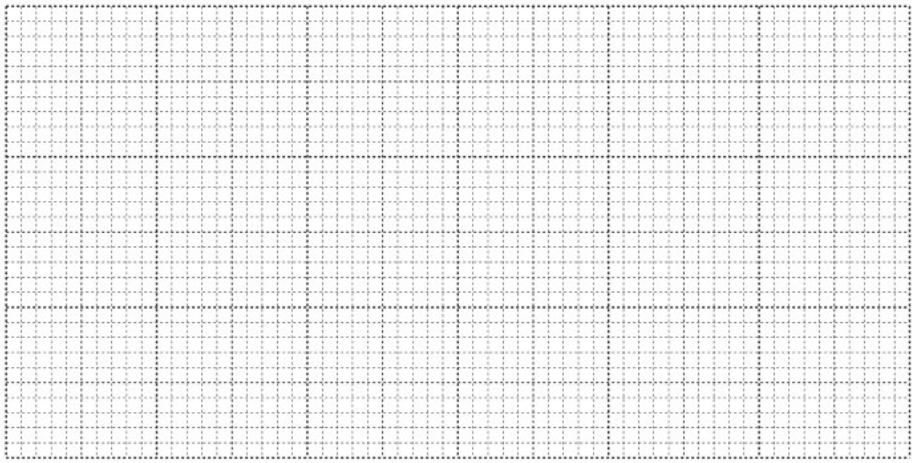
[2]

23 diagram shows four forces applied to a circular object.

Find the coordinates of the turning points of C.

a normal distribution, calculate a 95% confidence interval for the population mean.

(d) (iv)



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.

[10]

(v) 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.

$$x + 3y + kz = 4$$
$$4x - 2y - 10z = -5$$
$$x + y + 2z = 1$$

[3]

(c) (ii) Show that x satisfies the equation

the value of $\frac{\mathrm{d}^2y}{\mathrm{d}x^2}$ at the point $\left(4, \frac{1}{3}\right)$.

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.

[8]

(iii) that $T = \frac{U}{2g}(\sqrt{2} + \sqrt{6})$.

equation gives v in terms of A and u ?

[3]

(a) (ii) points A, B and C have position vectors $2\mathbf{i} - \mathbf{j} + \mathbf{k}, 3\mathbf{i} + 4\mathbf{j} - \mathbf{k}$ and $-\mathbf{i} + 2\mathbf{j} + 4\mathbf{k}$ respectively.

safety precautions to be taken.

[6]

(i) curve C has parametric equations

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]

(iii) The potential difference across any component connected to the battery will be 9.0 V .

overall efficiency of the turbine and generator system is 90%. The density of water is 1000 kg m^{-3}.

A	mass of stretching load	original length of wire	diameter of wire	extension of wire
B	mass of stretching load	new length of wire	cross-sectional area of wire	diameter of wire
C	mass of wire	original length of wire	cross-sectional area of wire	new length of wire
D	mass of wire	new length of wire	diameter of wire	extension of wire

[6]

(b) (vi) Given that $\tan 2\theta \cot \theta = 8$, show that $\tan^2 \theta = \frac{3}{4}$.

are the amplitude and period of the wave?

[8]

(ii) was the by-product of this reaction?

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Observed frequency	1	3	15	31	59	107

passengers flight arrive = ... yf **[4]**

(f) (i) Given that $\cos \alpha = \frac{1}{6}$, find the greatest speed achieved by the centre of the sphere in the subsequent motion.

much charge passes a given point in wire R in a time of $5s$?

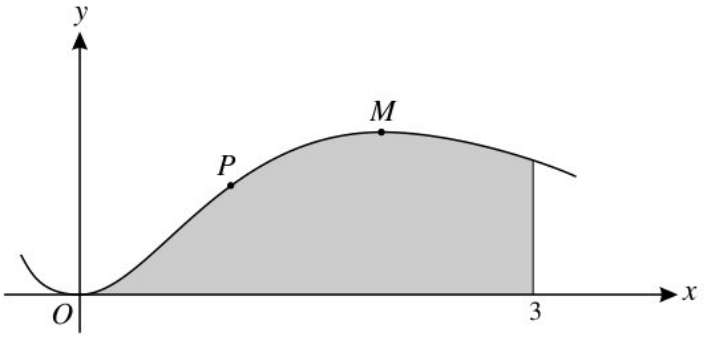
[6]

(vi) the value of $\left(\alpha^3 - 1\right)^3 + \left(\beta^3 - 1\right)^3 + \left(\gamma^3 - 1\right)^3$

$$(n-1)I_n = 2^{\frac{1}{2}n-1} + (n-2)I_{n-2}.$$

[5]

28 verify that this equation has a root between 5 and 5.05.



students are selected at random from the students who study Science.

(b) (iii) 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.

uniform metre rule of weight 2.0 N is pivoted at the 60 cm mark. A 4.0 N load is suspended from one end, causing the rule to rotate about the pivot.

[10]

(ii) 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.

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?

[5]

(c) (iv) 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.

$$\sum_{r=1}^{n}(2-3r)(5-3r) = an^3 + bn^2 + cn$$

[5]

(i) sample contains a single radioactive isotope that decays to form a stable isotope.

that u_{2n} is divisible by u_n for $n \geqslant 1$.

[3]

(v) student is investigating an electrical signal using a cathode-ray oscilloscope (c.r.o).

particles A and B have masses 0.3 kg and 0.1 kg respectively. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley, and the particles hang vertically below the pulley. Both particles are initially at a height of x m above horizontal ground (see diagram). The system is released from rest.

[6]

(a) (vi) Find the perpendicular distance of the point A from the line BC.

Show that $\frac{\mathrm{d}s}{\mathrm{d}x} = \frac{1}{2}\left(\mathrm{e}^{x} + \mathrm{e}^{-x}\right)$, where s denotes the arc length of C, and find the surface area generated when C is rotated through 2π radians about the x-axis.

[10]

(iv) the geometric effects of multiplying z_1 and z_2 by ω

Find the matrix product $\mathbf{A}\begin{pmatrix} -1 \\ 1 \\ -1 \\ 1 \end{pmatrix}$ and hence find the general solution of the equation $\mathbf{Ax} = \begin{pmatrix} 3 \\ 21 \\ 24 \\ 27 \end{pmatrix}$.

[2]

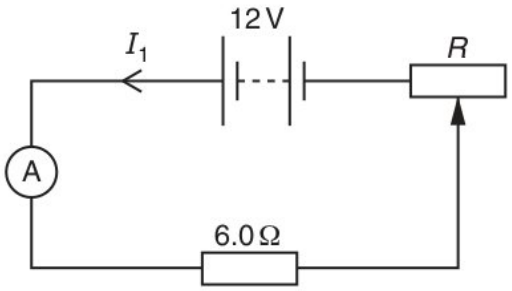
(iii) The total momentum and the total kinetic energy are always conserved.

specific heat capacity of water is 4.18 J $\mathrm{g}^{-1\circ}\mathrm{C}^{-1}$.

[6]

14 the principle of superposition.

(b) (ii)



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.

[6]

(v) that $\mathbf{B} = \mathbf{A}^{-1}$, use the characteristic equation of $\mathbf{A}$ to show that $\mathbf{B}^2 = p\mathbf{I} + q\mathbf{A}$, where p and q are constants to be determined.

$$\frac{\mathrm{d}y}{\mathrm{d}x} - \frac{x+5}{x^2+10x+61}y = 1,$$

diagram shows part of a current-carrying circuit. The ammeter has negligible internal resistance.

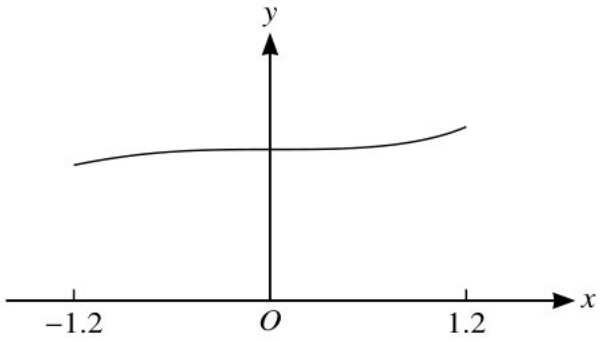
[5]

(g) (i) graph shows the relationship between force acting on a compression spring and change in length of the spring.

what can be deduced from this about the rotation of Mars on its axis.

[1]

(iii) your answers in the form $\tan k\pi$, where k is a rational number.



[6]

(ii) circuit symbol does not represent an electric component that is designed to emit sound waves?

down to antiup

[8]

(iv) the probability that more than 7 study Art or Music.

Show how the expected value of 22.18 , for $x = 3$, is obtained and find the expected values for $x = 6$ and for $x \geqslant 7$.

[8]

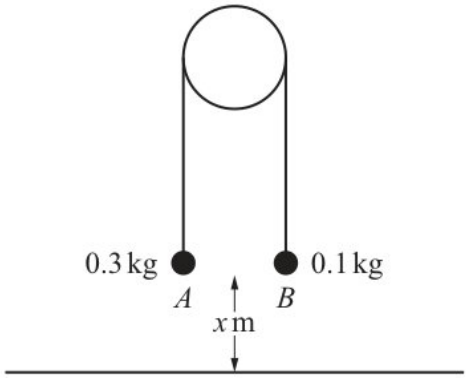
29 researcher records the time, T seconds, taken by adults to complete a questionnaire.

(b) (iii) a sketch of an Argand diagram, shade the region whose points represent complex numbers z which satisfy both the inequalities $|z| < 2$ and $|z| < |z - 2 - 2\mathrm{i}|$.

random sample of 12 customers who each bought a computer from this store is chosen.

[6]

(ii)



equation of a curve is $x^3y - 3xy^3 = 2a^4$, where a is a non-zero constant.

[12]

(i) Show that, at the points (other than the pole) at which a tangent to C is parallel to the initial line,

It consists of two quarks that must both be the same flavour.

[3]

(c) (iv) a cubic equation whose roots are $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$.

Show that, at the points (other than the pole) at which a tangent to C is parallel to the initial line,

[8]

(i) 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}.

Determine the decay constant, in min^{-1}, of the radioactive isotope.

[20]

(ii) your answer in (b)(ii) to determine the distance of the star in (b) from the Earth.

the graph of $y = |3x - 2a|$, where a is a positive constant.

Find also the exact value of the surface area generated when C is rotated through 2π radians about the x-axis.

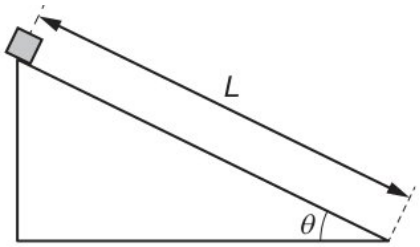
[15]

(f) (iii) the iterative formula in part (c) to calculate a correct to 4 decimal places. Give the result of each iteration to 6 decimal places.

lamina is freely suspended at A and hangs in equilibrium.

[5]

(iv)



gas is then cooled at constant volume so that its temperature decreases to $2T$.

The weight of the plank equals the force on the plank from the pivot.

[6]

7 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.

$$\mathbf{B} = \begin{pmatrix} 3 & 6 & 1 \\ 1 & -2 & -1 \\ 6 & 6 & -2 \end{pmatrix},$$

a, b and c are integers to be determined.

(d) (iv) the surface area generated when C is rotated through 2π radians about the x-axis.

exactly at point S

up the probability distribution table for X.

[3]

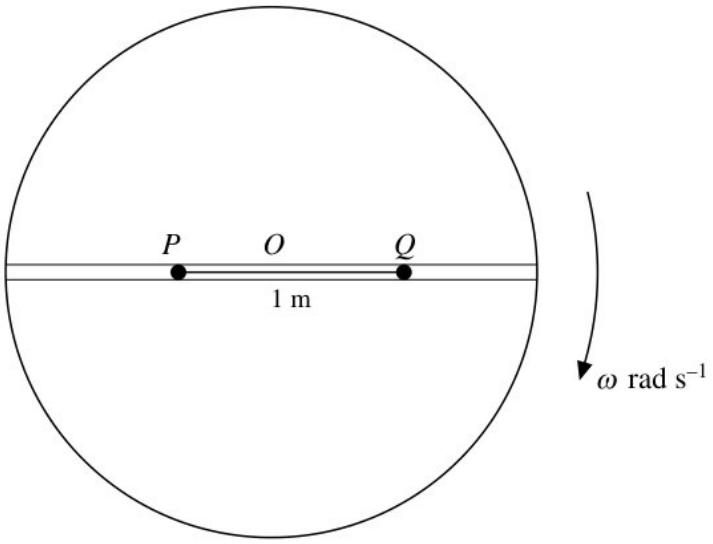
(iii) find corresponding eigenvectors.

the differential equation to obtain an expression for y^2 in terms of x.

cubic equation $x^3 + 2x + 1 = 0$ has roots α, β, γ

[10]

(b) (i)



row describes the horizontal and vertical components of its motion as it travels between the plates?

[1]

(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.

Calculate the distance of the centre of mass of the lamina from A.

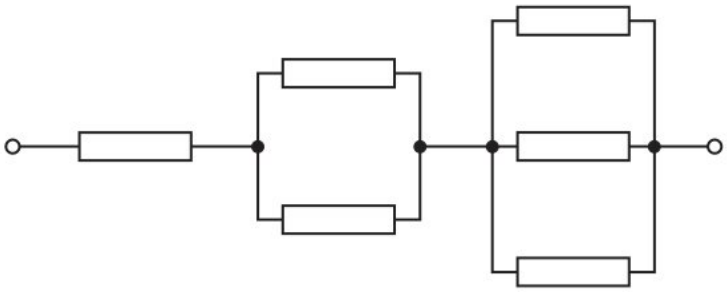
[6]

(ii) the significance level of the test.

measurements to be taken,

[4]

(c) (iv) your answer correct to 2 decimal places.



force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

[5]

(ii) $n \geqslant 0$. Show that, for all $n \geqslant 2$,

the distance AC.

[2]

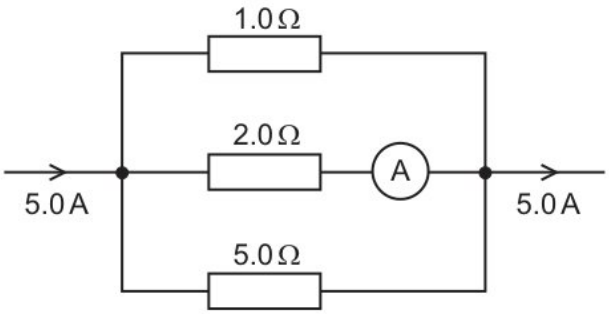
(i) Show that x satisfies the equation

the equation $2\ln(2x) - \ln(x+3) = \ln(3x+5)$.

[4]

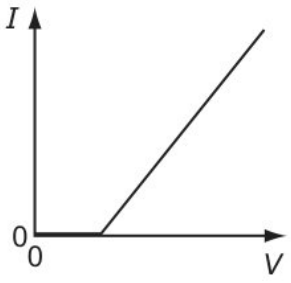
22 Given instead that $\mu = 0$ and that the tension in the string is 0.48 N , calculate

(d) (v) circuit symbol does not represent an electric component that is designed to emit sound waves?



[6]

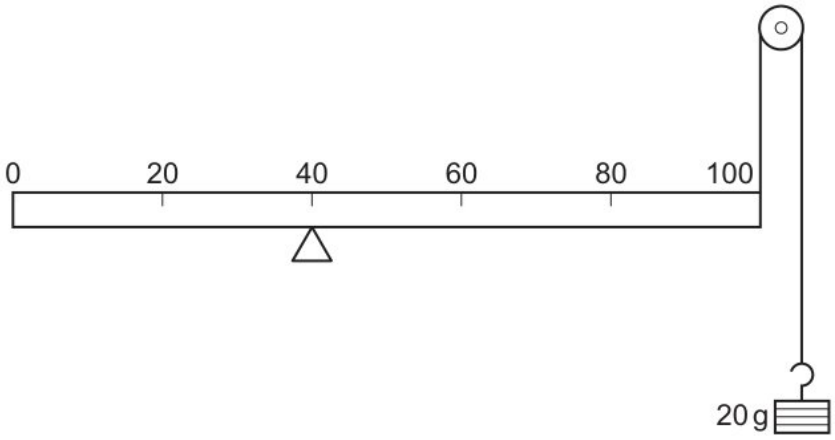
(ii)



8 Let $I_n = \int_0^{\frac{1}{4}\pi} \sec^n x \, \mathrm{d}x$ for $n > 0$.

[2]

(c) (i)

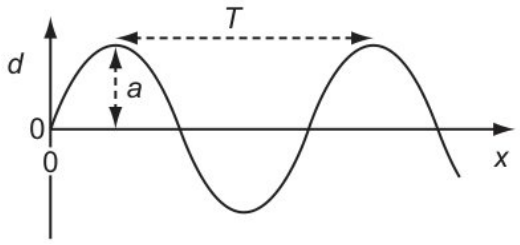


is the total elastic potential energy stored in the four springs?

[6]

(ii) 38% of these leaves are of length k cm or more.

gas is compressed so that its temperature increases to $3T$.



[4]

(e) (iv) activity of a radioactive sample.

238, $^{238}_{92}\mathrm{U}$, decays by α-emission into a daughter product which in turn decays by β-emission into a grand-daughter product.

them = ... *ad* **[4]**

(i) body travelling with a speed of 10 ms^{-1} has kinetic energy 1500 J .

It results in repeated measurements having different values from each other.

[10]

(iii) State what happens to the electron and to the positron.

Show that the equation

is given that $\mu = 0.15$ and $X = 20$.

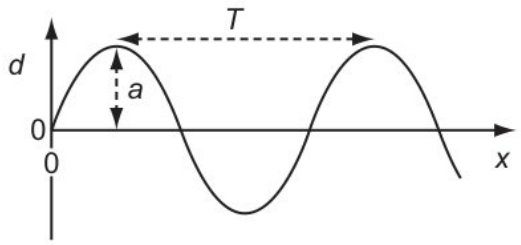
[4]

(a) (iii) vertical and horizontal gridlines have a spacing of 1.0 cm . The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.

Given also that C has a turning point when $x = 2$, find the value of c.

[12]

(i)



280 boxes are chosen randomly. Use an approximation to find the probability that at least 30 of these boxes are rejected.

[2]

(ii) Calculate the initial speed and the angle of projection of P.

$$x^3 - 2y^3 = 3xy.$$

[6]

11 the moment of a force about a point.

matrix **A** is given by

(a) (iv) that $\mathrm{E}(X) = \frac{47}{60}$, find $\mathrm{Var}(X)$.

1 and 2 only

hence = ... xs **[2]**

(ix) Find the coordinates of the turning points of C.

191.5 m^3 of water is mixed with 0.50 m^3 of alcohol. The density of water is 1000 kg m^{-3} and the density of alcohol is 800 kg m^{-3}.

[12]

(ii) Draw a sketch of C for the case $\lambda > 3$.

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.

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 .

[6]

(b) (iii) By using the substitution $y = \frac{1}{x^2}$, find the cubic equation with roots $\frac{1}{\alpha^2}$, $\frac{1}{\beta^2}$ and $\frac{1}{\gamma^2}$.

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.

[5]

(iv) moment of a force.

time T, particle P is moving at an angle of 60° below the horizontal.

[3]

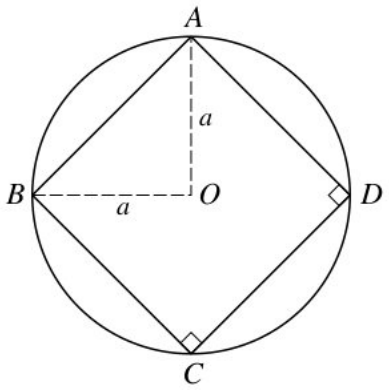
(i) State the gradient of the curve at the point $(-1, 2)$ and sketch the curve.

Hence, or otherwise, prove by mathematical induction that f(n) is divisible by 7 for every positive integer n.

what is meant by the de Broglie wavelength.

[3]

(ii)



Using $\alpha = 3$, find the acute angle between the planes ABC and ABD, giving your answer in degrees.

[6]

21 is given instead that the kinetic energy of P is twice the elastic potential energy stored in the string.

Hence obtain the expansion of f(x) in ascending powers of x, up to and including the term in x^2.

(f) (iii) Prove the identity $\frac{\cos\theta}{\tan\theta(1-\sin\theta)} \equiv 1 + \frac{1}{\sin\theta}$.

function f is such that $\mathrm{f}(x) = 3 - 4\cos^k x$, for $0 \leqslant x \leqslant \pi$, where k is a constant.

the acute angle between the planes ABC and ABD.

[1]

(ii) Show that $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{3x^2y-3y^3}{9xy^2-x^3}$.

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.

[10]

(ix) student wishes to investigate the effect of adding various thicknesses of glass in front of

$\mathbf{A}^{2n}$, where n is a positive integer.

[4]

(e) (iii) Find the value of t when the particle is instantaneously at rest.

Find the cartesian equation of the plane through A, B and C.

Its speed decreases to zero, then increases to 20 m s^{-1}.

[3]

(v) 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.

air resistance to be negligible, what will be the kinetic energy of the projectile when it reaches its highest point?

$$I_n = \frac{n-1}{n} I_{n-2}.$$

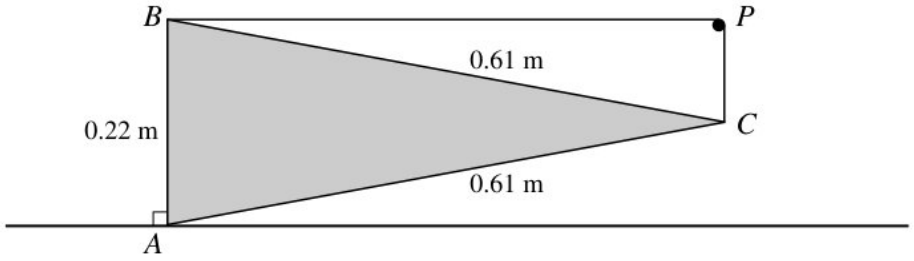
[3]

(ii) Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

system is released from rest with OP making a small angle α with the downward vertical. Find

[1]

(a) (vi)



results for a random sample of 60 adults who completed the questionnaire this year are summarised as follows.

polynomial $3x^3+pax^2+7a^2x+qa^3$ is denoted by f(x) where p, q and a are constants and $a \neq 0$

[10]

(ii) student investigates the cooling of a liquid in a beaker.

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.

with eigenvector eigenvector = ... *dd* **[4]**

(iv) constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135$ mm s^{-1}.

the standard deviation of these 40 values of x.

[5]

12 Calculate the greatest deceleration of P.

Interval	$0 \leqslant x < 1$	$1 \leqslant x < 2$	$2 \leqslant x < 3$	$3 \leqslant x < 4$	$4 \leqslant x < 5$	$5 \leqslant x < 6$
Observed frequency	1	3	15	31	59	107

Show that $a = 19$ and find the values of b and c.

(a) (iii) projectile is launched at 45° to the horizontal with initial kinetic energy E.

mean, $\bar{x}$, is 28.325 .

[12]

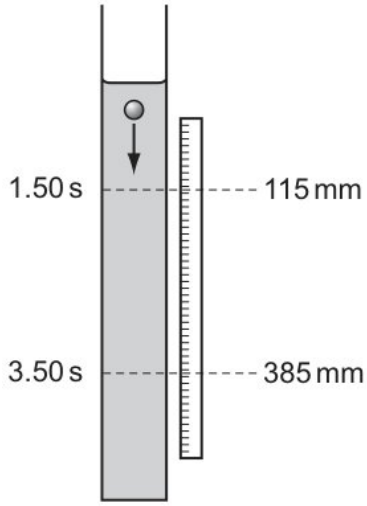
(ii) of the galaxy made on the Earth detect the maximum intensity of emission from the star at a wavelength of 4.91×10^{-7} m.

Draw a sketch of C for the case $\lambda > 3$.

the tension in the string and the acceleration of the particles.

[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.

[15]

(iv) the grid below, draw a cumulative frequency graph to illustrate this information.

curve C has equation $\tan y = x$, for $x > 0$.

[10]

(c) (ii) Young modulus E can be determined from measurements made when a wire is stretched.

force is caused only by a pressure difference?

[6]

(iii) is the effect of a systematic error on the measurement of a physical quantity?

is a general description of a baryon?

[8]

(i) 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.

Find the probability that the die lands on 3 and the number of times the coin shows heads is 3 .

[5]

(iv) sample of a radioactive substance emits particles that are positively charged and have a continuous range of kinetic energies.

$\frac{\text{force}}{\text{length} \times \text{speed}}$

[12]

(e) (iii) diagram best represents the electric field surrounding the charges?

Saturday, 600 competitors took part. The times taken to complete the puzzle were normally distributed with mean 32.4 minutes and standard deviation 2.5 minutes.

[4]

(i) $\mathbf{A} = \begin{pmatrix} 2 & 3 \\ 0 & 1 \end{pmatrix}$. Prove by mathematical induction that, for every positive integer n,

525 520 522 524 518 520 519 525 527 516

[4]