

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

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

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

[20]

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

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).

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

[3]

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

State the name of this type of reaction.

[8]

- (a) (ii) the term isotope.

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 .

[10]

- (i) the mean value of y with respect to x over the interval $0 \leq x \leq \ln 5$,
parametric equations of a curve are
that $k = 3$ and $p = 26$.

[4]

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

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

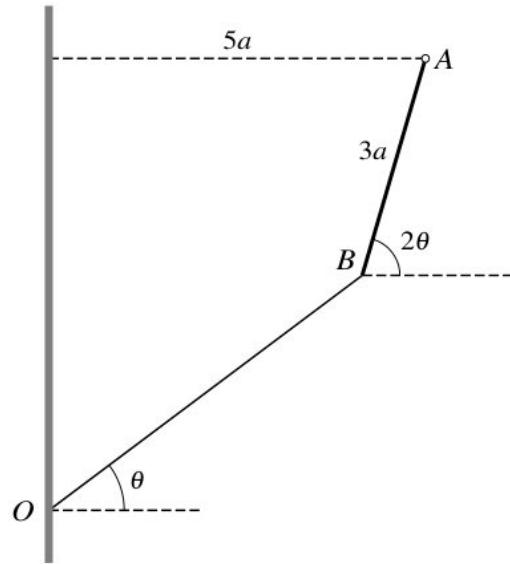
[6]

- (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

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.

[6]

(ix)



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

[5]

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

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.

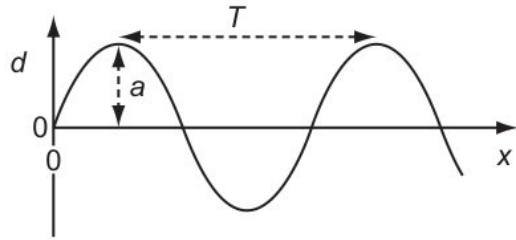
diagram illustrates successive wavefronts.

[5]

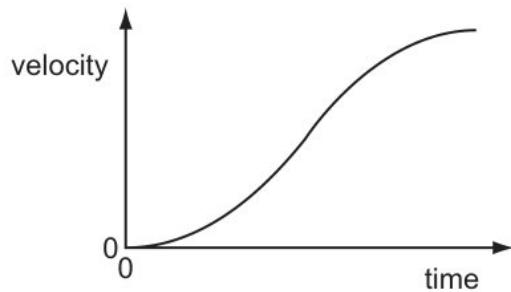
- (c) combined resistance is $66\text{k}\Omega$.

[5]

(b) (i)



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.



[6]

(ii) the period of small oscillations,

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

[4]

(iv) the speed of the aeroplane.

Show that, for $n > 2$,Find the coordinates of the turning points of C .

[6]

16 the general solution of the differential equation

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

(d) aeroplane is flying at a constant speed.

[12]

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

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

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

[6]

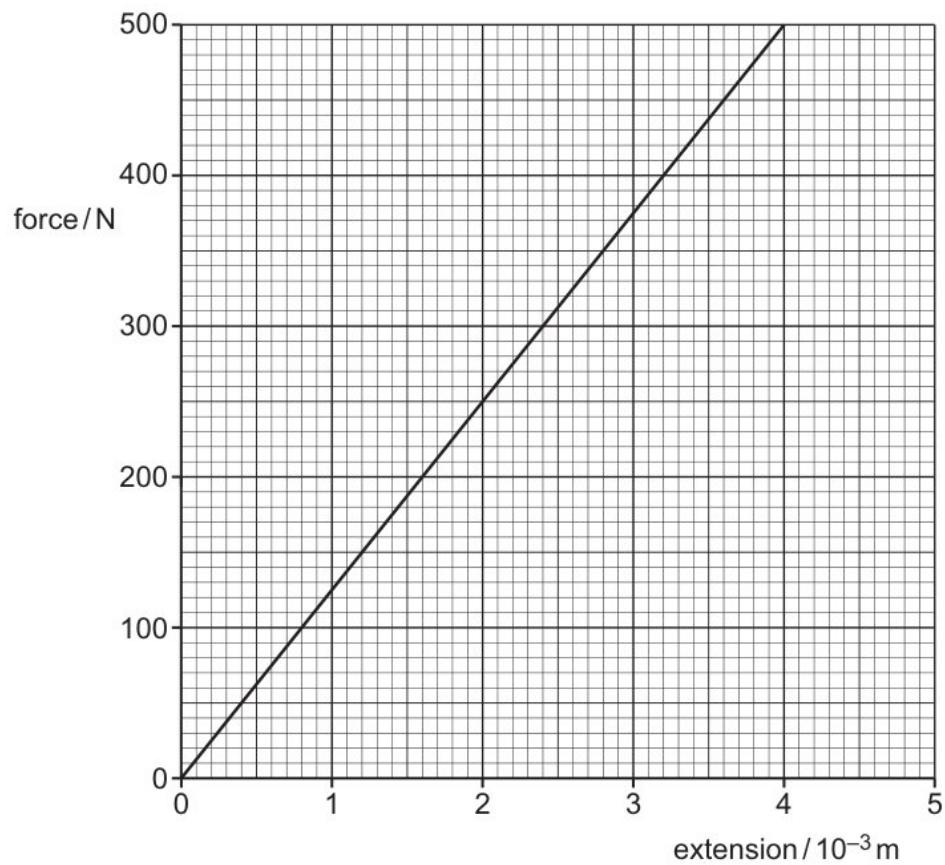
(c)

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

[6]

the period of small oscillations,

7



Find the exact value of the arc length of C .

[6]

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

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

[3]

- 18 Find, in the form $ax^3 + bx^2 + c = 0$, an equation of which α is a root.

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

far apart are two adjacent interference fringes that are formed on the laboratory wall?

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

[5]

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

[6]

- (e) (iii) for $0^\circ \leq \theta \leq 180^\circ$ the equation $\sin^2 2\theta (\operatorname{cosec}^2 \theta - \sec^2 \theta) = 3$,

diagram correctly represents the forces acting at point P ?

much energy is stored in the compressed column?

[6]

- (ii) much energy is stored in the compressed column?

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

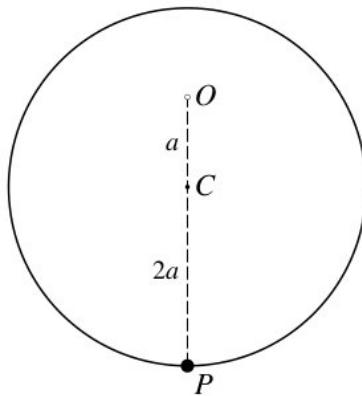
[8]

- (i) Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.
gravitational potential at a point.

[3]

only one of the following two alternatives.

17



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 .

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.

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

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 .

[4]

18 diagram shows part of the curve

(a) (vi) does this mean?

is the speed of the block at the bottom of the slope?

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

[2]

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

The curve C has equation $y = \sec^3 x$ for $0 \leq x \leq \frac{1}{4}\pi$. 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.

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

[6]

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

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

[5]

(iv)

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

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

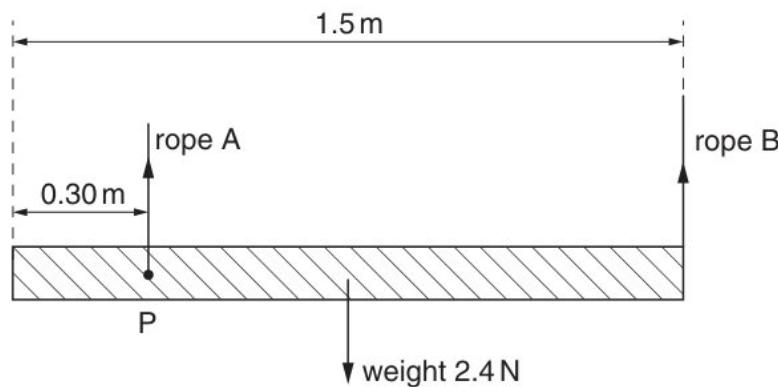
[10]

- (c) time taken by
- P
- to travel directly from
- L
- to
- M
- is 2 s .

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

[5]

- (e) 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.



[5]

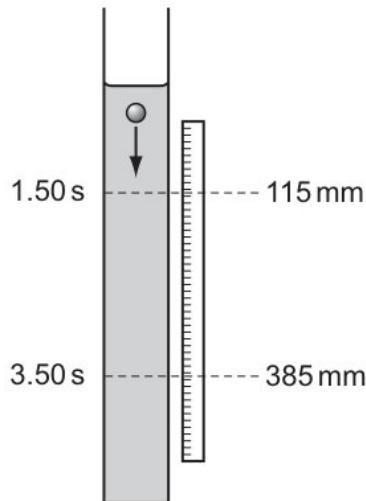
- (b) (i) is the ratio
- $\frac{\text{stress at } Y}{\text{stress at } X}$
- ?

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

the significance level of the test.

[10]

(iii)



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

[3]

(v) the value of μ .

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

direction = pj [3]

18 Given instead that $G = 0$ and the forces are in equilibrium, find the values of F and α .
the mean of the times taken by all 50 runners.

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

diagram shows the electric field between the plates?

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

[12]

(iii) the equation of the plane ABC , giving your answer in the form $ax + by + cz = d$.
your answer correct to 2 decimal places.

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

[5]

(d) the value of x .

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

[5]

(e) Find the rank of \mathbf{A} and a basis for the null space of T .

[5]

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

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

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 .

[3]

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.

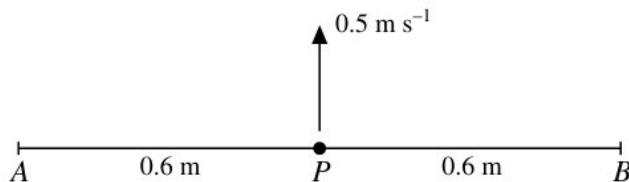
Calculate the gravitational potential ϕ at the surface of Mars. Give a unit with your answer.

- 19 A 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 $v \text{ m s}^{-1}$, where

[3]

- 13 The standard deviation of these 40 values of x .

(i)



A 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).

[5]

- (iii) (c) curve C has equation

Find the probability that the total income produced by the two fields in a day is at least \$670 million.

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

denoted = rh [5]

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

curve C has parametric equations

moment of a force.

[6]

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

diagram correctly represents the forces acting at point P ?

The waves must have equal amplitudes.

[12]

- (v) Find the value of I_2 .

[12]

random sample of 140 customers who each bought a computer from this store is chosen.

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

the probability density function of Y ,

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

[5]

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

- 17 V remains the same because the decrease of p.d. across r is balanced by the increase of p.d. across R .

$$\frac{3}{2}x + 3y + 8z = 1,$$

$$ax + 3y + 4z = 2,$$

$$ay - z = 3,$$

[6]

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

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

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

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

[2]

- (c) (iv) points A, B, C have position vectors

the general solution of the differential equation

[10]

- (i) continuous random variable, X , has probability density function given by

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.

[6]

- 16 Show that $\frac{dy}{dx} = \frac{3x^2y - 3y^3}{9xy^2 - x^3}$.

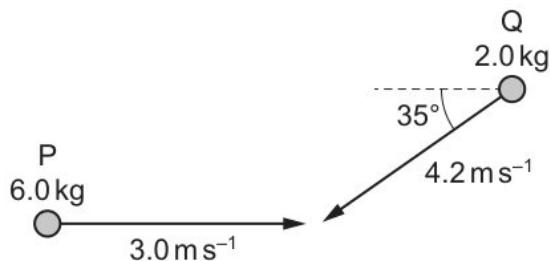
Find the value of a and show that $b = -7$.

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

[2]

- (b) 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.

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



[6]

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

resistors of equal value are connected as shown.

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

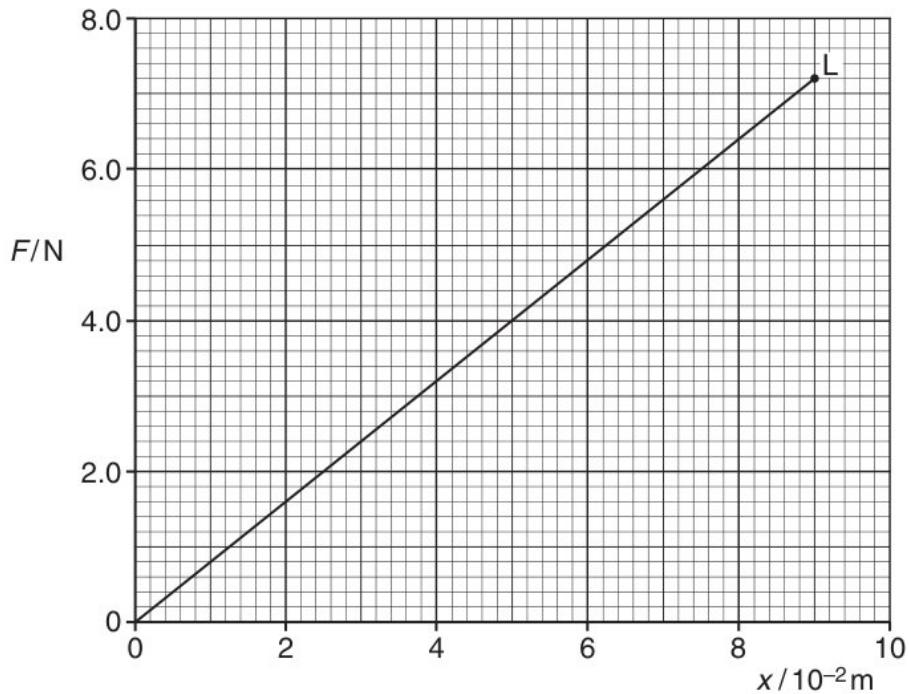
[5]

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

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

[6]

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



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

[6]

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

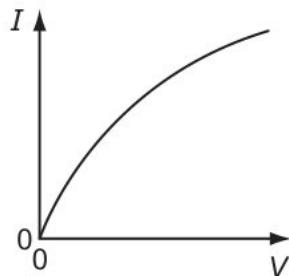
sequence x_1, x_2, x_3, \dots defined by

have ages = cp [12]

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

a, b and c are integers to be determined.

- (iv) (e)



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

[8]

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

525 520 522 524 518 520 519 525 527 516

[3]

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

height of the liquid in the beaker is $0.20\text{ m} \pm 2\%$.

point = ga [5]

(i) (g)

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

diagram shows the curve $y = x - 2 \ln x$ and its minimum point M .

[10]

- (a) far apart are two adjacent interference fringes that are formed on the laboratory wall?

up to antidown

[6]

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

[3]

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

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

Q hears a sound of decreasing frequency.

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

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

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

junction = tk [15]

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

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

[8]

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

width of the 99% confidence interval is double the width of the $x\%$ confidence interval.

restaurant manager buys 160 of these large bags of pasta.

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

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

the coordinates of any stationary points on C .

[6]

(b) (vi) The total momentum is conserved only in elastic collisions.

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

[12]

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

battery is marked 9.0 V .

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

[6]

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

three quantities that are conserved during the decay.

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

[6]

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

[5]

- 9 diagram shows the curve $y = x^2\mathrm{e}^{-x}$.

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

(g) (i) particle moves in a straight line. The velocity $v \text{ ms}^{-1}$ of the particle t s after leaving a fixed point O is given by $v = k(20 + pt - 6t^2)$, 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 .

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

[8]

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

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

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

[6]

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

[5]

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

ripple tank is used to demonstrate interference between water waves.

[3]

The curve C has equation $y = \sec^3 x$ for $0 \leq x \leq \frac{1}{4}\pi$. 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.

11 is the force on an electron when it is in the uniform electric field between the plates?

[5]

definition is correct and uses only quantities rather than units?

13 Find Σx^2 .

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).

[10]

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.

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

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.

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

[10]

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

- 8 weights of letters posted by a certain business are normally distributed with mean 20 g . It is found that the weights of 94% of the letters are within 12 g of the mean.

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

[3]

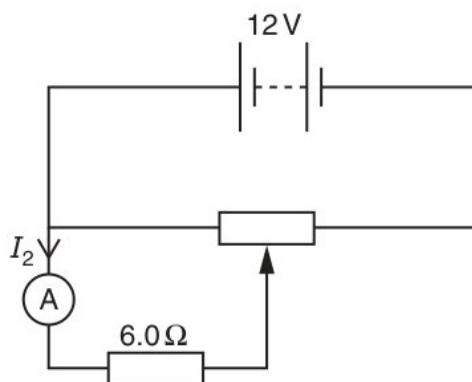
- 18 $n \geq 0$. Use the fact that $\tan^2 x = \sec^2 x - 1$ to show that, for $n \geq 2$,
row of the table gives an angle θ of 90° ?
diagram shows a trace of a wave on a cathode-ray oscilloscope.



Find the set of values of t for which the particles are travelling in opposite directions.

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

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



[5]

- (d) (i) stationary nucleus has nucleon number A .

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

[4]

- (iii) curve $y = 4x^2 \ln x$ has one stationary point.

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

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

[20]

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

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 $0 < \theta < 2\pi$

[15]

- 23 matrix \mathbf{A} is given by

- (a) (i) The orbit has a period of 25 hours.

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_{in} . The p.d. across R_1 is V_{out} .
the process by which α -particles lose energy when they pass through air.

[5]

(iv)



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

[4]

- (b) 1,2 and 3

after = dh [12]

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

- (b) Obtain another equation relating u^2 , v^2 , a and g , and hence find u in terms of a and g . Express $f(x)$ in partial fractions.

Calculate from = vu [3]

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

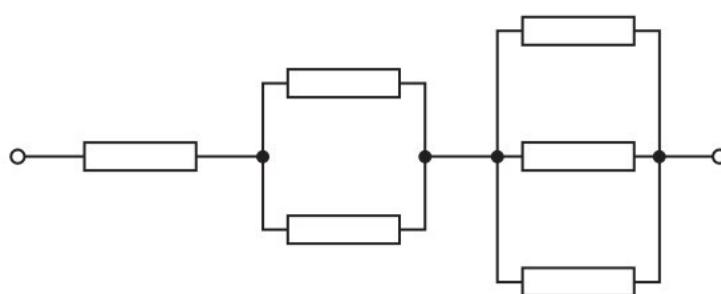
a 90% confidence interval for the difference in mean crop mass associated with each type of fertiliser.

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

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

[5]

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



[4]

- (i) the general solution of the differential equation

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

[4]

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

- falling freely with the parachute closed,

[6]

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

(b) the values of a for which the system of equations

$$\text{the value of } (\alpha^3 - 1)^3 + (\beta^3 - 1)^3 + (\gamma^3 - 1)^3.$$

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

[12]

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

[6]

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

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,

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

[5]

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.

28 an electron and a neutrino

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

Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

[5]

Find the values of p and q .

- 11 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 .

[15]

- 12 only one of the following two alternatives.

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

function f is such that $f(x) = 3 - 4 \cos^k x$, for $0 \leq x \leq \pi$, where k is a constant.

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

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

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

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

[5]

- (c) 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 .

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

[5]

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

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.

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

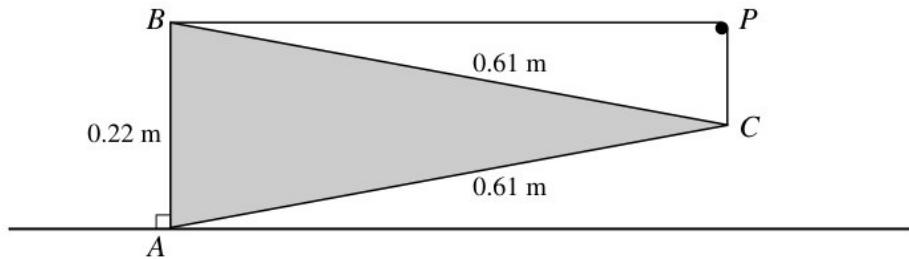
[20]

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

- (c) 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 .

[5]

(a) (i)



B contains 5 red marbles and 3 blue marbles.

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

[12]

- (ii) The potential difference across any component connected to the battery will be 9.0 V .

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

1 Which quantity is a scalar quantity?

[5]

- (v) the probability that all three cars are the same colour.

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

$$\text{down} = \dots \text{ } mv \quad [12]$$

- (e) 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.

[5]

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

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

[10]

- 14 State the name of this type of reaction.

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

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).

[8]

- (c) (i) 1.1 shows a thin coil of cross-sectional area A and length l connected to a resistor of resistance S and two terminals.

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

[5]

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

$$\begin{aligned} v &= 1.5 + 0.4t && \text{for } 0 \leq t \leq 5 \\ v &= \frac{100}{t^2} - 0.1t && \text{for } t \geq 5 \end{aligned}$$

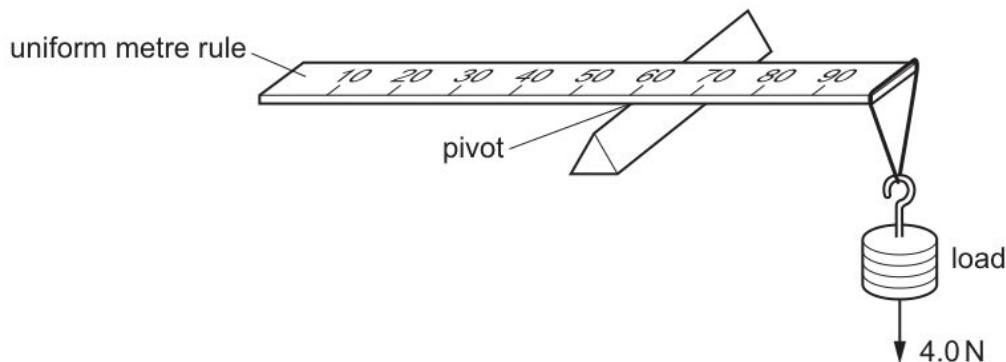
[12]

- (iv) Hence solve the equation $\tan 2\theta \cot \theta = 8$ for $0^\circ < \theta < 180^\circ$.

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

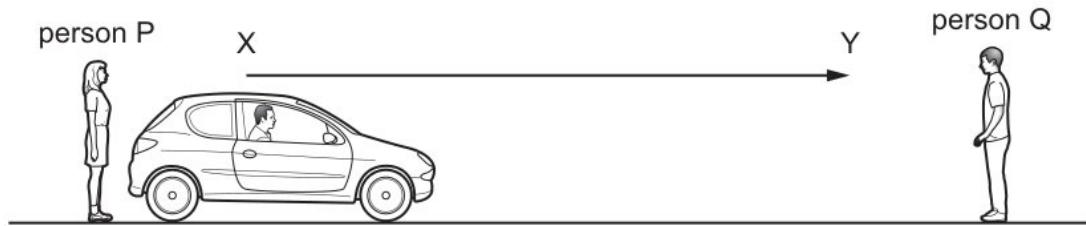
[3]

- (e) (i) 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?



[8]

- (v) equation $x^2 + px + q = 0$, where p and q are constants, has roots -3 and 5 .



[5]

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

- 15 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.

[5]

- 10 marks of the pupils in a certain class in a History examination are as follows.

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

[10]

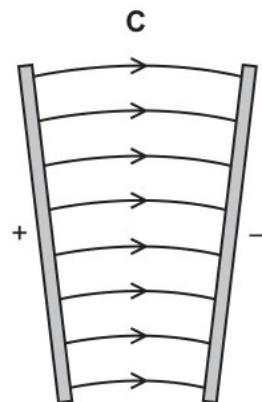
- (d) (iii) far apart are two adjacent interference fringes that are formed on the laboratory wall?

Use implicit differentiation to show that

it is given that $y = 2$ when $x = 1$. Solve the differential equation and obtain an expression for y in terms of x .

[6]

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



[6]

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

Find the area of one loop of C .

the experimental observations that show radioactive decay is

[10]

(a) (iv) Q has mass 2.0 kg and is moving at a speed of 4.2 m s^{-1} at an angle of 35° to the path of P.

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

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

[6]

(ii) is the reading on the ammeter?

diagram correctly represents the forces acting at point P ?

[5]

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

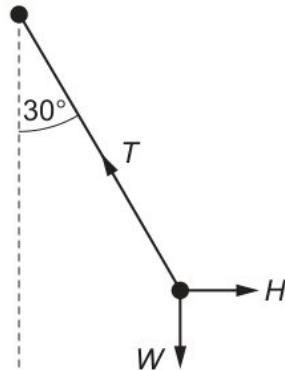
adjustments are made to the machine. Assume that a normal distribution is still appropriate and that the population variance remains unchanged. A second random sample, this time of ten metal rods, is now taken. The results for hardness are as follows.

[3]

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

- 8 the values of p and q

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



curve C has equation

[6]

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

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 interquartile range of X .

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

Show that $f(n+1) + f(n) = 28(3^{3n}) + 7(6^{n-1})$.

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.

[10]

- (i) down to antiup

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

[12]

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

the distribution function of X .

[8]

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

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

[8]

- (g) (ii) specific heat capacity of water is $4.18 \text{ J g}^{-1}\text{C}^{-1}$.

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

[6]

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

Use the iterative formula $x_{n+1} = \tan^{-1}(x_n + \pi)$ to determine x correct to 2 decimal places. Give the result of each iteration to 4 decimal places.

[6]

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

curve C has equation

[3]

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

[4]

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

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

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

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

- (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 .

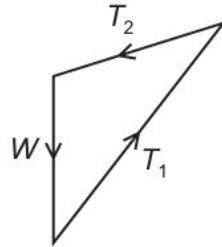
[6]

- (a) (v) Find the total distance travelled by the particle in the first 10 seconds of motion.

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]

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



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

[6]

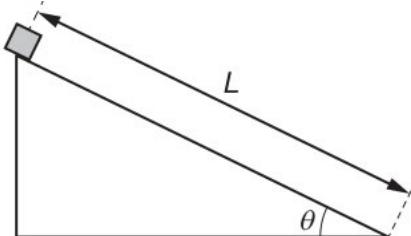
- (ix) is given that $f(n) = 3^{3n} + 6^{n-1}$.

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

[20]

- (b) 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.



[2]

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

[2]

- 21 (iii) the probability that more than 7 study Art or Music.

- (a) students are selected at random from the students who study Science.

[4]

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

[4]

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

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

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

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

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

[5]

- (f) the Young modulus.

[5]

- (a) A ductile material in the form of a wire is stretched up to its breaking point. On Fig. 3.1, sketch the variation with extension x of the stretching force F .

Find the equations of the asymptotes of C .

[5]

- (ii) what is meant by work done.

[6]

- (iv) restaurant manager buys 160 of these large bags of pasta.

[4]

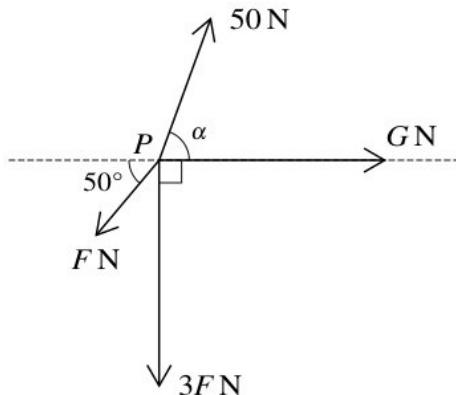
- 11 observer views the slit through the grating at different angles, moving his head from X parallel to the grating, through Y , opposite the slit, to Z parallel to the grating on the opposite side.

- (b) (ii) the moment of a force about a point.

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

[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 .

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

[5]

- (iii) 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 .

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

[4]

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

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.

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.

[6]

- (e) (iii) State the magnitude and direction of the resultant force at P when the force of magnitude 12 N is removed.

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

[5]

- (ii) matrix \mathbf{A} is given by



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

[8]

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

is given that

[10]

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

is given that a is a positive constant such that

[6]

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

[8]

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

- 19 is the magnitude of F when the child stands at X and when the child stands at Y ?
 the probability that, in a randomly chosen week, the first day on which less than 59.1 kg of cherries are sold is the fifth day of the week.

[6]

- 20 Wavelength is proportional to amplitude.
 (b) (i) 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.
 Stating suitable hypotheses and assuming a normal distribution, test the coach's belief at the 10% significance level.
 the probability density function of Y ,

[5]

- (iv) Carry out the test.
 Show that $a = 19$ and find the values of b and c .

[4]

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

[4]

- 14 the probability that fewer than 6 rolls of this dice are required to obtain an A .
 (a) force is caused only by a pressure difference?
 (b) (i) State the equation of the other asymptote.
 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.
 a vector equation for the line l_1 .

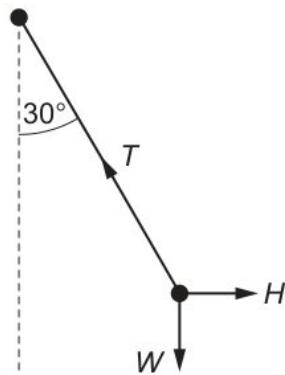
[3]

- (iv) Find the cartesian equation of the plane through A, B and C .
 Calculate the density, in kgm^{-3} , of the material from which the paving slab is made.

[8]

- 12 a cubic equation with roots α, β and γ , given that
 $n \geq 0$. Show that, for all $n \geq 2$,
 the principle of moments.

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



[6]

(a) (i) and N are two electromagnetic waves.

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

$$y^2 + 5\tan^{-1} = \dots \text{hm} \quad [8]$$

(iii) wavelength of light is 550 nm .

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

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.

[4]

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

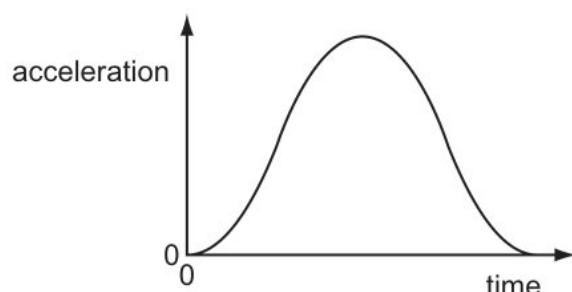
27 the team contains more boys than girls.

[12]

17 the value of $(\alpha^3 - 1)^2 + (\beta^3 - 1)^2 + (\gamma^3 - 1)^2$
 $\mathbf{i} - 2\mathbf{k}, \quad \mathbf{i} + 2\mathbf{j} + 2\mathbf{k}, \quad 2\mathbf{i} - \mathbf{j} - \mathbf{k}$

an estimate for the mean length of these 250 leaves.

(a) (iv)



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

[8]

- (ii) 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.

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

[8]

- (d) (iii) internal diameter of the beaker is $0.05 \text{ m} \pm 3\%$.

linear transformation $T: \mathbb{R}^4 \rightarrow \mathbb{R}^4$ is represented by the matrix \mathbf{M} , where
Calculate the initial speed and the angle of projection of P .

[8]

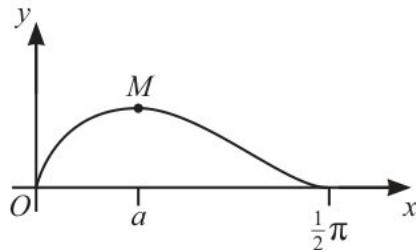
- (i) statement is correct?

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

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

[6]

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



[8]

- (c) State the work W done by F .

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

[8]

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

- (a) (ii) support at end X exerts a force F vertically upwards on the plank.

525 520 522 524 518 520 519 525 527 516

[10]

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

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

[10]

- (e) 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.

A 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.

[8]

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

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

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

discrete random variable X has the following probability distribution.

[5]

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

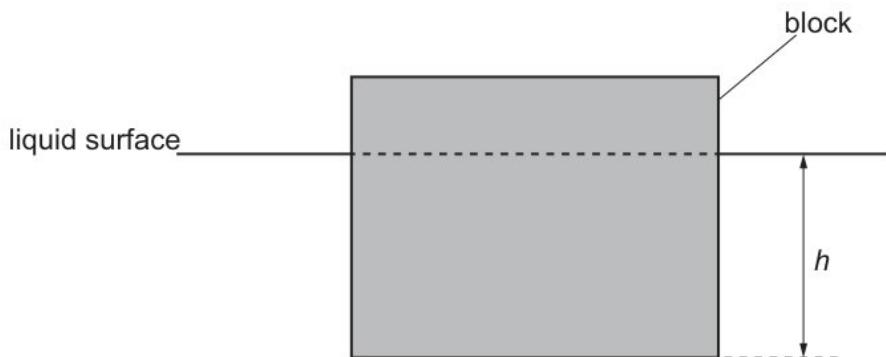
$$f(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{2} & 1 \leq x \leq 3 \\ 0 & x > 3 \end{cases}$$

[8]

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

[3]

(b)



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

[5]

state an eigenvector of the matrix \mathbf{CD} and give the corresponding eigenvalue.

12 Find the period of the motion.

[1]

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

16 an estimate for the mean length of these 250 leaves.

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

[8]

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

17 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.

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

all solutions in the interval $0^\circ \leq \theta \leq 360^\circ$.

[6]

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

13 Hence solve the equation

[5]

the median and the interquartile range of the times of the runners from the Gulls.

30 measurements to be taken,

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

[6]

the distribution function of X .

11 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.

[10]

the exact value of I_2

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

[5]

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

Find the area of the region enclosed by C .

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

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

[12]

- (d) (iv) Find the interquartile range of X .

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

[5]

- (v) from the definitions of \tanh and sech in terms of exponentials, prove that

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.

[1]

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

[4]

- (c) is the angle θ ?

[12]

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

- (a) 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 .

Science = ed [5]

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

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

width of the 99% confidence interval is double the width of the $x\%$ confidence interval.

[8]

- (b) (ii) suitable hypotheses, test at the 10% significance level whether there is any difference between the population means before and after the adjustments.
the value of μ .

[10]

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

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.

[12]

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

[8]

- (f) (ii) Find the coordinates of the turning points of C .

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

[6]

- (i) Over 50 198 212 217 229 235 242

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

[8]

- (v) light is incident on the front of a photocell, an e.m.f. is generated in the photocell.
the de Broglie wavelength of an electron moving at a speed of $4.9 \times 10^7 \text{ m s}^{-1}$.
parallel plates, a distance 25 mm apart, have a potential difference between them of 12 kV .

[6]

- (iii) momentum = mass \times velocity

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

[5]

specific latent heat.

- 16 Show that $v^2 = u^2 + \frac{14}{5}ag$.

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

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

$$\text{rests} = \dots \dots \dots \quad rq \quad [8]$$

- 19 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).

the equations of the asymptotes of C

Using these values of p and q, find the value of the constant r for which the equation $x^2 + px + q + r = 0$ has equal roots.

- (c) (vi) tension in the string of the pendulum is T. The weight of the pendulum bob is W. The string is held at an angle of 30° to the vertical.

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.

for $0^\circ \leq \theta \leq 180^\circ$ the equation $\sin^2 2\theta (\operatorname{cosec}^2 \theta - \sec^2 \theta) = 3$,

[4]

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

gravitational potential at a point.

[2]

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

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

[6]

(ii)

	transverse wave	longitudinal wave	can travel in free space	key 5* ✓ = property of an electromagnetic wave ✗ = not a property of an electromagnetic wave
A	✓	✗	✓	
B	✓	✗	✗	
C	✗	✓	✓	
D	✗	✓	✗	

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

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

[3]

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

Find a set of corresponding eigenvectors.

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

[3]

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

[10]

27 (c) Find the value of I_2 .

[6]

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

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

[4]

(i) a cubic equation whose roots are $\alpha^3 - 1, \beta^3 - 1, \gamma^3 - 1$ that $y = 0$ when $x = 3$ Give your answer in an exact form

[3]

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

curve C has equation $2x^3 + 3x^2y - 3y^3 - 16 = 0$.(iii) a similar method to find a lower bound for $\sum_{r=1}^n \frac{n}{r^2 + r^2}$. Give your answer in terms of n and π .

[12]

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

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

[15]

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

24 random variable X is the number of heads obtained.

[5]

9 matrix \mathbf{M} represents a sequence of two geometrical transformations in the $x - y$ plane.

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

[5]

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

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

$$\begin{aligned}\frac{3}{2}x + 3y + 8z &= 1, \\ ax + 3y + 4z &= 2, \\ ay - z &= 3,\end{aligned}$$

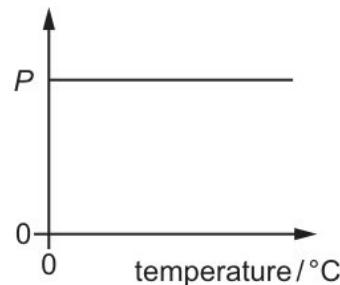
[8]

(vi) curves C_1 and C_2 intersect at the point with polar coordinates (a, β). State the value of β .

the position vector of P .

[4]

(a) (vi)

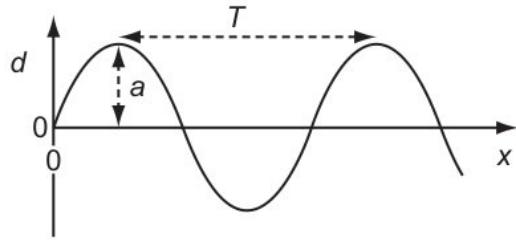


microphone connected to a cathode ray oscilloscope (c.r.o.) is positioned between L and S as shown in Fig. 6.1. The trace obtained on the c.r.o. is shown in Fig. 6.2.

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

[12]

(iii)



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

[6]

- (iv) 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 .

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

[8]

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

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

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

[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.

- 20 the length of C .

[10]

the general solution of the differential equation

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

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

[5]

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

- 9 only one of the following two alternatives.

[8]

- 17 (b) curve C has equation $\tan y = x$, for $x > 0$.

[1]

- (c) line l passes through B and C .

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

[6]

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

[8]

- (a) the length of C .

- (i) Show that $\frac{ds}{dx} = \frac{1}{2}(\mathrm{e}^x + \mathrm{e}^{-x})$, 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.

[8]

- (ix) student wishes to investigate projectile motion.

[5]

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

[6]

- (d) 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.

- (v) 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.

[8]

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

[4]

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 .

- 25 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 $t = 2$.

[6]

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

- 18 $\frac{\text{force}}{\text{length} \times \text{time}}$

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.

[10]

curve C has parametric equations

Find, in the form $ax^3 + bx^2 + c = 0$, an equation of which α is a root.

- 10 There will always be 9.0 V across the battery terminals.

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

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

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

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.

[3]

- 14 a, b and c are integers to be determined.

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

[20]

- (i) (a) Find the values of F and θ .

should pay particular attention to

[20]

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

variables x and y satisfy the differential equation

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

[5]

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

- 10 Express u in the form $x + iy$, where x and y are real.

[6]

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

- 12 Q has mass 2.0 kg and is moving at a speed of 4.2 m s^{-1} at an angle of 35° to the path of P.

State one difference, which can be seen from the diagram, between the marks for History and Physics.

[4]

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

- (i) (c) 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.

function f is such that $f(x) = 3 - 4 \cos^k x$, for $0 \leq x \leq \pi$, where k is a constant.

[6]

- (b) stationary nucleus has nucleon number A.

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

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

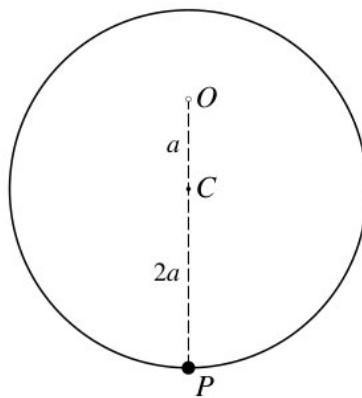
[1]

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

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.

[6]

- (iii) (c) State the name of this type of reaction.



[8]

- (d) solid plastic cylinder floats in water. It is used to support one end of a horizontal uniform beam AB as shown in Fig. 2.1.

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.

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

[6]

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

[12]

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

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

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

[5]

- (b) 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.

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

[4]

not have a unique solution.

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

[8]

- 10 only one of the following two alternatives.

- (e) Find the exact value of the arc length of C .

[5]

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

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

[5]

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

[6]

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

the position vector of D .

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 .

[8]

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

the standard deviation of these 40 values of x .

[5]

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

- 23 Find the exact value of the arc length of C .

[6]

that, when $t = 0, x = 3$ and $\frac{dx}{dt} = 0$.

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

that $(z_1 z_2)^* = z_1^* z_2^*$.

[5]

up the probability distribution table for X .

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

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

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

[8]

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

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

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

should pay particular attention to

[4]

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

the term ultimate tensile stress.

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

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

[15]

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

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

[10]

(i) variables x and y satisfy the differential equation

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

wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

[8]

(b) (iv) by calculation that a lies between 2 and 2.1.

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

[10]

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

there are no restrictions,

[6]

- (iii) considering the sum of the areas of these rectangles, show that gravitational potential at a point.

[10]

- (c) 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.

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

[5]

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

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

[5]

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

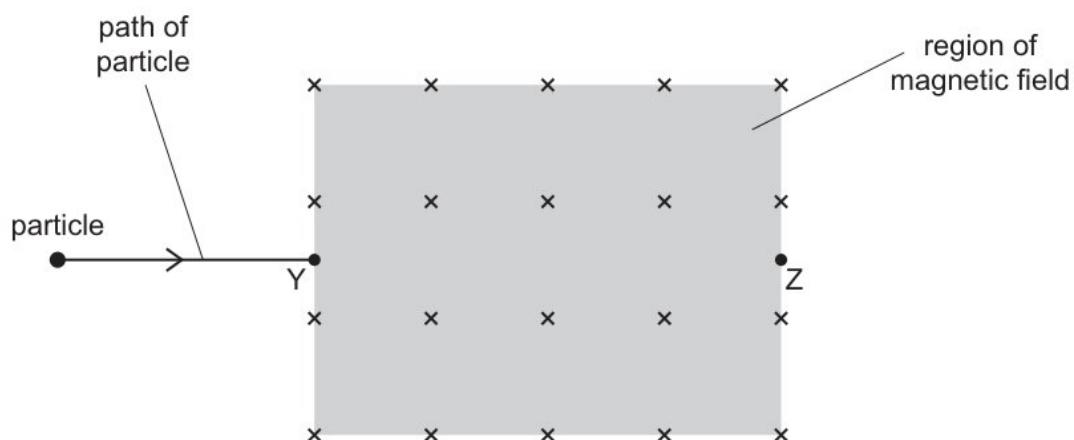
- 13 V remains the same because the sum of the p.d.s across r and R is still equal to E .

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

[12]

Find the standard deviation of the weights of the letters.

- 23 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 .



[4]

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

- (d) 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.

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

[6]

- (c) (iii) Sketch on Fig. 5.4 the $I - V$ characteristic of a filament lamp.

a positron and a neutrino

[6]

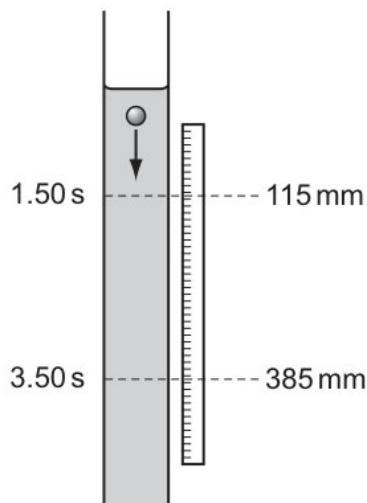
- (i) Find the value of α correct to 3 decimal places. Show your working, giving each calculated value of the sequence to 5 decimal places.

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

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.

have = gs [5]

(ii)



The potential difference across any component connected to the battery will be 9.0 V .

[4]

- (b) Find the work done by the tension.

[12]

- (e) (ii) is the horizontal force exerted by the wall on r r Y ?

$$2xy^2 + 3x^2y = 1$$

[12]

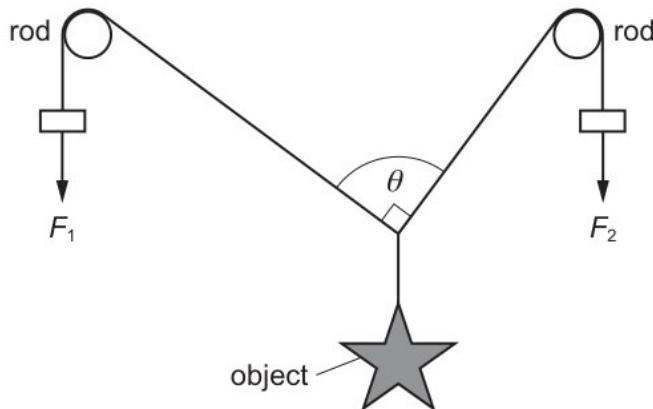
- (iv) molecule of mass m travelling horizontally with velocity u hits a vertical wall at right-angles to its velocity. It then rebounds horizontally with the same speed.

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 $\lambda\mu$.

[6]

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

- (c) 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 .



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

[5]

- (a) (iv) far apart are two adjacent interference fringes that are formed on the laboratory wall?

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

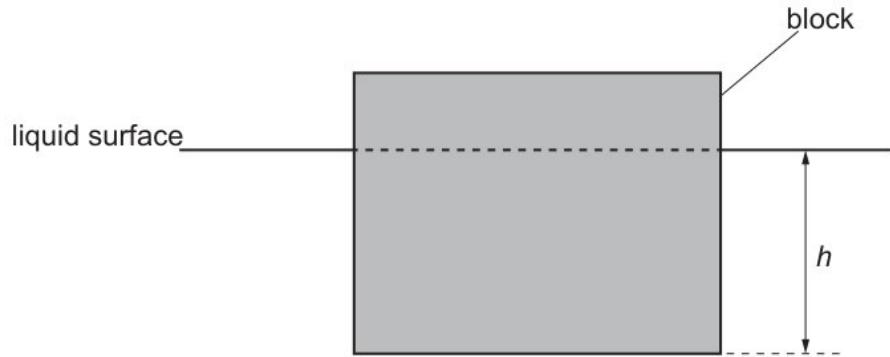
[4]

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

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

[2]

(b) (iii)

Find the area of one loop of C .

[20]

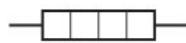
- (i) Calculate the exact value of I_1 and deduce the exact value of I_3 .

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

Show that x satisfies the equation

[12]

(ii)



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

[4]

- 17 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.

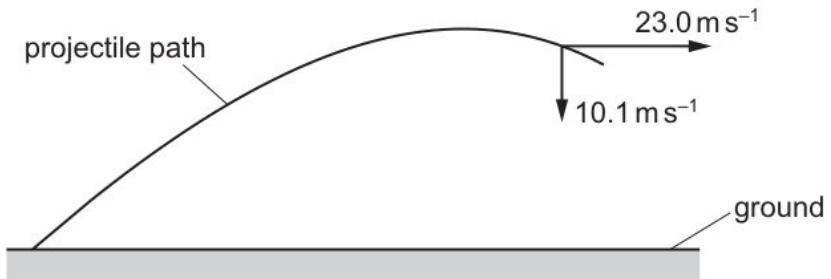
- (b) (ii) basic principle of note production in a horn is to set up a stationary wave in an air column.

is the value of R ?

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

[3]

- (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 .
 polarised beam of light with intensity I is incident normally on a polarising filter.



[4]

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

Find the distance OM .

[5]

- (c) (iv) projectile is launched at 45° to the horizontal with initial kinetic energy E .
 random variable T has probability density function given by
 a normal distribution, calculate a 95% confidence interval for the population mean.

[3]

- (i) the period of small oscillations,
 diagram shows a trace of a wave on a cathode-ray oscilloscope.

[6]

- (ii) row describes the momentum and kinetic energy of the two bodies after the collision?
 is the mass of the car?

[10]

10 Show that $\frac{dy}{dx} = \frac{3x^2y - 3y^3}{9xy^2 - x^3}$.

waves are emitted from two sources.

- (b) (ii) variable resistor is used to control the current in a circuit, as shown in Fig. 5.1.
 Find the coordinates of the turning points of C .
 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.

[5]

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

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

[6]

- (c) (i) then it converges to a .

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

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

[5]

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

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

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

[5]

- (iv) activity of a radioactive sample.

an estimate for the mean length of these 250 leaves.

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

[4]

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

- 15 filter is rotated about the normal axis through an angle θ .

Use de Moivre's theorem to prove that

[6]

weight of the parachutist is 850 N .

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

- 25 Deduce that the cartesian equation of C is

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

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

[4]

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

- 30 continuous random variable X has probability density function f given by

Nucleon numbers of nuclei are unchanged by the emission of β -particles.

[10]

- 26 is given that $\mu = 0.15$ and $X = 20$.

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

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

[6]

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

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

divided = ls [6]

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

Find the 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.

[4]

- (vi) object hangs by means of two cords around two rods, as shown.

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.

[2]

- (b) (iii) 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 .

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 $\lambda\mu$.

[6]

(vii) 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.

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.

[8]

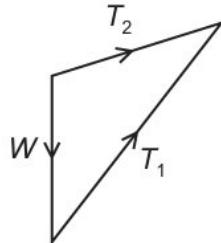
(f) de Moivre's theorem to prove that

[10]

the geometric effects of multiplying z_1 and z_2 by ω

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

Calculate the greatest deceleration of P .



[2]

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

- (a) (i) 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 .

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

[12]

- (iii) 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 .

Find the standard deviation of x .

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

[6]

- (ii) The total momentum is conserved provided that no external forces act.

the probability of a Type II error.

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

[10]

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

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.

[3]

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

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

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

[12]

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

[8]

21 the period of small oscillations,

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

[10]

- (e) (i) matrix M represents a sequence of two geometrical transformations in the $x - y$ plane

that $k = 3$ and $p = 26$.

[8]

- (ii) 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.

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

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

[6]

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

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

[5]