

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

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

[5]

- 10 the solution of the differential equation

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

$\frac{\beta}{k}, \beta, k\beta$ , where  $p, q, r, k$  and  $\beta$  are non-zero real constants. Show that  $\beta = -\frac{q}{p}$ .

upward = ..... fe [8]

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

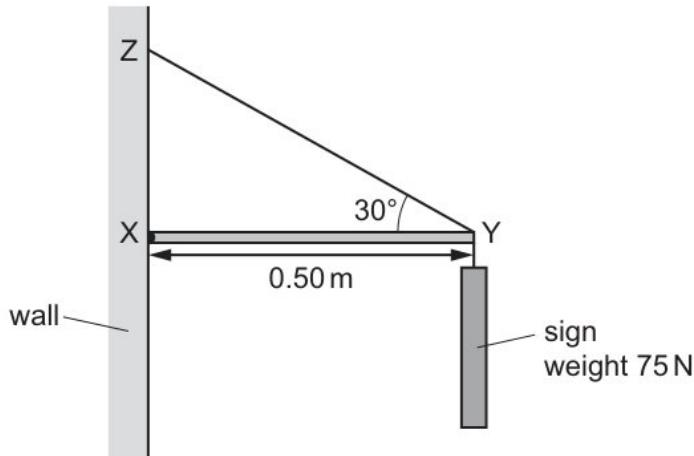
[5]

- 15 is a planet that may be considered to be an isolated uniform sphere of radius  $3.4 \times 10^6$  m. student takes measurements to calculate the density of a liquid in a beaker.

Hence find the largest integer  $y$  satisfying the inequality  $|2 \ln y - 5| < |\ln y + 3|$ .

[4]

27



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

is the diameter of the wire?

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

neutron decays to form a proton.

compares = .....  $ug$  [8]

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

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

then it converges to  $a$ .

pushing then = .....  $vu$  [3]

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

[5]

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

$X$  and  $Y$  are connected in series to a cell.

- (a) Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

[5]

- (c) the range of  $f$ ,

Show that if

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

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

[10]

- 16 Find the rank of  $M$ .

force is caused only by a pressure difference?

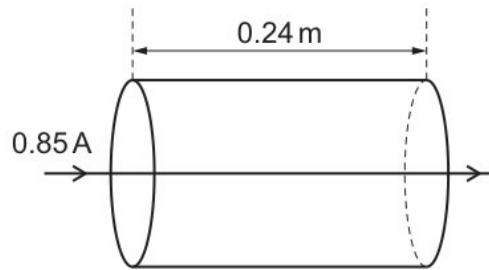
- (a) wire of length 1.70 m hangs vertically from a fixed point, as shown in Fig. 4.1.

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.

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.

correct Using = .....  $ja$  [10]

(b)



Find the value of  $I_2$ .

vertical. small = ..... or [4]

- 8 uniform rod of length 1.5 m and weight 2.4 N is shown in Fig. 2.1.

$$\int_2^5 (x - 2 \ln x) dx$$

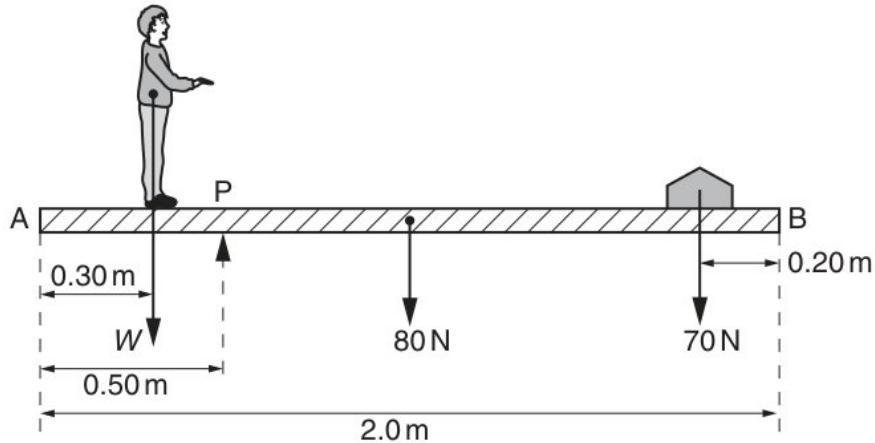
For this value of  $k$ , find the set of possible solutions, giving your answer in the form the value of  $\mu$  and the value of  $X$  for which the block is on the point of moving up the plane.

[2]

- 19  $B$  contains 5 red marbles and 3 blue marbles.

[20]

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



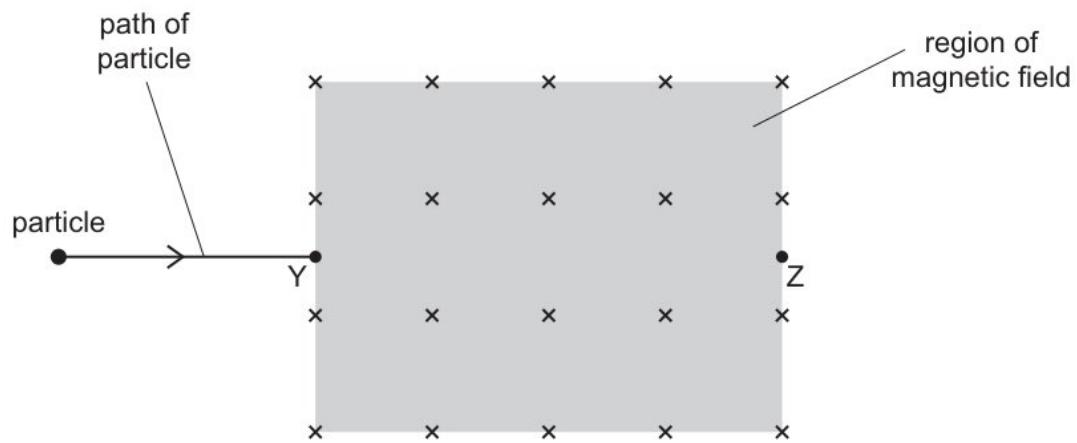
- (a)  $\omega = \cos \frac{1}{5}\pi + i \sin \frac{1}{5}\pi$ . Show that  $\omega^5 + 1 = 0$  and deduce that

[1]

- (e) Calculate the gravitational potential  $\phi$  at the surface of Mars. Give a unit with your answer.

[6]

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



[4]

- 11 the speed of the combined particle after this collision.

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

Find the least tension in the string during the motion.

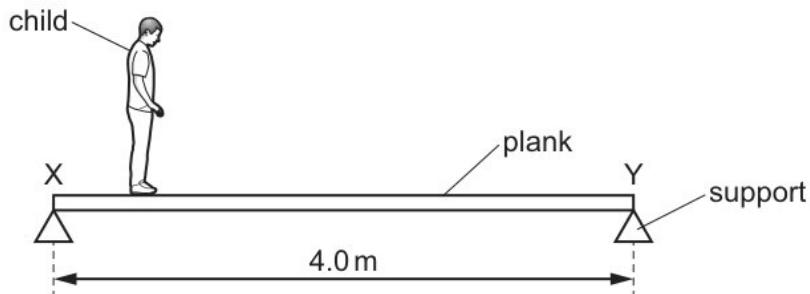
[15]

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

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

chosen weighs = ..... pt [6]

- (f) State the name of this type of reaction.



Find the values of  $a$  and  $b$ .

[8]

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

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.

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

[6]

- (a) two assumptions of the simple kinetic model of a gas.

[6]

- (f) 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.

[2]

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

number result = .....  $kl$  [4]

- 16 Show that, for  $n > 2$ ,

[12]

- 17 wires  $X$  and  $Y$  are made of different metals. The Young modulus of wire  $X$  is twice that of wire  $Y$ . The diameter of wire  $X$  is half that of wire  $Y$ .

[8]

- 29 (d) Find the position vector of  $D$ .

[6]

- (b) Nucleon numbers of nuclei are unchanged by the emission of  $\beta$ -particles.

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

[6]

- 17 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]

- 7 Find the set of values of  $k$  for which the line  $y = k$  does not intersect  $C$ .

product third = ..... *ow* [4]

- 9 (c) probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

number = ..... *ct* [4]

- (a) this compression, work  $W$  is done on the gas.

[3]

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

[2]

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

collides = ..... *sy* [6]

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

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

[8]

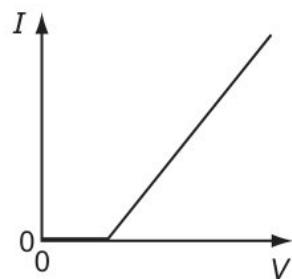
- (a) Find the perpendicular distance of the point  $A$  from the line  $BC$ .

negligible thickness = .....  $rd$  [4]

- (c) the term interference.

[6]

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

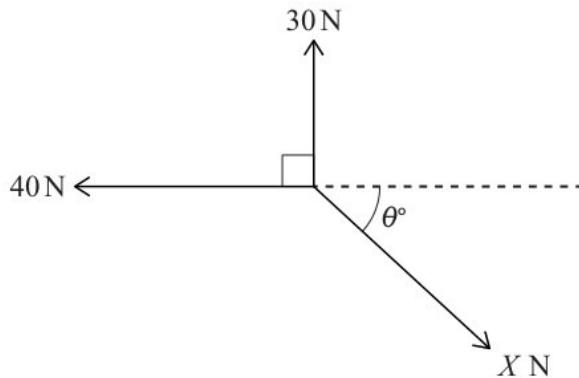


[5]

- 18 Show that the possible values of  $\alpha$  are 3 and 5 .

were = .....  $wb$  [12]

13



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).

lifetime hours, randomly = .....  $vz$  [5]

17 The orbit has a period of 25 hours.

[4]

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

amplitude = .....  $cq$  [6]

19 probability that Julian gets a good night's sleep on a randomly chosen flight is 0.285 .

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

Find the magnitude and direction of the force exerted by the surface on the lamina at  $A$ .

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

Find the probability that the die lands on 3 and the number of times the coin shows heads is 3 .

[12]

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

$a, b$  and  $c$  are integers to be determined.

[5]

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

[8]

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

[5]

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

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

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

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

why Kieran is incorrect.

[4]

- 20 Let  $z = \cos \theta + i \sin \theta$ . Show that  $z - \frac{1}{z} = 2i \sin \theta$  and hence express  $16 \sin^5 \theta$  in the form  $\sin 5\theta + p \sin 3\theta + q \sin \theta$ , where  $p$  and  $q$  are integers to be determined.

flights. = .....  $mt$  [6]

- 17 much energy is stored in the compressed column?  
 changes to  $R_1$  and to  $R_2$  will increase the value of  $V_{\text{out}}$  ?  
 the roots of the equation  $z^3 = 27 - 27i$ , giving your answers in the form  $r e^{i\theta}$ , where  $r > 0$  and  $-\pi \leq \theta < \pi$ .

Find the standard deviation of the weights of the letters.

$$p(x) = 6x^3 + ax^2 + bx + 10$$

- (d) are the amplitude and period of the wave?

attached = .....  $nh$  [8]

- (f) the term ultimate tensile stress.

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

[4]

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

[5]

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

[6]

- 23 two assumptions of the simple kinetic model of a gas.  
 is the mass of the car?

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

the distribution function of  $X$ .

from = ..... *kw* [4]

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

your answer = ..... *ad* [6]

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

both = ..... *eo* [5]

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

resistors, each of resistance  $R$ , are connected as shown.

[6]

- 10 polynomial  $p(x)$  is defined by

[20]

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

- (c) 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,

there divided = ..... *al* [10]

- (a) in either order the value of  $\mu$  and the value of  $\sigma$

[12]

- (f) random variable  $Y$  is defined by  $Y = \sqrt[3]{X}$   
a vector equation for  $l$ .

ties mass over = .....  $hh$  [15]

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

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 .

[10]

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

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

[5]

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

one. = .....  $iv$  [6]

- 22 de Moivre's theorem to show that

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

[5]

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

years = .....  $ty$  [6]

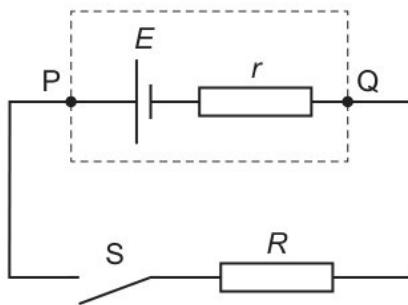
- 26 A block is released from rest at the top of a slope inclined at an angle to the horizontal. The slope has length  $L$  as shown in the diagram.

[4]

- 21 resistors, each of resistance  $R$ , are connected as shown.

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

(b)



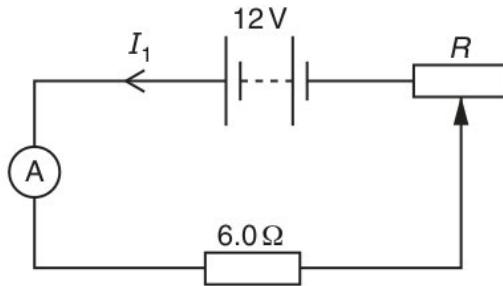
is the speed of the block after falling this distance?

direction = .....  $ym$  [2]

- (a) the Young modulus.

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

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



correct significant = ..... *uz* [5]

- (c) Calculate the distance of the centre of mass of the lamina from  $A$ .

find the position vectors of  $P$  and  $Q$ .

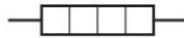
load from weight = ..... *cf* [12]

- (d) a cubic equation with roots  $\alpha, \beta$  and  $\gamma$ , given that

[2]

- 32 Calculate the acute angle between the planes.

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



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

[8]

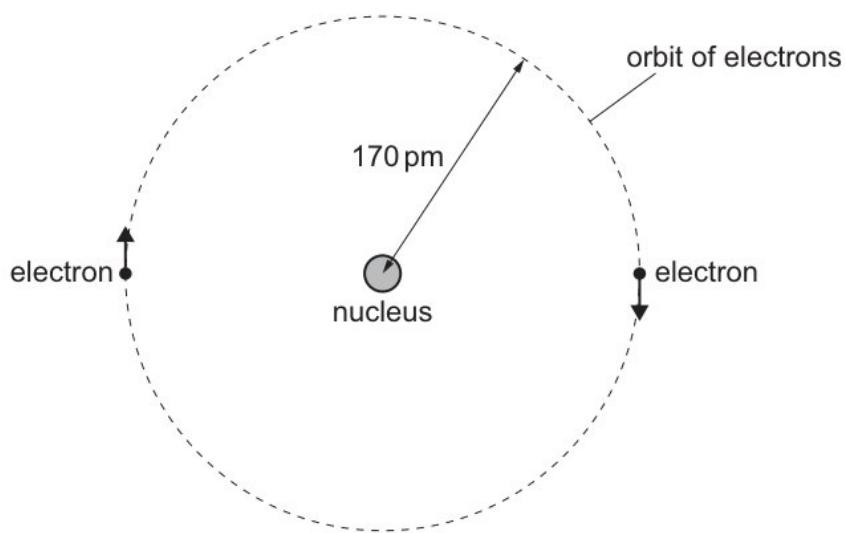
- 20 Find the greatest height that  $P$  reaches above the level of  $O$ .

diagram shows a uniform thin rod  $AB$  of length  $3a$  and mass  $8m$ . The end  $A$  is rigidly attached to the surface of a sphere with centre  $O$  and radius  $a$ . The rod is perpendicular to the surface of the sphere. The sphere consists of two parts: an inner uniform solid sphere of mass  $\frac{3}{2}m$  and radius  $a$  surrounded by a thin uniform spherical shell of mass  $m$  and also of radius  $a$ . The horizontal axis  $l$  is perpendicular to the rod and passes through the point  $C$  on the rod where  $AC = a$ .

the term isotope.

particles = .....  $lv$  [3]

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



[5]

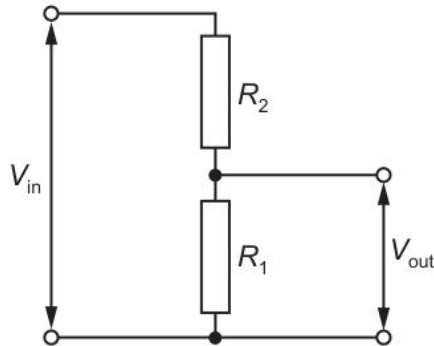
- 12 Calculate the gravitational potential  $\phi$  at the surface of Mars. Give a unit with your answer.  
 the value of  $(\alpha^3 - 1)^3 + (\beta^3 - 1)^3 + (\gamma^3 - 1)^3$   
 is the work done by  $F$  on the skateboarder and skateboard?

chosen that = .....  $rd$  [5]

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

[4]

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



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

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

- (a) Determine the decay constant, in  $\text{min}^{-1}$ , of the radioactive isotope.

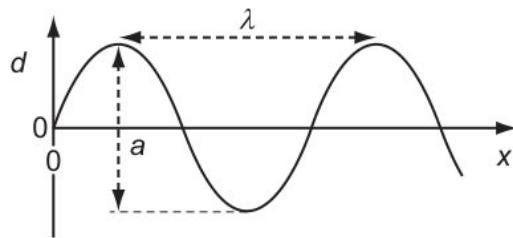
$$\text{people sudden years} = \dots \quad rk \quad [5]$$

- (c) Find the interquartile range of  $X$ .

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

[3]

- (d)



measuring instrument should be used?

[4]

- (b) Explain why the observed wavelength and the emitted wavelength have different values.

$$\mathbf{x} = \begin{pmatrix} p + 2\lambda + \mu \\ q + 2\lambda + 3\mu \\ -\lambda \\ \mu \end{pmatrix},$$

turn = ..... vp [6]

- 14 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.

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

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

[4]

- (b) Find the coordinates of the turning points of  $C$ .

[4]

- (c) the exact volume of the solid generated

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

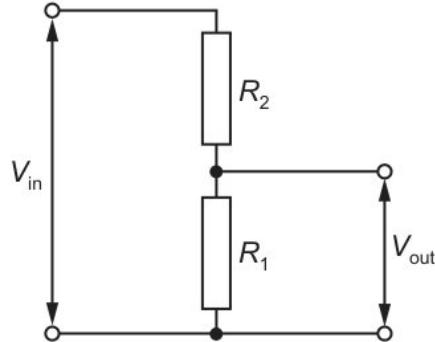
[6]

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

[5]

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

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



[3]

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

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

[6]

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

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

only one of the following two alternatives.

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

[3]

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

[1]

17 Show that, for  $n > 2$ ,

$$\text{elasticity horizontal} = \dots \quad vq \quad [12]$$

11 s friend says, "This survey is about sports facilities, so you should choose a sample of students from the school sports teams."

$$\text{mouthpiece note} = \dots \quad hr \quad [6]$$

24 the experimental observations that show radioactive decay is

[6]

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

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

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

[5]

30 Calculate the acute angle between the planes.

[8]

26 quantities would be measured in order to determine  $E$  ?

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

$$\text{mark. suspended} = \dots \quad ti \quad [10]$$

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

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

[8]

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

the 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.

plane = ..... zo [8]

- 11 de Moivre's theorem to prove that

$5 \sin(x + \frac{1}{6}\pi) - 4 \cos x$  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  $\alpha$  correct to 3 decimal places.

[3]

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

$$\mathbf{x} = \begin{pmatrix} p + 2\lambda + \mu \\ q + 2\lambda + 3\mu \\ -\lambda \\ \mu \end{pmatrix},$$

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

[15]

- (a) variables  $x$  and  $y$  satisfy the differential equation

[10]

- (c) Find the cartesian equation of the plane through  $A$ ,  $B$  and  $C$ .

a crossword competition the times,  $x$  minutes, taken by a random sample of 6 entrants to complete a crossword are summarised as follows.

[5]

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

[5]

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

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

[5]

- 23 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.

- (d) state the corresponding eigenvalue.

produced meets = .....  $ew$  [8]

- (f) Draw box-and-whisker plots in a single diagram on graph paper to illustrate the marks for History and Physics.

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

[4]

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

[4]

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

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

[8]

- 30 Find the value of  $x$  for which  $P$  reaches its maximum velocity, and calculate this maximum velocity.

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

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

Jimpuri the weights, in kilograms, of boys aged 16 years have a normal distribution with mean 61.4 and standard deviation 12.3.

only one of the following two alternatives.

[6]

- 18 row correctly identifies the properties of all electromagnetic waves?  
with a reason, whether it was necessary to use the Central Limit Theorem in your answer to part (b).  
a positron and a neutrino  
(d) by calculation that  $a$  lies between 2 and 2.1.

[5]

- (b) radius of the circle in which  $P$  moves and the radius of the circle in which  $Q$  moves,

population = .....  $vx$  [5]

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

spheres directly = .....  $ik$  [3]

- 13 is a planet that may be considered to be an isolated uniform sphere of radius  $3.4 \times 10^6$  m.

- (d)  $a$  and  $b$  are constants. 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 24 .

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

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

[10]

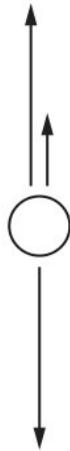
- (a) Given that on a particular flight Julian does not get a good night's sleep, find the probability that he is flying economy class.

[4]

- 9 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).

[2]

17



$k$  is a positive constant. The relevant expected frequencies are given in the following table. safety precautions to be taken.

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

[2]

24  $\lambda$  is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

- (c) tractor comes to a hill inclined at  $4^\circ$  above the horizontal. The power output is increased to 25 kW and the resistance to motion is unchanged.

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

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

$$\text{smallest} = \dots \ fg \quad [5]$$

- (f) variable resistor in (a) is now connected as a potential divider, as shown in Fig. 5.3.  
direction = .....  $su$  [12]

- (a) is the speed of the block at the bottom of the slope?

[5]

- (e) 1.1 shows the measurements for cube A.

[3]

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

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \mathbf{a} + t\mathbf{b}$$

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

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

- (i) the vertical and horizontal components of velocity at time  $t$ .

ties = ..... ju [3]

- (iii) time  $T$ , particle  $P$  is moving at an angle of  $60^\circ$  below the horizontal.

[8]

- (vii) by calculation that  $a$  lies between 2 and 2.1.

time  $T$ , particle  $P$  is moving at an angle of  $60^\circ$  below the horizontal.

[5]

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

horizontal. = ..... bp [6]

- 11 It consists of three quarks that do not need to be the same flavour.

- (d) should pay particular attention to

[8]

- (b) is the phase difference between two points on the wave that are a distance of 0.50 m apart?  
 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  $B$ .

[2]

- 13 Find the set of values of  $k$  for which the line  $y = k$  does not intersect  $C$ .

State the equation of the other asymptote.

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

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

horizontal. = .....  $lr$  [6]

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

[12]

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

give where = .....  $qq$  [5]

- 16 moment of a force.

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

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.

[2]

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

[3]

- 19 Find the angle between the vertical and the side  $AO$  of the lamina.
- (a) could M and N be?  
 a certain time, the projectile has a horizontal velocity of  $23.0 \text{ ms}^{-1}$  and a vertical velocity of  $-10.1 \text{ m s}^{-1}$ .

tomato = ..... gs [2]

- (c) the other root and hence find the values of  $b$  and  $c$ .  
 the graph to estimate how many people took between 4 and 7.5 minutes to complete the puzzle.

[3]

(g)

Patient	$A$	$B$	$C$	$D$	$E$	$F$	$G$	$H$
Before	183	165	172	165	143	176	161	153
After	164	148	164	149	134	153	155	148

three quantities that are conserved during the decay.

find the variance of the number of 4 s obtained in 30 throws,

[10]

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

- (e) 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  $\frac{8}{3}Ma^2$ .

[3]

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

these = .....  $nt$  [6]

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

[3]

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

number, randomly = .....  $nw$  [6]

- 18 cubic equation  $x^3 + 2x + 1 = 0$  has roots  $\alpha, \beta, \gamma$ .

number = .....  $yt$  [8]

- 12 variables  $x$  and  $y$  satisfy the differential equation

$$\text{random machine} = \dots\dots jd \quad [6]$$

- 12 The battery supplies 9.0 J to an external circuit for each coulomb of charge.

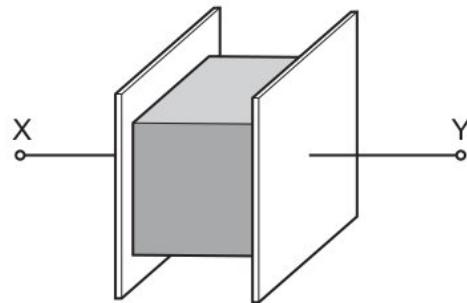
[4]

- 10 a positron and an antineutrino

$$\text{point} = \dots\dots oz \quad [4]$$

- 9 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  $30^\circ$  above the horizontal. The car then immediately descends another ramp of length 10 m inclined at  $20^\circ$  below the horizontal. The resistance to motion acting on the car is 640 N throughout the motion.

- (c) 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.



[4]

- (h) cubic equation  $2x^3 - 3x^2 + 4x - 10 = 0$  has roots  $\alpha, \beta$  and  $\gamma$ .

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

the ductile material,

[8]

- (e) The potential difference across any component connected to the battery will be  $9.0 \text{ V}$

[8]

- 11 particle  $P$  of mass  $0.2 \text{ kg}$  is released from rest at a point  $O$  on a smooth horizontal surface. A horizontal force of magnitude  $te^{-v} \text{ N}$  directed away from  $O$  acts on  $P$ , where  $v \text{ m s}^{-1}$  is the velocity of  $P$  at time  $t \text{ s}$  after release. Find the velocity of  $P$  when  $t = 2$ .

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

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

[5]

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

modelled = ....  $kk$  [6]

- (b) that  $v = y^3$ , show that

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.

collides opposite = ....  $al$  [8]

- 11 the probability that both marbles chosen are the same colour.  
the ratio  $H : D$ .

[8]

- 12 pendulum bob is held stationary by a horizontal force  $H$ . The three forces acting on the bob are shown in the diagram.  
curve  $C$  has equation  $\tan y = x$ , for  $x > 0$ .

work energy = .....  $pb$  [8]

- 21 roots of the cubic equation  $x^3 + 2x^2 - 3 = 0$  are  $\alpha, \beta$  and  $\gamma$ .

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

[5]

- 10 the value of  $\frac{dy}{dx}$  at  $P$ ,  
linear transformation  $T : \mathbb{R}^4 \rightarrow \mathbb{R}^4$  is represented by the matrix  $\mathbf{A}$ , where

[6]

- 27 (b) that  $k = 3$  and  $p = 26$ .

[8]

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

[8]

- (a) Find the mean and variance of the daily income, in millions of dollars, generated by field  $A$ .

[10]

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

[5]

- 20 transmitted light has intensity  $I$ .

Find the probability that a box is rejected.

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

against = .....  $gq$  [6]

- 23 amplitude  $\propto$  (intensity) $^2$

[3]

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

[4]

- 24 is the value of  $R$  ?

- (d) sequence  $x_1, x_2, x_3, \dots$  defined by

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

first = ..... al [4]

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

[6]

- 8 matrix  $\mathbf{A}$  is given by

[6]

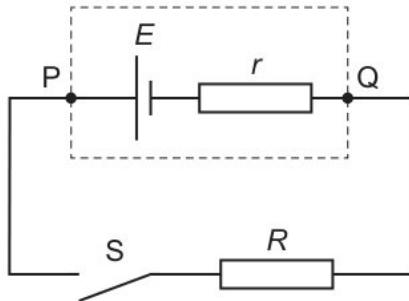
- 26 water is added to an insulated beaker, as shown in Fig. 2.1.

$$\frac{d^n}{dx^n} (e^x \sin x) = 2^{\frac{1}{2}n} e^x \sin \left( x + \frac{1}{4}n\pi \right)$$

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

between = ..... pp [10]

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



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  $\frac{15}{2}\sqrt{2} \text{ m}$ .

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

[6]

- 21 Calculate the modulus of elasticity of the string.

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

[8]

(c) cubic polynomial  $p(x)$  is defined by

with = ..... ee [6]

(a) 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.

[10]

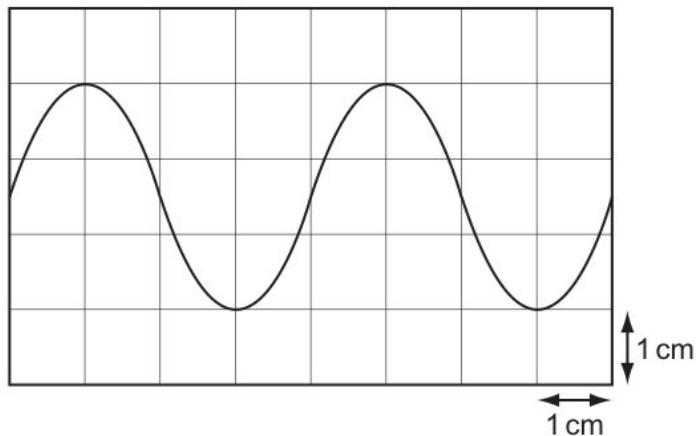
- 25 the time from release until  $OP$  makes an angle  $\frac{1}{2}\alpha$  with the downward vertical for the first time.

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

[5]

- 15  $\mathbf{A} = \begin{pmatrix} 2 & 3 \\ 0 & 1 \end{pmatrix}$ . Prove by mathematical induction that, for every positive integer  $n$ , all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is  $10.3^\circ\text{C}$ .

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



Brigville the weights, in kilograms, of boys aged 16 years have a normal distribution. 99% of the boys weigh less than 97.2 kilograms and 33% of the boys weigh less than 55.2 kilograms.

$$\text{angle} = \dots\dots mx \quad [3]$$

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

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

[10]

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

velocity surface. = ..... tu [4]

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

	energy / J	time / s
A	3.0	2.0
B	3.0	8.0
C	48	2.0
D	48	8.0

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

plane plane. = ..... gu [6]

- 21 Calculate the maximum pressure a slab could exert on the ground when resting on one of its surfaces.

the principle of superposition.

- (e) Velocity is proportional to wavelength.

[10]

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

[3]

- (a) 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 equations of the asymptotes of  $C$ .

[5]

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

[4]

- 33 Find the area of one loop of  $C$ .

[5]

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

definition is correct and uses only quantities rather than units?

$$\int_0^a (1 + 2x + 3e^{3x}) dx = 250$$

- (c) 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.

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

[6]

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

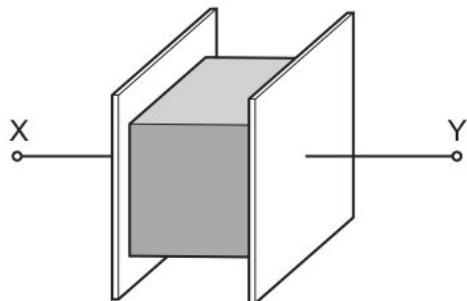
[3]

- 26 the team contains more boys than girls.

what is meant by a fundamental particle.

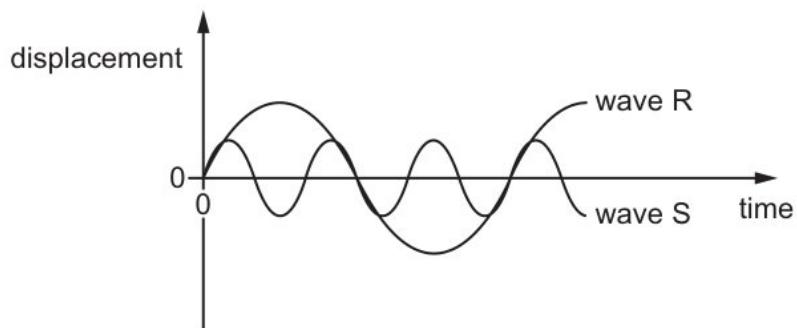
[2]

- 16 students are selected at random from the students who study Science.  
is the reading on the ammeter?



[15]

- 23 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  
plank rests on fixed supports at its ends  $X$  and  $Y$ .
- (c) diagram shows a uniform thin rod  $AB$  of length  $3a$  and mass  $8m$ . The end  $A$  is rigidly attached to the surface of a sphere with centre  $O$  and radius  $a$ . The rod is perpendicular to the surface of the sphere. The sphere consists of two parts: an inner uniform solid sphere of mass  $\frac{3}{2}m$  and radius  $a$  surrounded by a thin uniform spherical shell of mass  $m$  and also of radius  $a$ . The horizontal axis  $l$  is perpendicular to the rod and passes through the point  $C$  on the rod where  $AC = a$ .



[6]

- (a) the value of  $\theta$ .

[5]

- (b) team of 4 is to be randomly chosen from 3 boys and 5 girls. The random variable  $X$  is the number of girls in the team.

[6]

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

[5]

- 9 a basis for the null space of  $T$ .

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

final changes = .....  $xg$  [6]

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

[6]

- (b) an electron and a neutrino

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

[2]

- 10 the arc length of  $C$ ,

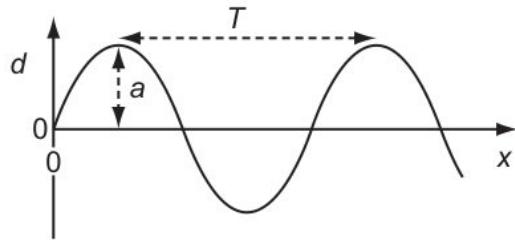
beech = ..... to [2]

- 17 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  $O$ .

- (a) height of the orbit is increased to  $6.8 \times 10^6$  m above the surface. This increases the gravitational potential energy of the satellite by  $5.1 \times 10^8$  J.

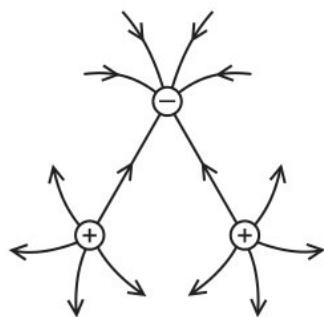
emitting = .....  $md$  [5]

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



[4]

- 13 Find the equation of the tangent to the curve at the point where  $x = 0$ .  
your answers in the form  $\tan k\pi$ , where  $k$  is a rational number.

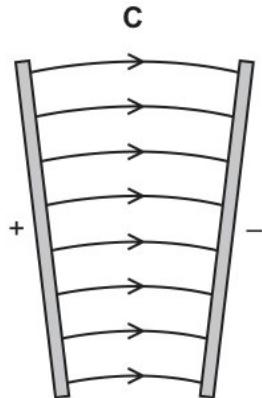


is the charge, in terms of the elementary charge  $e$ , on a charm quark?

- (c) is the gravitational force on the astronaut when the spacecraft is launched vertically upwards with an acceleration of  $0.2g$  ?

[6]

(b)



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

diagram radians. tangent = .....  $ke$  [8]

21 Find the value of  $I_2$ .

[2]

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

(a) the period of small oscillations,

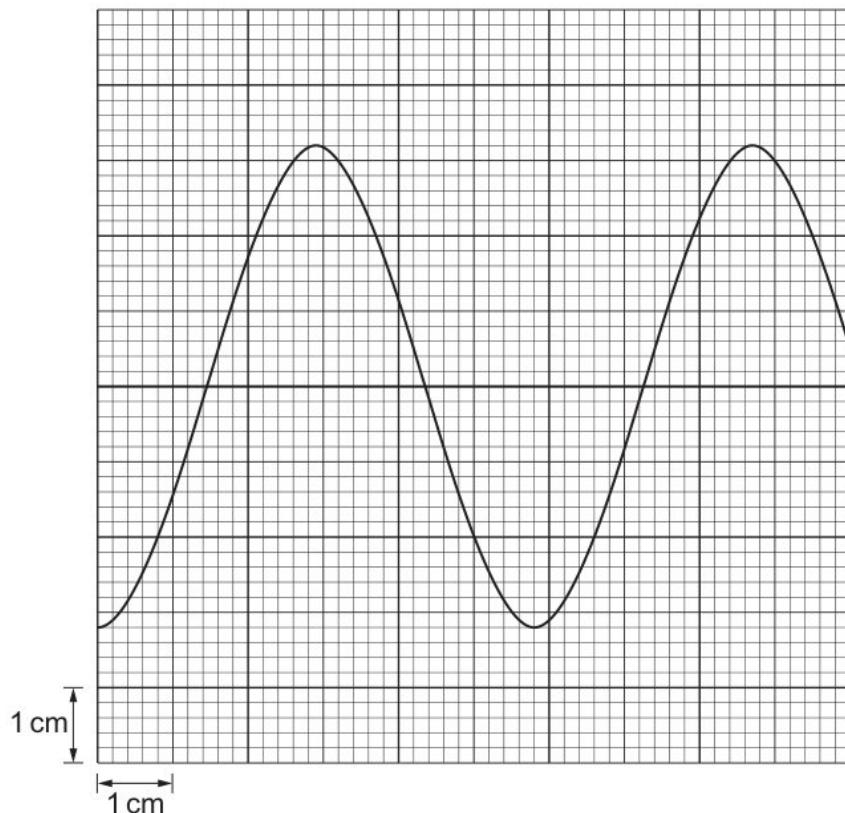
Member	$A$	$B$	$C$	$D$	$E$	$F$	$G$	$H$
$x$	24.2	23.8	22.8	25.1	24.5	24.0	23.8	22.8
$y$	23.9	23.6	22.8	24.5	24.2	23.5	23.6	22.7

[6]

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

[5]

10



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

$$\text{distance particles} = \dots \quad ug \quad [6]$$

- 19 is the force exerted on the wall by the water?

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

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

- (b) 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  $30^\circ$  to the vertical.

[4]

- (d) in terms of  $a$ , the distance that  $P$  moves down the plane before coming to rest.

[4]

- (c) 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

[2]

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

[5]

- 14 The power to  $X$  will increase and the powers to  $Y$  and  $Z$  will remain unaltered.  
marks of the pupils in a Physics examination are summarised as follows.

- (a) weight of the parachutist is 850 N .

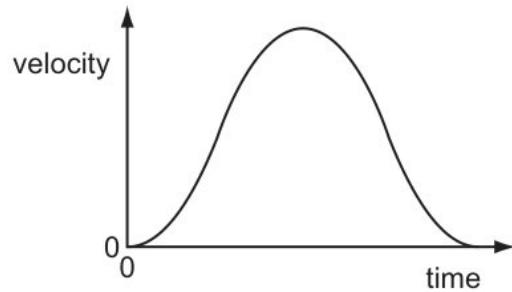
Find the volume obtained when the shaded region is rotated through  $360^\circ$  about the  $x$ -axis, giving your answer in terms of  $\pi$ .

Show = .....  $ry$  [6]

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

circle = .....  $nd$  [12]

- 11 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  $H$ .



[2]

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

[12]

- 14 is the angle between the second-order maximum and the third-order maximum?

[4]

- 15 Find the value of  $I_2$ .

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

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.

[2]

- 7 Let  $z = \cos \theta + i \sin \theta$ . Show that  $z - \frac{1}{z} = 2i \sin \theta$  and hence express  $16 \sin^5 \theta$  in the form  $\sin 5\theta + p \sin 3\theta + q \sin \theta$ , where  $p$  and  $q$  are integers to be determined.

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 .

[12]

- 13 that, when  $t = 0$ ,  $x = \frac{dx}{dt} = 0$ .

Given that  $v = 2.5$ , find  $x$ .

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

[20]

- 17 the total time for which she is in motion from the instant that she passes  $O$ .

[2]

- 15 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  $AB$ .

[6]

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

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

leaving = .....  $xa$  [12]

- 12 lowest mark was 17 and the highest mark was 74 .

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

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

thermistor is connected to a cell with negligible internal resistance.

current-carrying coil produces a magnetic field.

[6]

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

[6]

- (a) Given that  $E(X) = 1.2$ , find the value of  $a$ .

number = .....  $vc$  [10]

- 21 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?

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

points = .....  $zj$  [4]

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

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

[8]

(c) by calculation that  $a$  lies between 2 and 2.1.

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

[8]

15  $a, b$  and  $c$  are integers to be determined.

(c) up the probability distribution table for  $X$ .

direction. = .....  $ef$  [6]

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

[2]

(d) the matrix  $\mathbf{A}$ ,

lamina is freely suspended at  $A$  and hangs in equilibrium.

[4]

28 the jet of water hits the wall, it has horizontal velocity  $v$  and cross-sectional area  $A$ .

[3]

22 the SI base units of resistivity.

lengths, = .....  $iq$  [10]

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

- (a) parametric equations of a curve are

[2]

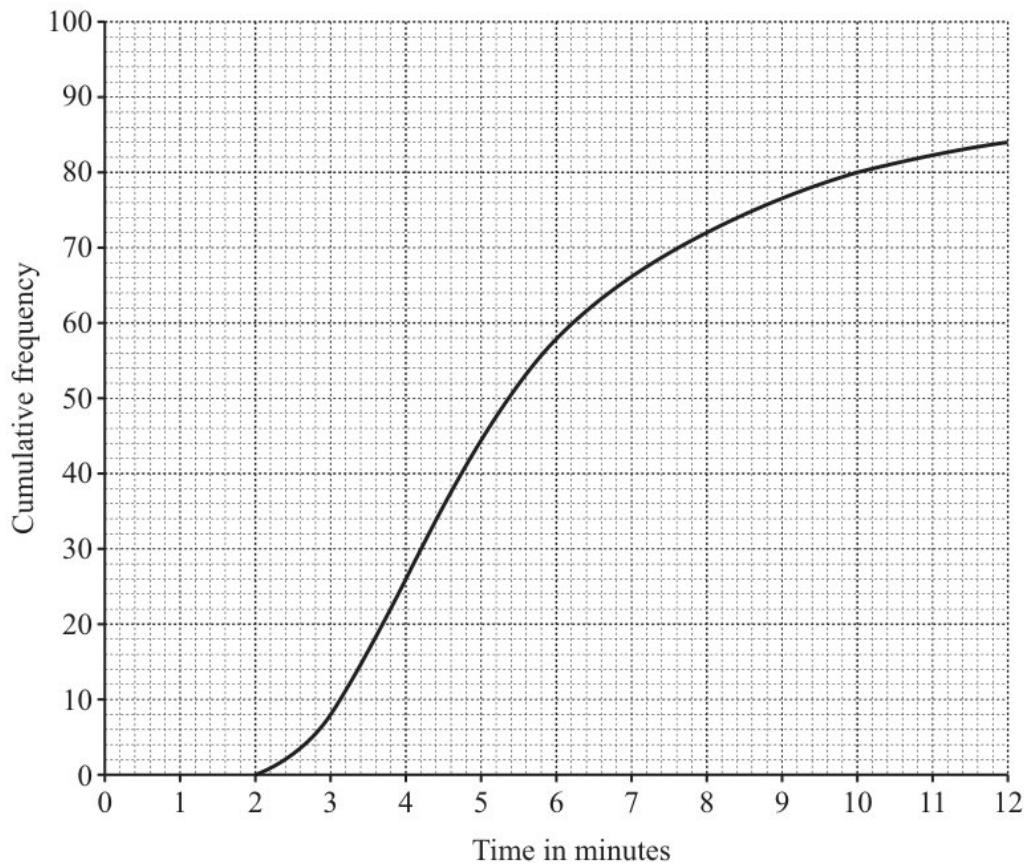
- (c) polynomial  $p(x)$  is defined by

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

curve  $C$  has parametric equations  $x = e^t \cos t, y = e^t \sin t$ , for  $0 \leq t \leq \pi$ . Find the arc length of  $C$ .

[12]

(b)



Show that  $\frac{dy}{dx} = 2t^{\frac{1}{2}} \frac{dy}{dt}$  and  $\frac{d^2y}{dx^2} = 2 \frac{dy}{dt} + 4t \frac{d^2y}{dt^2}$ .

[6]

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

[6]

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

[6]

- 38 Determine the decay constant, in  $\text{min}^{-1}$ , of the radioactive isotope.  
is given instead that the kinetic energy of  $P$  is twice the elastic potential energy stored in the string.

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

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

It limits the range of values obtained in repeated measurements.

line = ..... *ow* [8]

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

[4]

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

[20]

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

[6]

- (c) specific latent heat.

[8]

- 19 function  $f$  is such that  $f(x) = 3 - 4 \cos^k x$ , for  $0 \leq x \leq \pi$ , where  $k$  is a constant.
- (a) diagram shows a child  $X$  of mass 20 kg and a child  $Y$  of mass 15 kg seated on a uniform plank.
- Show that the cartesian equation of  $C$  is  
 the set of values of  $x$  for which the expansion in part (b) is valid.

[10]

- (c) curves  $C_1$  and  $C_2$  have polar equations  
 the number of different ways in which the 12 letters of the word STRAWBERRIES  
 can be arranged

[6]

- 8 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.

[3]

- 16 that, at the point  $A(-1, 1)$  on  $C$ ,  $\frac{dy}{dx} = -4$ .
- (a) is the energy transferred in the resistor and the time taken for the charge to pass through the resistor?

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

[6]

- (c) 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]

- (e) Q hears a sound of decreasing frequency.

[12]

- 11 the rank of  $\mathbf{M}$  and a basis for the range space of  $T$  ,  
that the object is on the point of toppling in its vertical plane about the vertex  $D$ , find the value of  $k$ .

[10]

- 8 the values of the constants  $k_1$  and  $k_2$  are to be determined.  
the probability that both marbles chosen are the same colour.

[1]

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

Find the exact area of the shaded region.

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

[6]

- (iii) student determines the ratio  $\frac{\text{upthrust acting on the object}}{\text{weight of the object}}$ .

[4]

- 27 the coordinates of any stationary points on  $C$ .

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

[6]

- 28 all solutions in the interval  $0^\circ \leq \theta \leq 180^\circ$ .

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  $V_{\text{out}}$ .

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

$$x = \ln(\cosh t), \quad y = \tan^{-1}(\sinh t), \quad \text{for } 0 \leq t \leq 1.$$

motion = .....  $ta$  [3]

- 7 (b) team of 4 is to be randomly chosen from 3 boys and 5 girls. The random variable  $X$  is the number of girls in the team.

the equation representing this decay.

[6]

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

[6]

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

[2]

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

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

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

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

[2]

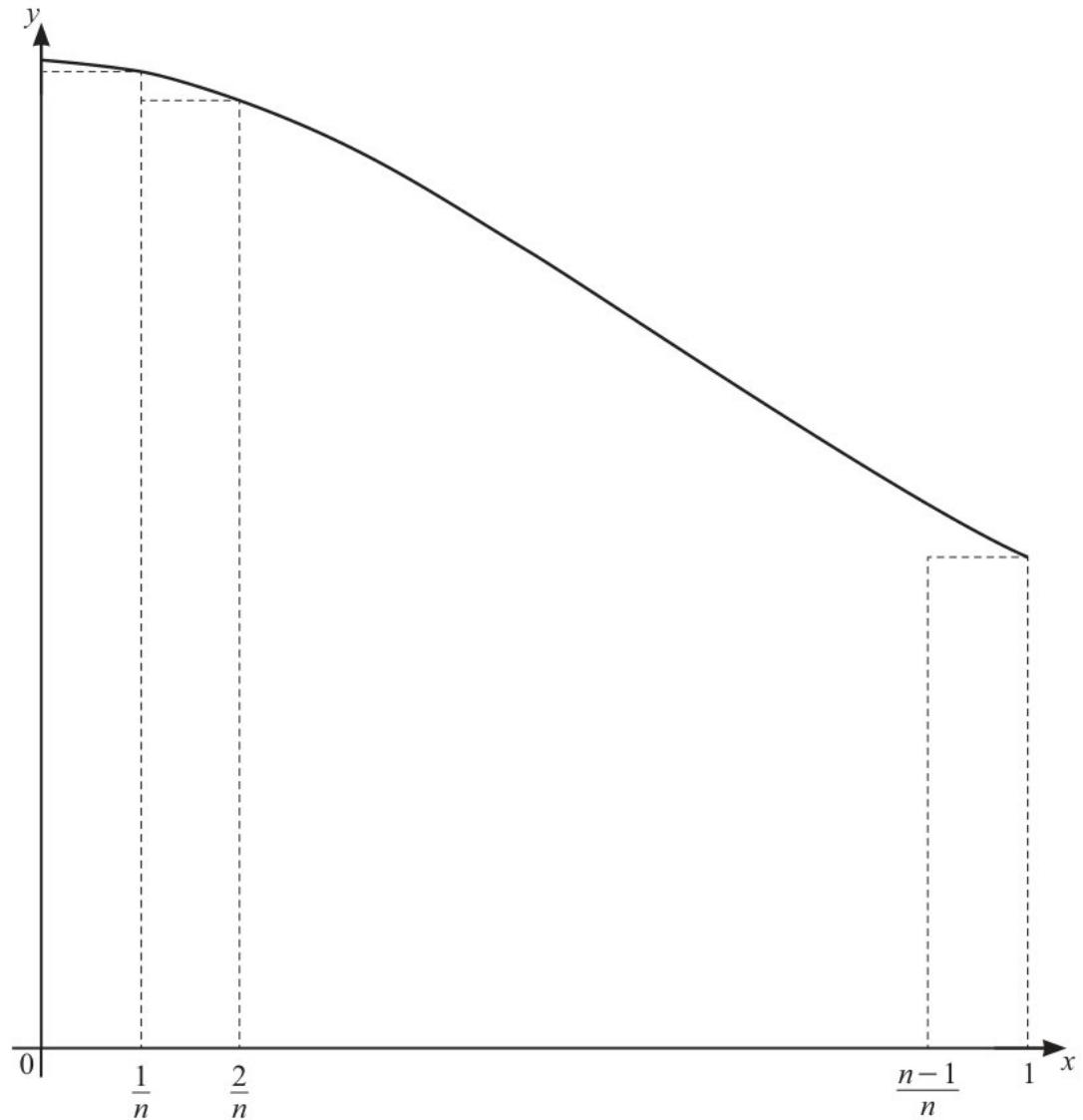
- 20 Find the exact area of the shaded region.

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

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

[8]

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



is the angle  $\theta$  ?

[15]

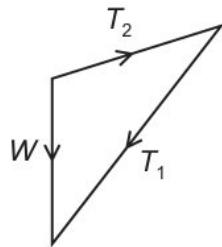
- (a) the values of  $t$  such that the shortest distance between the lines  $AB$  and  $CD$  is  $\sqrt{2}$ .

[10]

- 15 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.

[4]

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



[8]

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

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.

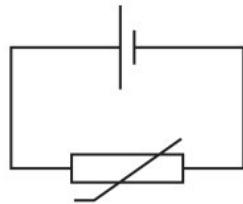
point = .....  $fl$  [5]

- 19 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.

(b) Determine the decay constant, in  $\text{min}^{-1}$ , of the radioactive isotope.

[4]

- (c) the expected value and variance of  $Y$ .



load = ..... er [4]

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

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

Find the distance of  $B$  from the wall when it collides with  $A$  for the second time.

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

[5]

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

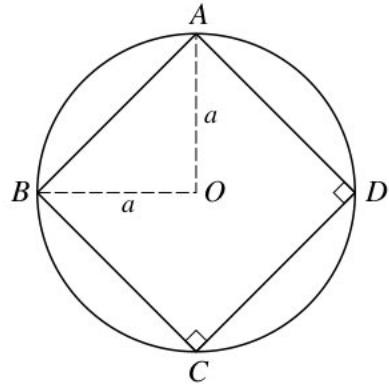
[6]

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

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

[5]

- (a) 1.1 lists some physical quantities. Identify with ticks ( $\checkmark$ ) which quantities are vectors and which are scalars.



[6]

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

- (b) Calculate the initial speed and the angle of projection of  $P$ .

[4]

- (f) 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.

force is caused only by a pressure difference?

[12]

- (c) curve  $C$  has equation  $y = \frac{2x^2 - 5x}{2x^2 - 7x - 4}$   
the mean of the times taken by all 50 runners.

[8]

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

[4]

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

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

- (c) flows out of a pipe and hits a wall.

student determines the ratio  $\frac{\text{upthrust acting on the object}}{\text{weight of the object}}$ .

[5]

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

the exact area of one loop of the curve.

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

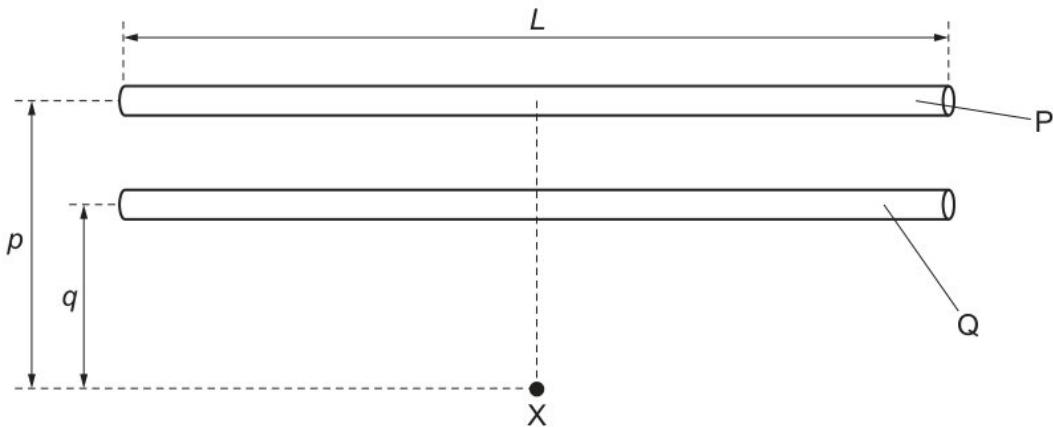
[5]

- (d) Under 25 178 181 183 192 203 209 223 231

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

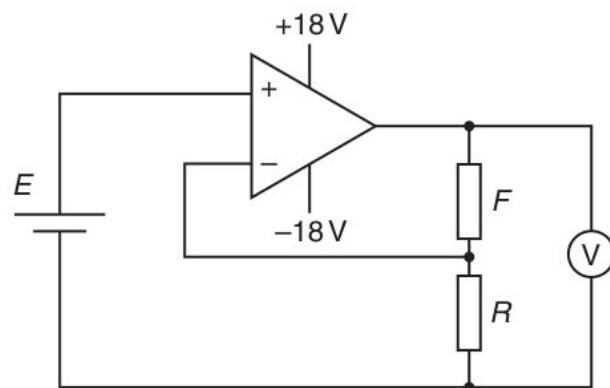
[6]

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



[3]

(a)



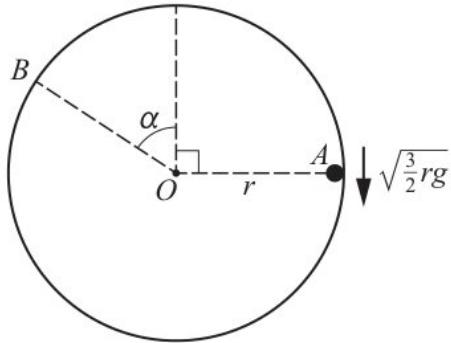
all the ice has melted, and all the water in the beaker has reached thermal equilibrium, the final temperature of all the water is  $10.3^{\circ}\text{C}$ .

[4]

- 22 (c) Find the value of  $t$  when the particle is instantaneously at rest.

[4]

- (e) that if a sequence of values given by the iterative formula



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

[8]

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

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<sup>-2</sup>.

[8]

- (f) 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  $\rho$ . Diameter  $D$  is much greater than diameter  $d$ .

[8]

- 18 Hence find the largest integer  $y$  satisfying the inequality  $|2 \ln y - 5| < |\ln y + 3|$ .

- (b) that  $\mathbf{e}$  is an eigenvector of  $\mathbf{A}^3$  with corresponding eigenvalue  $\lambda^3$ .

$$\text{power} = \text{force} \times \text{velocity}$$

small = .....  $ck$  [20]

- (c) will the powers to the resistors change when resistor W is removed?

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 .

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

[4]

- (a) the distribution function of  $X$ .

Find the magnitude and direction of the force exerted by the surface on the lamina at  $A$ .

[15]

- (d) Obtain another equation relating  $u^2, v^2, a$  and  $g$ , and hence find  $u$  in terms of  $a$  and  $g$ .

$10^7 = \dots \text{on}$  [12]

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

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

- (d) Use de Moivre's theorem to prove that

[4]

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

[6]

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

524    526    520    523    530

[8]

- 30 (c) that  $k = 3$  and  $p = 26$ .

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

[5]

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

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]

- 9 Find the values of  $a$  and  $b$ .

[4]

- 18  $800 \text{ nm to } 1000\mu \text{ m}$

$$[\Sigma x = 191, \quad \Sigma x^2 = 4564.46, \quad \Sigma y = 188.8, \quad \Sigma y^2 = 4458.4, \quad \Sigma xy = 4510.99.]$$

- (a) the complex numbers  $z$  for which  $\frac{z+5i}{z-5}$  is real and  $|z| = \sqrt{17}$  Give your answers in the form  $z = x + iy$  where  $x$  and  $y$  are real

[6]

- (c) number of cars sold per day at another showroom has the independent distribution Po(0.6). Assume that the distribution for the first showroom is still Po(0.7).

[6]

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

the probability that the 3 customers bought computers all made by different companies.  
graphs show possible current-voltage (  $I - V$  ) relationships for a filament lamp and  
for a semiconductor diode.

rebounds = ..... cb [6]

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

[4]

19  $a$  and  $b$  are constants. 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 24 .

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

[5]

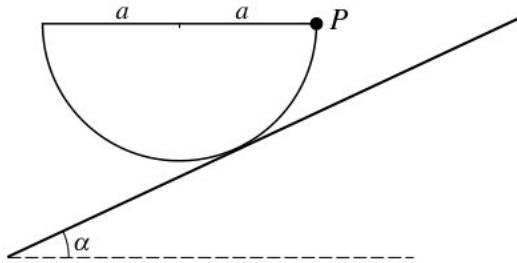
- (a) the time that it takes from when  $P$  is initially projected until the instant at which  $P$  collides with the combined particle

than = ..... ew [6]

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

[3]

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



claim, = ..... lr [6]

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

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

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

[6]

- 7 continuous random variable  $X$  takes values in the interval  $0 \leq x \leq 3$  only. For  $0 \leq x \leq 3$  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

then it converges to  $a$ .

[8]

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

Find the coordinates of the turning points of  $C$ .

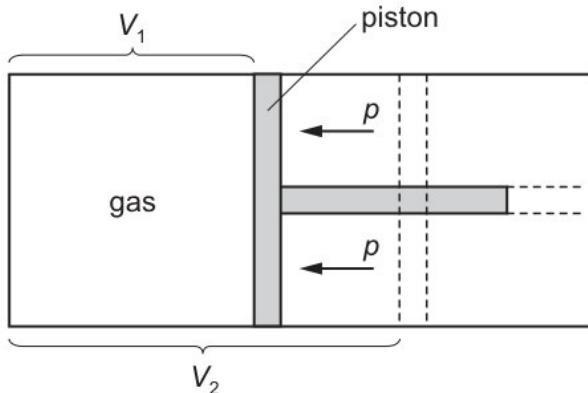
[5]

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

- (c) throws three coins at the same time.

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

$a, b$  and  $c$  are integers to be determined.



[5]

- (a)  $3 \times 3$  matrix  $\mathbf{A}$  has eigenvalues  $-1, 1, 2$ , with corresponding eigenvectors

The total momentum is conserved only in elastic collisions.

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

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

both = .....  $v_o$  [6]

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

[5]

- 8 tree of mass 270 kg grows out of sloping ground and is supported by a post, as shown in Fig. 2.1.

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

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

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

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

junction = ..... zz [4]

- 21 When  $a$  and  $b$  have these values, factorise  $p(x)$  completely.

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

[5]

- 26 quantities would be measured in order to determine  $E$  ?

travels = .....  $du$  [5]

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

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

[3]

- 16 diagram shows a uniform plank XY of length 4.0 m and weight 300 N .  
why the variation with time of the activity of a radioactive sample is exponential in nature.

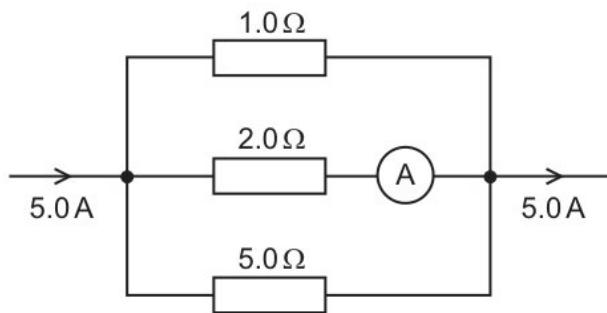
$$x^2 - 11 = \dots \text{vr} \quad [5]$$

- 29 resistor of resistance  $240\Omega$  is now replaced by a new resistor X of unknown resistance. A galvanometer is connected as shown in Fig. 6.2.

- (d) P hears a sound of increasing frequency.

$$\text{meets area} = \dots \text{rl} \quad [5]$$

- (b) to the origin  $O$ , the position vectors of the points  $A, B$  and  $C$  are given by  
Sunday, teams of runners took part in a charity event. The time taken, in seconds, to run 50 m was recorded, correct to 1 decimal place, for each runner. The times recorded for 11 runners from each of the Gulls and the Herons are shown in the table.



[3]

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

$$\text{speed} = \dots \text{tl} \quad [2]$$

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

[15]

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

[2]

16 The battery supplies 9.0 J to an external circuit for each coulomb of charge.

- (c) radio-controlled toy car travels along a straight line for a time of 15 s .  
the probability density function of  $Y$ ,

[8]

- (b) the value of  $\theta$  for which the transformation represented by  $\mathbf{M}$  has a line of invariant points. [7]

[6]

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

[12]

16 up to antidown

[10]

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

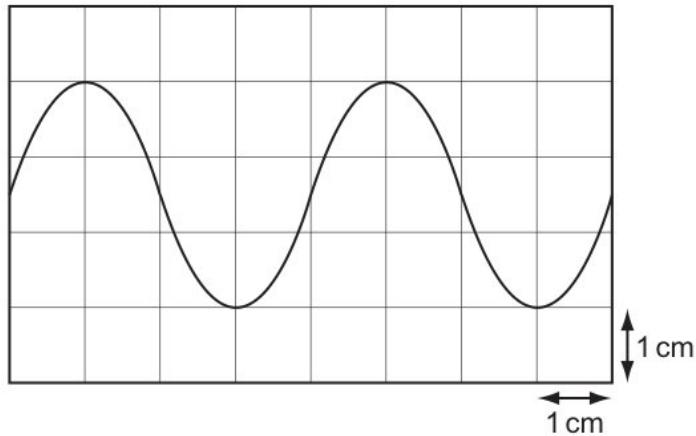
[5]

- 19 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.

also = .....  $ds$  [6]

- 18 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

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



[4]

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

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  $\theta$  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  $e$ .

- (c) are the frequencies of the next two higher notes for this air column?

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

[10]

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

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

[4]

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

[8]

(a)

	$\alpha$ -particles	$\gamma$ -rays
A	least ionizing	least penetrating
B	least penetrating	most ionizing
C	most ionizing	most penetrating
D	most penetrating	least ionizing

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

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

[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.

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

[2]

- (c) electron moving at a speed of  $4.9 \times 10^7 \text{ ms}^{-1}$  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.

[6]

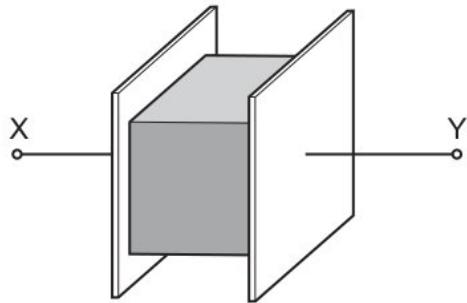
- (d) Given that  $\mu = 0.36$  and that both  $P$  and  $Q$  move in the same horizontal circle of radius 0.5 m , calculate the greatest possible value of  $\omega$  and the corresponding tension in the string.

[10]

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

[8]

9



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 value of  $I_2$ .

[8]

- 31 the probability that both marbles chosen are the same colour.

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.

- (b) 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.

[6]

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

[10]

- (g) Find the equation of the tangent to the curve at  $P$ .

seeds. find find = .....  $ag$  [5]

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

[12]

12 the exact volume of the solid generated

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

[5]

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

[4]

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

[12]

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

[10]

- 19 Calculate the speed of the star relative to the Earth.

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

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

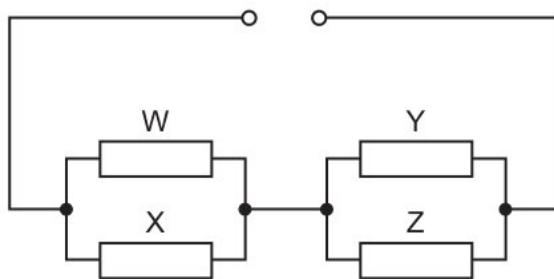
$$\text{vertical} = \dots \text{ha} \quad [5]$$

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

[5]

- 20 the period of small oscillations,

(i)



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

$$\text{segments.} = \dots \text{tq} \quad [10]$$

- (ii)  $a$  and  $b$  are constants. 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 24 .

$$\text{ground} = \dots \text{xg} \quad [6]$$

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

[6]

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

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

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

- (b) Frequency is inversely proportional to wavelength.

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

[15]

- (c) the graph of  $y = f(x)$ ,

Find the weight of the lamina.

[12]

- 15 much energy is stored in the compressed column?

[6]

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

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

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]

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

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

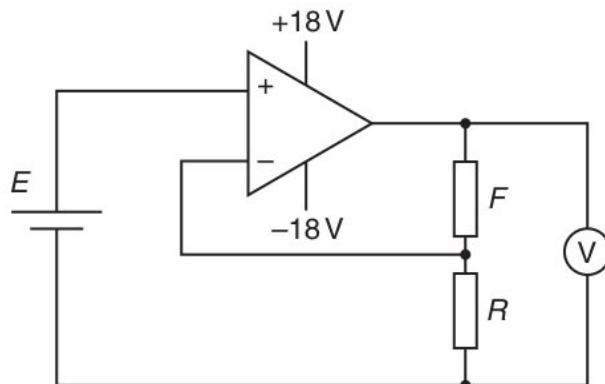
the probability that at least 2 and fewer than 8 of these competitors had times less than 36.0 minutes.

[1]

- (e) statement describes the speed of the object after it is fired until immediately before it reaches the ground again?

[10]

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



find the variance of the number of 4 s obtained in 30 throws,  
the polar coordinates of the points of intersection of  $C$  and  $l$ .

[5]

- 22 is the horizontal distance of the van's centre of gravity from the front of the van?

[12]

- 19 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  $\omega$  and the corresponding tension in the string.

[6]

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

$\lambda$  is a positive constant. Given that the mean lifetime of Trulite bulbs is 2000 hours, find the probability that a randomly chosen Trulite bulb has a lifetime of at least 1000 hours.

[8]

- 19 Fig. 7.1, complete the charge and mass of  $\alpha$ -particles,  $\beta$ -particles and  $\gamma$ -radiation. Give example speeds of  $\alpha$ -particles and  $\gamma$ -radiation emitted by a laboratory source.

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

along distance = ..... cu [10]

- 14 row describes the relative ionizing power and the relative penetration power per unit length in air of  $\alpha$ -particles and  $\gamma$ -rays?

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

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.

(c) Prove that, for  $n \geq 2$ ,

value = .....  $nq$  [2]

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

[4]

- (f) 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.

horizontal particles masses = ....  $ff$  [4]

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

- (d) changes to  $R_1$  and to  $R_2$  will increase the value of  $V_{\text{out}}$  ?

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.

[10]

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

[1]

- 22 potential difference is applied between two metal plates that are not parallel.

[10]

- 35 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 .

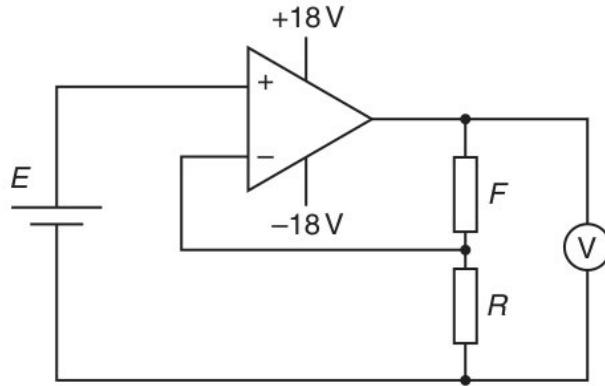
[6]

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

ball ball = .....  $fq$  [4]

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

region enclosed between the  $x$  axis and the curve is rotated through  $2\pi$  radians about the  $x$  axis



- (b) is a planet that may be considered to be an isolated uniform sphere of radius  $3.4 \times 10^6$  m.

Fig. = ....  $xq$  [2]

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

equation = .....  $ht$  [8]

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

525 520 522 524 518 520 519 525 527 516  
Over 50 198 212 217 229 235 242

much smaller = .....  $gf$  [10]

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

[8]

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

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.

The weight of the plank is causing a clockwise moment.

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

[6]

- (c) force is caused only by a pressure difference?

[12]

- 28 State the name of this type of reaction.

[4]

- 13 Given that  $\tan 2\theta \cot \theta = 8$ , show that  $\tan^2 \theta = \frac{3}{4}$ .  
 curve  $C$  has equation  
 row best specifies the correct  $I - V$  graphs for the lamp and the diode?

[12]

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

[8]

13 is given that

[6]

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

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

- (d) linear transformation  $T : \mathbb{R}^4 \rightarrow \mathbb{R}^4$  is represented by the matrix  $\mathbf{A}$ , where equation of a curve is  $x^3y - 3xy^3 = 2a^4$ , where  $a$  is a non-zero constant.  
Show that  $a = 19$  and find the values of  $b$  and  $c$ .

[15]

- (c) expression has the same SI base units as pressure?

[4]

- (e) Calculate the distance of the centre of mass of the lamina from  $A$ .

[6]

14 Show that the deceleration of the car with the brakes applied is  $4.1 \text{ m s}^{-2}$ .

coefficient = ..... pp [5]

11 Obtain a basis for the null space of  $T$ .

found. = .....  $qm$  [10]

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

- (c) Find the distance of  $B$  from the wall when it collides with  $A$  for the second time.  
 the value of  $c$  such that  $P(-c < t < c) = \frac{1}{2}$ .

[5]

- (e) specific latent heat.

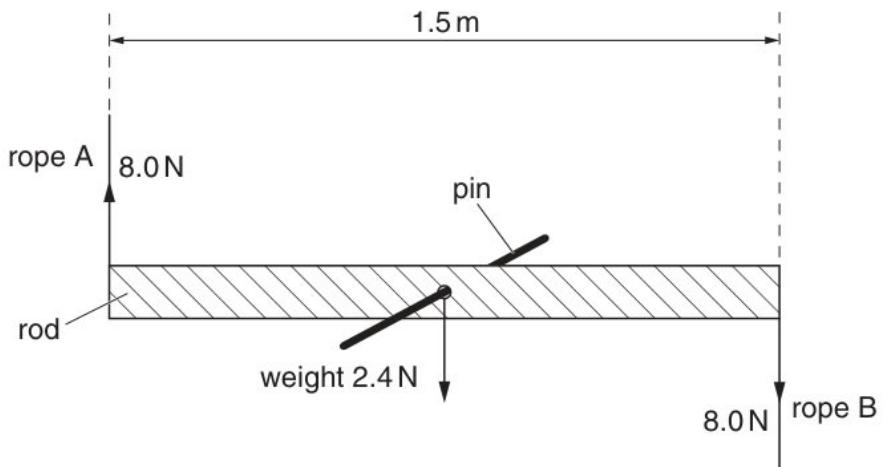
[5]

- (a) Hence solve the equation  
 the probability that the second A is obtained on the 6th roll of the dice.

[6]

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

Find the value of  $a$ .



line = ..... as [4]

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

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

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  $\omega$  and with the string inclined at an angle of  $\theta$  to the downward vertical.

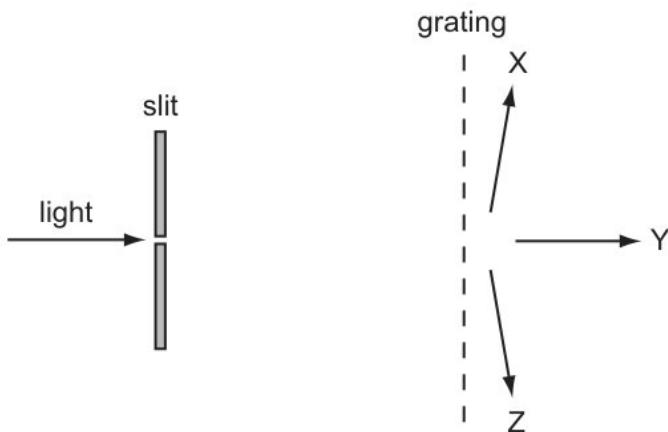
Find the interquartile range of  $X$ .

[4]

- 10 Use a different object that has twice the density and the same volume as the original object.  $\lambda$  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.
- (ii) is the efficiency of the process?

[5]

- (iv) is the density of the mixture with volume  $2.0 \text{ m}^3$  ?



[5]

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

car then travels up a slope at  $2^\circ$  to the horizontal, maintaining the same constant speed.

[2]

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

responses = ..... wb [10]

- 9 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.  
row describes the momentum and kinetic energy of the two bodies after the collision?

[8]

- 20 curve  $C$  with equation  
throws three coins at the same time.

- (b) graph shows the variation with temperature of power,  $P$ , dissipated in the thermistor?  
three coplanar forces shown in the diagram act at a point  $P$  and are in equilibrium.

[12]

- (a) curves  $C_1$  and  $C_2$  intersect at the point with polar coordinates  $(a, \beta)$ . State the value of  $\beta$ .  
the number of different arrangements of the 7 men in a line in which Ali and Ben do not stand next to each other.

[8]

- 33 Find the value of  $\alpha$  correct to 3 decimal places. Show your working, giving each calculated value of the sequence to 5 decimal places.

- (b) the standard deviation of these 40 values of  $x$ .

mark = .... hl [5]

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

[1]

- (c) the circuit shown,  $XY$  is a length  $L$  of uniform resistance wire.  $R_1$  and  $R_2$  are unknown resistors.  $J$  is a sliding contact that joins the junction of  $R_1$  and  $R_2$  to points on  $XY$  through a small signal lamp  $S$ .

[8]

17 curve  $C$  has equation

planes  $p$  and  $q$  have equations  $x + y + 3z = 8$  and  $2x - 2y + z = 3$  respectively.

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

stationary nucleus has nucleon number  $A$ .

[4]

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

- (ii) the arc length of  $C$ ,

[2]

- (iii) the acute angle between the planes  $ABC$  and  $ABD$ .

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

[8]

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

Draw up a probability distribution table for  $X$ .

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

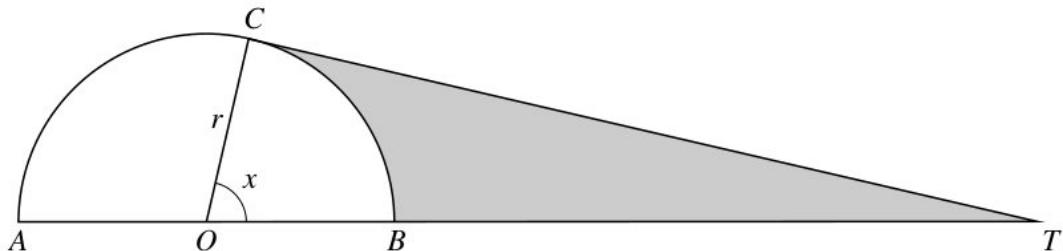
done = .....  $hp$  [8]

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

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

passing = .....  $th$  [12]

9



the exact value of  $I_2$

length = .....  $la$  [6]

- 14 Find the equations of the asymptotes of  $C$ .

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  $OL = 1.5 \text{ m}$ . The magnitudes of the accelerations of  $P$  at  $L$  and at  $M$  are in the ratio 3 : 4.

four = .....  $sb$  [8]

- 15 student wishes to investigate the effect of adding various thicknesses of glass in front of isotopes of the element uranium are  $^{235}_{92}\text{U}$  and  $^{238}_{92}\text{U}$ .

[6]

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

$$\mathbf{a} = 3\mathbf{i} + 2\mathbf{j} - \mathbf{k}, \quad \mathbf{b} = 4\mathbf{i} - 3\mathbf{j} + 2\mathbf{k}, \quad \mathbf{c} = 3\mathbf{i} - \mathbf{j} - \mathbf{k}$$

[4]

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

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

situated rate = .....  $jz$  [6]

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

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

matrix  $\mathbf{A}$ , given by

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

ages = .....  $bi$  [2]

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

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

up to down

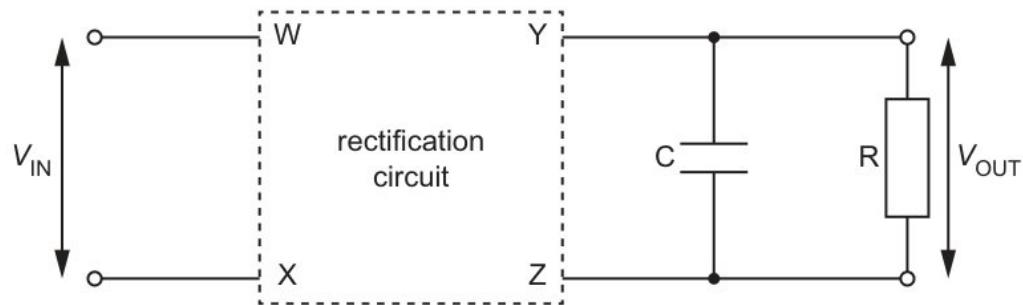
(b) measurements to be taken,

[5]

- (f) Explain why the observed wavelength and the emitted wavelength have different values.

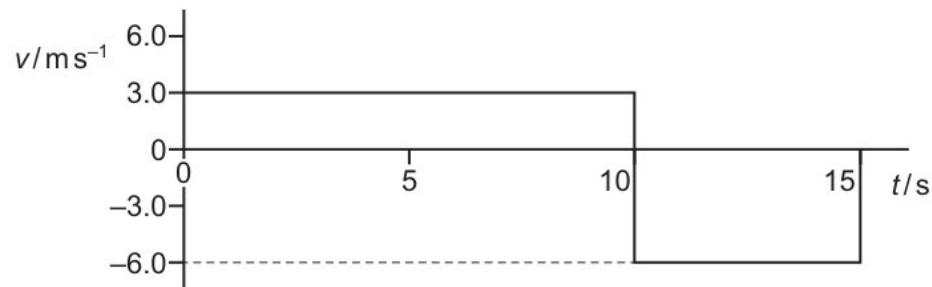
[15]

(d)



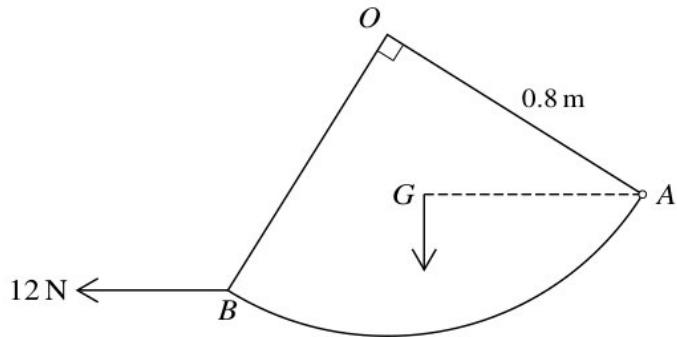
is the relationship between the amplitude of a wave and its intensity?

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



[10]

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



a different investigation, Nikki uses another large random sample to calculate a 99% confidence interval and an  $x\%$  confidence interval.

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

[10]

- 13 Show that  $\frac{dy}{dx} = \frac{1}{\sin \theta \cos^3 \theta}$ .

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

[6]

- 20 Hence solve the equation

[2]

- 12 random variable  $X$  has the distribution  $Po(1.5)$ .

probability = .....  $hs$  [6]

- 19 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.

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

$$\text{advertising showroom} = \dots \text{ } pz \quad [10]$$

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

cubic equation  $2x^3 - 3x^2 + 4x - 10 = 0$  has roots  $\alpha, \beta$  and  $\gamma$ .

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

[8]

- (e) copper wire of cross-sectional area  $2.0 \text{ mm}^2$  carries a current of  $10 \text{ A}$ .

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

[8]

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

[6]

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

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

[5]

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

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

[2]

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

[6]

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

[20]

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

than athletics = .....  $xg$  [6]