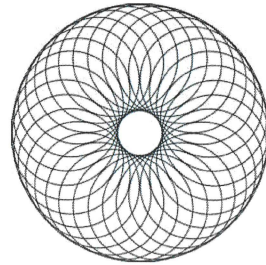


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| <ul style="list-style-type: none"><li>(1) Indices</li><li>(2) Expanding Brackets</li><li>(3) Factorising Expressions</li><li>(4) More Indices (Negative and Fractional)</li><li>(5) Working with Surds</li><li>(6) Solving Quadratic Equations</li><li>(7) Completing the Square for Quadratics Expressions</li><li>(8) Function Notation</li><li>(9) Sketching Quadratic Graphs</li><li>(10) The Discriminant for Quadratic Equations</li><li>(11) Applications of Quadratics Equations</li><li>(12) Solving Linear Simultaneous Equations</li><li>(13) Linear &amp; Non-Linear Simultaneous Equations</li><li>(14) Graphing Simultaneous Equations</li><li>(15) Linear Inequalities</li><li>(16) Quadratic Inequalities</li><li>(17) Graphing Inequalities</li><li>(18) Shading Inequalities</li><li>(19) Cubic Graphs</li><li>(20) Quartic Graphs</li><li>(21) Reciprocal Graphs</li><li>(22) The Intersection of Graphs</li><li>(23) Transforming Graphs (Translations)</li><li>(24) Transforming Graphs (Stretching/Reflecting)</li><li>(25) Straight Line Graphs in the form <math>y = mx + c</math></li><li>(26) More Straight Line Graphs</li><li>(27) Straight Line Graphs (Parallel &amp; Perpendicular)</li><li>(28) The Geometry of Straight Lines</li><li>(29) The Application of Linear Graphs</li><li>(30) Circle Geometry Midpoint &amp; Perpendicular</li></ul> | <ul style="list-style-type: none"><li>(31) The Equation of a Circle</li><li>(32) Circles and Straight Lines (Intersections)</li><li>(33) Circles (Tangents and Chords)</li><li>(34) Circles and Triangles</li><li>(35) Algebraic Fractions</li><li>(36) Polynomial Division</li><li>(37) The Factor and Remainder Theorem</li><li>(38) An Introduction to Mathematical Proof</li><li>(39) Methods of Proof</li><li>(40) Binomial Expansion (Using Pascal's Triangle)</li><li>(41) Binomial Expansion (Factorial Notation)</li><li>(42) Binomial Expansion (The <math>\binom{n}{r}</math> Method)</li><li>(43) Binomial Expansion (Problem Solving)</li><li>(44) Binomial Expansion (Estimations and Approximations)</li><li>(45) The Cosine Rule</li><li>(46) The Sine Rule</li><li>(47) Areas of a Triangles</li><li>(48) Triangles (Problem Solving)</li><li>(49) Sine, Cosine &amp; Tangent Graphs</li><li>(50) Transforming Graphs (Trigonometry)</li><li>(51) The 'CAST' Diagram for Trig Ratios</li><li>(52) Trigonometry (Exact Values)</li><li>(53) Proving Trigonometric Identities</li><li>(54) Solving Basic Trigonometric Equations</li><li>(55) More Challenging Trigonometric Equations</li><li>(56) Using Identities to Solve Trig Equations</li><li>(57) Vectors (Introduction)</li></ul> | <ul style="list-style-type: none"><li>(58) Vector Notation (Column and i and j form)</li><li>(59) Vectors (Magnitude and Direction)</li><li>(60) Vectors (Position and Direction Vectors)</li><li>(61) Vector Geometry</li><li>(62) Application of Vectors</li><li>(63) Differentiation (Gradients of Curves)</li><li>(64) Differentiation from 1st Principles</li><li>(65) Differentiating <math>x^n</math> (Basic Powers of)</li><li>(66) Differentiation (Quadratic Expression)</li><li>(67) Differentiation (Multiple Terms)</li><li>(68) Differentiation (Gradients, Tangents and Normals)</li><li>(69) Differentiation (Increasing and Decreasing Functions)</li><li>(70) Differentiation (Stationary Points)</li><li>(71) Differentiation (Gradient Functions)</li><li>(72) The Applications of Differentiation</li><li>(73) Integration (Basic Expressions (<math>x^n</math>))</li><li>(74) Indefinite Integrals</li><li>(75) Integration (Finding <math>c</math> and Finding Functions)</li><li>(76) Integration (Definite Integrals)</li><li>(77) Integration (Basic Areas Under Curves)</li><li>(78) Integration ('Negative and Positive Areas')</li><li>(79) Integration (Areas between Curves and Lines)</li><li>(80) Basic Exponential Functions</li><li>(81) 'The' Exponential Function <math>y = e^x</math></li><li>(82) Applications of Basic Exponential Models</li><li>(83) Logarithms (Simplifying &amp; Evaluating)</li><li>(84) Logarithms (The Log Laws)</li><li>(85) Logarithms (Log and Exponential Equations)</li></ul> |
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# Applications of Quadratics

(1) Initial velocity  $\therefore t=0$

(a)  $V=3$

(b) Sub in  $t=2$

$$V = -(4) + 8(2) + 3$$

$$V = 15$$

(c) NOT using differentiation

(d) Solve  $V=0$   $\leftarrow$  Stationary  
 $\therefore$  velocity = 0

$$0 = -t^2 + 8t + 3$$

$$0 = t^2 - 8t - 3$$

Using equation:

$$t = 8.558 \dots \quad t = -0.35$$

$\uparrow$  Stationary at 8.4 seconds but the model is only valid for  $0 \leq t \leq 3$

\* You can use differentiation here!

(1)  $t=0$  for initial @ height  $\therefore$  sub in  $t=0$

$$h = 0 + 0$$

$$h = 0 \text{ m}$$

(b)  $h=18$

c/13

$$18 = -t^2 + 10t$$

$$t^2 - 10t + 18 = 0$$

$$t = 7.65 \text{ secs} \quad t =$$

$$2.35 \text{ seconds}$$

$$\therefore 2.35 \text{ seconds}$$

(c) You can differentiate here if you have learned it, otherwise complete the square

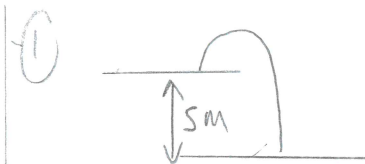
$$h = -[t^2 - 10t]$$

$$= -[(t-5)^2 - 25]$$

$$= -(t-5)^2 + 25$$

$$\therefore 25 \text{ m}$$

(d)  $t > 10$  as it would give a negative height



(a)  $t=0, K=5$

(b)  $h=0 \therefore$

$$-2t^2 + 2t + 5 = 0$$

$$2t^2 - 2t - 5 = 0$$

$$t = 2.16 \quad t = -1.16$$

$$\therefore 2.16 \text{ seconds}$$

(c) Max height. You can use differentiation or complete the square

$$h = -2t^2 + 2t + 5$$

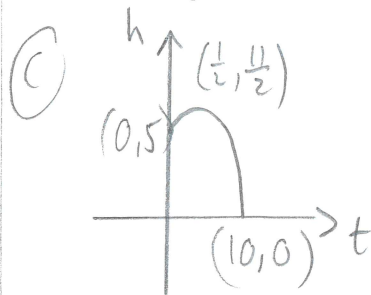
$$= -2[t^2 - t] + 5$$

$$= -2\left[\left(t - \frac{1}{2}\right)^2 - \frac{1}{4}\right] + 5$$

$$= -2\left(t - \frac{1}{2}\right)^2 + \frac{1}{2} + 5$$

$$t = \frac{1}{2} \text{ and height} = 5.5 \text{ m.}$$

(d) The impact with the water will decrease the velocity of the diver.

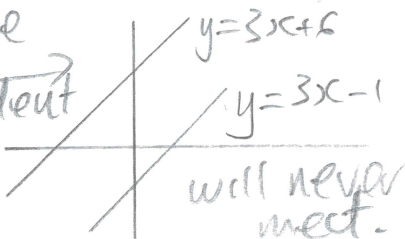


\* finding max and min values is often quicker using differentiation which you learn later.

Pure (12) Linear Simultaneous Equations

①  $4x + 10y = 28 \times 2$   
 $15x - 10y = 10 \times 5$   
 ① + ②  $19x = 38$   
 $x = 2$   
 $4(2) + 10y = 28$   
 $10y = 20$   
 $y = 2$

② Set  $y = y$   
 $7x - 11 = 2x + 4$   
 $5x = 15$   
 $x = 3$   
 Sub in  $y = 2(3) + 4$   
 $y = 10$

③ Set  $y = y$   
 $3x + 6 = 3x - 1$   
 $6 \neq -1 \therefore$  no solutions  
 Same gradient  


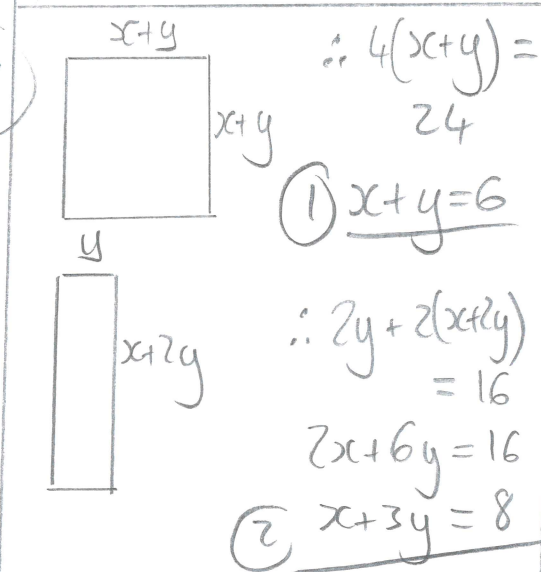
①  $0.1x + 4y = 9$   
 $1.2x - 4y = 4$   
 $1.3x = 13$   
 $x = 10$   
 Sub in:  
 $0.1(10) + 4y = 9$   
 $4y = 8$   
 $y = 2$

②  $6y = 12 - 6x$   
 $6y = 15x - 9$   
 $\therefore 15x - 9 = 12 - 6x$   
 $21x = 21$   
 $x = 1$   
 $2y = 5(1) - 3$   
 $y = 1$

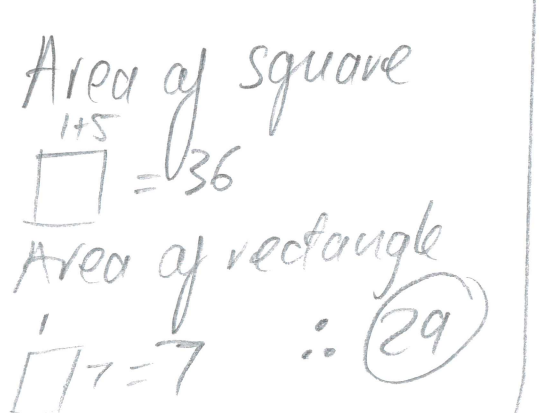
③ The gradients of the lines must be the same when in the form  $y = mx + c$

①  $py = -3x + 14$   
 $y = \frac{-3}{p}x + \frac{14}{p}$   
 ②  $7y = 2x + 9$   
 $y = \frac{2}{7}x + \frac{9}{7}$

$\therefore \frac{-3}{p} = \frac{2}{7}$   
 $p = \frac{-21}{2}$



②  $-$  ①  $2y = 2$   
 $y = 1$   
 $\therefore x = 5$



② Sub in  
 $\frac{1}{2}pq + 7p = 26$  ①  
 $2p - 7 + q = 0$  ②  
 $\therefore$  ②  $q = 7 - 2p$   
 ①  $\frac{1}{2}(p)(7 - 2p) + 7p = 26$   
 $7p - 2p^2 + 14p = 52$   
 $2p^2 - 21p + 52 = 0$   
 $p = \frac{13}{2}$  or  $p = 4$  ✓  
 $\therefore q = 1$

③ Anything where the gradient of the 2 lines are equal!  
 eg  $6y = x - 8$   
 $6y = x + 12$   
 or  
 $y = 9x + 7$   
 $y = 4 + 9x$

# 13 Linear and Non-Linear Simultaneous Equations

$$x = \pm 6$$

$$\therefore y = \pm 6$$

①  $y = y \therefore$

$$x^2 + 5x - 13 = 2x - 3$$

$$x^2 + 3x - 10 = 0$$

$$(x+5)(x-2) = 0$$

$$x = -5 \text{ or } x = 2$$

$$\downarrow \qquad \qquad \downarrow$$

$$y = -13 \qquad y = 1$$

② Sub ① into ②

$$x(x-1) = 6$$

(D/E)

$$x^2 - x = 6$$

$$x^2 - x - 6 = 0$$

$$(x-3)(x+2) = 0$$

$$\downarrow \qquad \qquad \downarrow$$

$$x = 3 \qquad x = -2$$

$$\therefore y = 2 \qquad y = -3$$

③ Sub ① into ②

$$x^2 + (x^2) = 72$$

$$2x^2 = 72$$

$$x^2 = 36$$

①  $x = 10 - 2y$

②  $(10 - 2y)y = 8$

$$10y - 2y^2 = 8$$

$$2y^2 - 10y + 8 = 0$$

$$y^2 - 5y + 4 = 0$$

$$(y-1)(y-4) = 0$$

$$y = 1, y = 4$$

$$\therefore x = 8 \qquad x = 2$$

②  $y = \frac{7 - 5x}{3}$

$$x^2 + \left(\frac{7 - 5x}{3}\right)^2 = 5$$

$$x^2 + \frac{49 - 70x + 85x^2}{9} = 5$$

$$9x^2 + 49 - 70x + 85x^2 = 45$$

$$34x^2 - 70x + 4 = 0$$

③ Sub in:

$$(x-8)^2 + (10)^2 = 4$$

$$(x-8)^2 + 100 = 4$$

$$(x-8)^2 = -96$$

$\therefore$  no real roots!

N.B. You can use the discriminant too!

①  $x^2 + y^2 = 50$  ①

$y = -x$  ②

$\therefore$  ② into ①

$$x^2 + (-x)^2 = 50$$

$$2x^2 = 50$$

$$x^2 = 25$$

$$x = \pm 5 \quad \begin{matrix} c & b \\ (5, -5) \end{matrix}$$

$$\therefore y = \mp 5 \quad \begin{matrix} a & d \\ (-5, 5) \end{matrix}$$

②  $x = \frac{13 - 3y}{2}$

①  $= \left(\frac{13 - 3y}{2}\right)y + 2y^2 = -30$

(B/c)

(A/A)

$$13y - 3y^2 + 4y^2 = -30$$

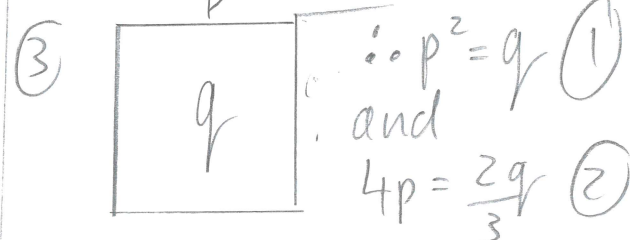
$$y^2 + 13y + 30 = 0$$

$$(y+3)(y+10) = 0$$

$$\downarrow \qquad \qquad \downarrow$$

$$y = -3 \qquad y = -10$$

$$\therefore x = 1 \qquad x = \frac{43}{2}$$



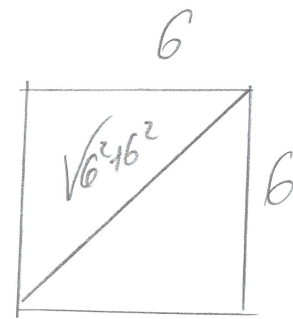
$$q = 6p$$
 ②

$$\therefore p^2 = 6p$$
 ①

$$p^2 - 6p = 0$$

$$p(p-6) = 0$$

$$p \neq 0 \therefore p = 6$$

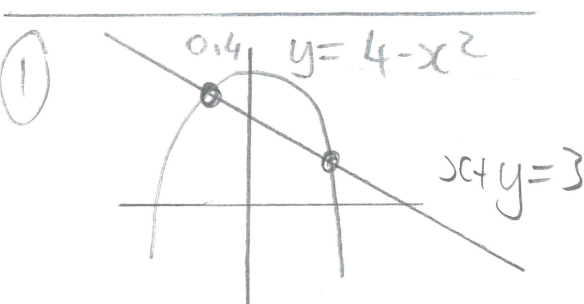
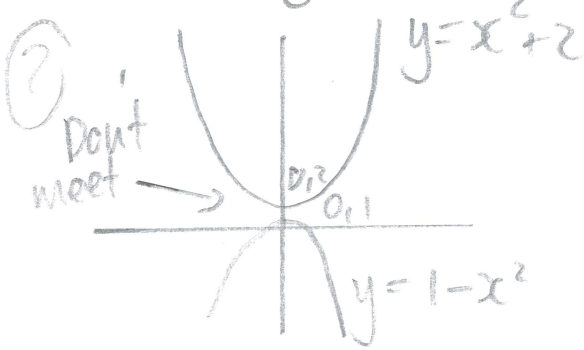


$$\sqrt{6^2 + 6^2} = \underline{\underline{6\sqrt{2}}}$$

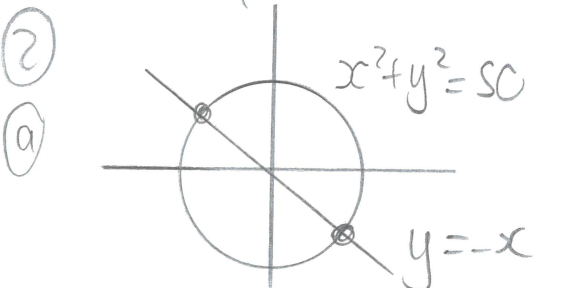
**14** Simultaneous Equations on Graphs

① Point of intersection are the solutions. (3, -1)

∴  $x=3, y=-1$



2 solutions as two points of intersection



⑥  $x^2 + (-x)^2 = 50$  ①  
 $2x^2 = 50$   
 $x^2 = 25$   
 $x = \pm 5$

∴  $y = \mp 5$   
 Points are (5, -5) and (-5, 5)

③  $x^2 - y = 3$  ①  
 $y = 5 - x$  ②

Sub in ② into ①

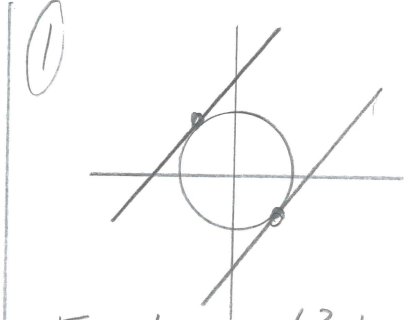
$x^2 - (5 - x) = 3$   
 $x^2 + x - 5 - 3 = 0$   
 $x^2 + x - 8 = 0$

$a=1, b=1, c=-8$   
 $b^2 - 4ac$

$1 - 4(1)(-8) = 33$

∴ 2 real roots as  $b^2 - 4ac > 0$

Two points of intersection:



Touches ∴  $b^2 - 4ac = 0$  as repeated root

①  $x^2 + y^2 = 30$   
 ②  $y = 2x + k$

①  $x^2 + (2x + k)^2 = 30$   
 $x^2 + 4x^2 + 4kx + k^2 = 30$

$5x^2 + 4kx + k^2 - 30 = 0$   
 ↑ a    ↑ b    ↑ c

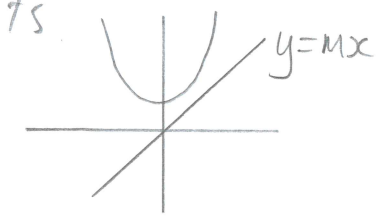
$b^2 - 4ac = 0$

$(4k)^2 - 4(5)(k^2 - 30) = 0$

$16k^2 - 20k^2 + 600 = 0$   
 $-4k^2 + 600 = 0$

$k^2 = 150$   
 $k = \pm \sqrt{150}$   
 $k = \pm 5\sqrt{6}$

⑦ Do not intersect ∴  $b^2 - 4ac < 0$  as no real roots



$3x^2 + k = mx$   
 $3x^2 - mx + k = 0$   
 $b^2 - 4ac < 0$

$m^2 - 4(3)k < 0$

$(m + 2\sqrt{3}k)(m - 2\sqrt{3}k) < 0$   
 ∴  $-2\sqrt{3}k < m < 2\sqrt{3}k$

③  $-2 \left[ t^2 - \frac{k}{2}t \right]$   
 $-2 \left[ \left( t - \frac{k}{4} \right)^2 - \frac{k^2}{16} \right]$   
 $-2 \left( t - \frac{k}{4} \right)^2 + \frac{k^2}{8}$

∴  $\frac{k^2}{8} = 30$

$k^2 = 240$

$k = \pm 4\sqrt{15}$

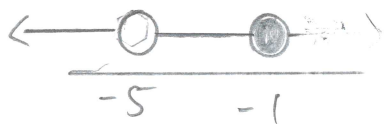
∴  $+4\sqrt{15}$

# Pure (15) Linear Inequalities

$$\textcircled{1} \quad 4x < 12 \\ x < 3$$

$$\textcircled{2} \quad 2x < 10$$

$$\textcircled{a} \quad x < 5$$



$$\textcircled{b} \quad -4, -3, -2, -1$$

$$\textcircled{3} \quad -0.1x \leq 5 \\ x \geq \underline{5} \\ -0.1 \\ x \geq -50$$

$$\textcircled{1} \quad \textcircled{x} \quad 6 - 4x > -6 \quad \textcircled{x > 0} \\ 12 > 4x \\ 3 > x$$

$$\textcircled{2} \quad x^2 - x < x^2 - 8 \\ -x < -8 \\ x > 8$$

$$\textcircled{3} \quad 3 - 6x \leq 0 \\ 3 \leq 6x \\ \underline{\frac{1}{2} \leq x}$$

$$-8 < 2x + 14 < 24$$

$$-22 < 2x < 10$$

$$\underline{-11 < x < 5}$$

$\therefore$

$$\underline{\frac{1}{2} \leq x < 5}$$

$$\textcircled{1} \quad x \leq \frac{1}{2k} \quad \textcircled{1}$$

$$12x - 24 \geq x$$

$$11x \geq 24$$

$$x \geq \frac{24}{11}$$

$$\frac{1}{2k} = \frac{24}{11}$$

$$k = \frac{11}{48} \quad \therefore k \geq \frac{11}{48}$$

$$\textcircled{2} \quad 6 \leq kx + 1 < 10$$

$$5 \leq kx < 9$$

$$\frac{5}{k} \geq x > \frac{9}{k}$$

$$\therefore \frac{9}{k} < x \leq \frac{5}{k}$$

Questions and  
Answers available  
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