KING EDWARD VI
HANDSWORTH GRAMMAR
SCHOOL FOR BOYS

KING EDWARD VI
ACADEMY TRUST
BIRMINGHAM

Year 11

2025 Mathematics 2026

Unit 24 Booklet – Part 1

HGS Maths

Tasks

Dr Frost Course

Name: ______________________________

Class: ______________________________

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Unit 24 Booklet – Part 2

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Dr Frost Course

Name: ____________________________________

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Contents

1 Equations of Circles and Tangents

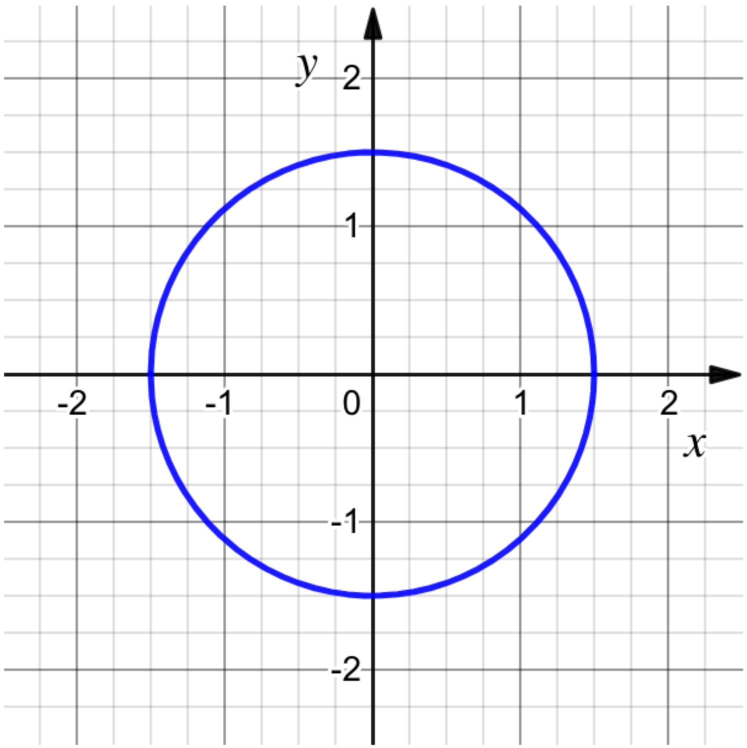
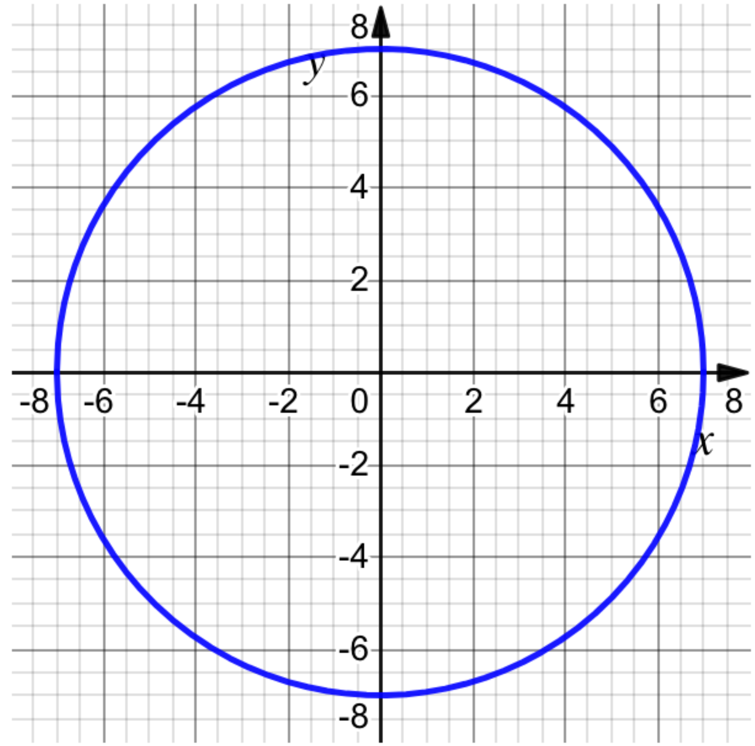
Worked Example	Your Turn
Determine whether the point with coordinates $(-5, 7)$ lies on the circle with the equation $x^2 + y^2 = 85$.	Determine whether the point with coordinates $(6, -8)$ lies on the circle with the equation $x^2 + y^2 = 100$.

Worked Example	Your Turn
Find the radius of the circle with equation: a) $x^2 + y^2 = 196$ b) $x^2 + y^2 = 326$	Find the radius of the circle with equation: a) $x^2 + y^2 = 169$ b) $x^2 + y^2 = 362$

Dr Frost 446c

Worked Example	Your Turn
Find an equation of the circle with radius $3\sqrt{5}$ and centre $(0, 0)$.	Find an equation of the circle with radius $5\sqrt{2}$ and centre $(0, 0)$.

Dr Frost 446d

Worked Example	Your Turn
Find an equation of the circle drawn below.  	Find an equation of the circle drawn below. 

Dr Frost 446e

Worked Example	Your Turn
The point $(-5, 3)$ lies on a circle centered on the origin. Find an equation for this circle.	The point $(-7, -2)$ lies on a circle centered on the origin. Find an equation for this circle.

Dr Frost 446f

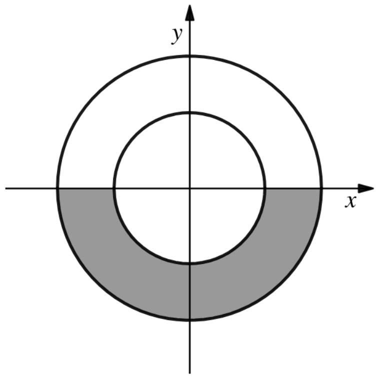
Worked Example	Your Turn
The circle below is given by the equation $x^2 + y^2 = 16$. a) Calculate its circumference, C. b) Calculate the shaded area, A. Give your answers correct to 2 decimal places.	The circle below is given by the equation $x^2 + y^2 = 64$. a) Calculate its circumference, C. b) Calculate the shaded area, A. Give your answers correct to 2 decimal places.

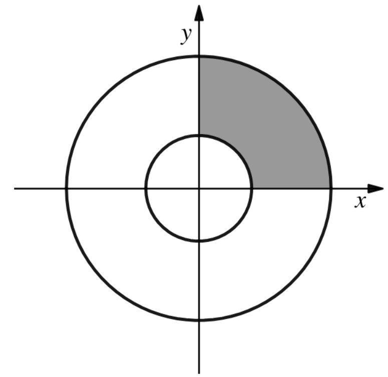
Dr Frost 446g

Worked Example	Your Turn
a) A circle has a circumference of 6π. Find an equation for the circle. b) A circle has an area of 49π. Find an equation for the circle.	a) A circle has a circumference of 12π. Find an equation for the circle. b) A circle has an area of 25π. Find an equation for the circle.

Fill in the Gaps

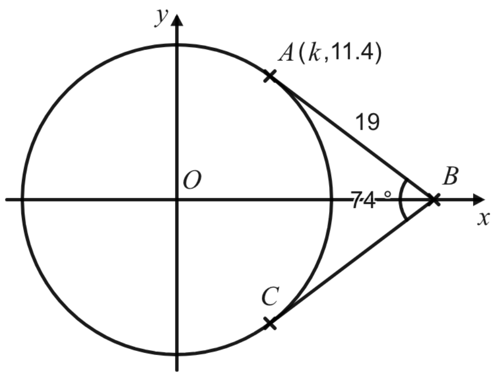
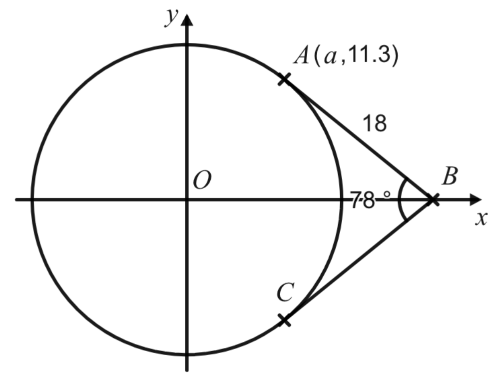
Equation	Radius	Area	Point 1	Point 2	Where is $(3, 7)$?
$x^2 + y^2 = 25$			$(3, \_\_\_\_)$	$(\_\_\_\_, 0)$	Outside
$x^2 + y^2 = 50$			$(-5, \_\_\_\_)$	$(\_\_\_\_, 7)$	
$x^2 + y^2 = 65$			$(1, \_\_\_\_)$	$(\_\_\_\_, 7)$	
	15		$(9, \_\_\_\_)$	$(\_\_\_\_, 0)$	
	$5\sqrt{5}$		$(-5, \_\_\_\_)$	$(\_\_\_\_, 11)$	
		130π	$(-7, \_\_\_\_)$	$(\_\_\_\_, 11)$	
		2042	$(19, \_\_\_\_)$	$(\_\_\_\_, 11)$	
			$(-4, \_\_\_\_)$	$(8, 11)$	
			$(1, \_\_\_\_)$	$(-7, 11)$	
			$(-7, \_\_\_\_)$	$(\_\_\_\_, \sqrt{22})$	On the circle

<table>
<tr><th>Worked Example</th><th>Your Turn</th></tr>
<tr><td>
The annulus below is formed of two circles centred on the origin. The equations of the circles are:
$x^2 + y^2 = 49$
$x^2 + y^2 = 16$

a) Calculate the perimeter of the shaded shape.
b) Calculate the area of the shaded shape.

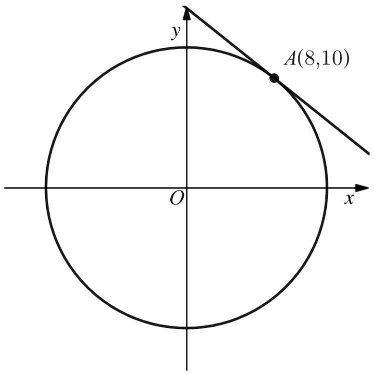
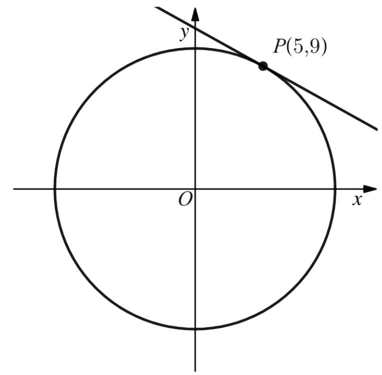
Give your answers correct to 2 decimal places.
</td><td>
The annulus below is formed of two circles centred on the origin. The equations of the circles are:
$x^2 + y^2 = 25$
$x^2 + y^2 = 4$

a) Calculate the perimeter of the shaded shape.
b) Calculate the area of the shaded shape.

Give your answers correct to 2 decimal places.
</td></tr>
</table>

Dr Frost 446i

Worked Example	Your Turn
The diagram shows a circle, centre O  AB and BC are tangents to the circle. Angle $ABC = 74°$ AB has a length of 19 units. Calculate the value of k Give your answer correct to 1 decimal place.	The diagram shows a circle, centre O  AB and BC are tangents to the circle. Angle $ABC = 78°$ AB has a length of 18 units. Calculate the value of a Give your answer correct to 1 decimal place.

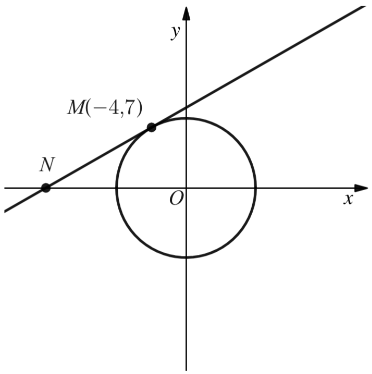
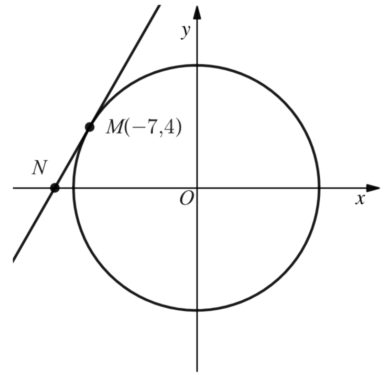
Dr Frost 446j

Worked Example	Your Turn
The diagram shows the circle with equation $x^2 + y^2 = 164$  A tangent to the circle is drawn at point A with coordinates $(8, 10)$. Find an equation of the tangent at A.	The diagram shows the circle with equation $x^2 + y^2 = 106$  A tangent to the circle is drawn at point P with coordinates $(5, 9)$. Find an equation of the tangent at P.

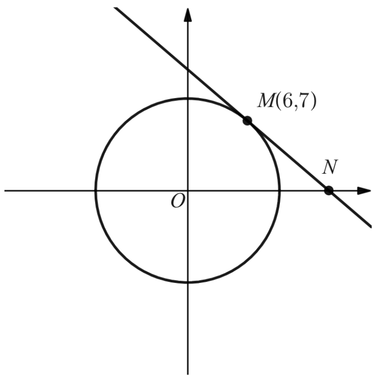
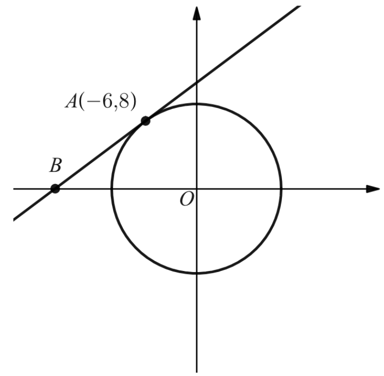
Dr Frost 447a

Fill in the Gaps

Equation of Circle	Point on Circle	Gradient of Radius	Gradient of Tangent	Equation of Tangent
$x^2 + y^2 = 45$	$(3, 6)$	2	$-\frac{1}{2}$	
$x^2 + y^2 = 10$	$(3, -1)$	$m = -\frac{1}{3}$		
$x^2 + y^2 = 68$	$(-2, -8)$			
$x^2 + y^2 = 25$	$(-4, 3)$			
$x^2 + y^2 = 73$	$(8, 3)$			
$x^2 + y^2 = \frac{53}{2}$	$\left(\frac{5}{2}, -\frac{9}{2}\right)$			
$x^2 + y^2 = 6$	$\left(-2, \sqrt{2}\right)$			
$x^2 + y^2 = 100$				$y = \frac{3}{4}x - \frac{25}{2}$

Worked Example	Your Turn
A circle has equation $x^2 + y^2 = 65$ M is the point on the circle with coordinates $(-4, 7)$  The tangent to the circle at M intersects the x-axis at point N. Work out the x-coordinate of N.	The diagram shows a circle with centre $(0, 0)$ and a tangent at the point $M(-7, 4)$  The tangent to the circle at M intersects the x-axis at point N. Work out the x-coordinate of N.

Dr Frost 447b

Worked Example	Your Turn
A circle has equation$x^2 + y^2 = 85$ M is the point on the circle with coordinates $M(6, 7)$  The tangent to the circle at M intersects the x-axis at point N. Work out the area of triangle OMN.	A circle has equation $x^2 + y^2 = 100$ A is the point on the circle with coordinates $A(-6, 8)$  The tangent to the circle at A intersects the x-axis at point B. Work out the area of triangle OAB.

Dr Frost 447c

Extra Notes

2 Advanced Simultaneous Equations

Worked Example	Your Turn
Solve the following pair of simultaneous equations: $y = x^2 + x - 2$ $y = 2x + 4$	Solve the following pair of simultaneous equations: $y = x^2 + 7x - 2$ $y = 2x + 4$

Dr Frost 419b

Worked Example	Your Turn
Solve the following pair of simultaneous equations: $xy = 2$ $y = x + 1$	Solve the following pair of simultaneous equations: $xy = 2$ $y = x - 1$

Worked Example	Your Turn
Solve the following pair of simultaneous equations: $9x^2 - xy - 6 = 0$ $y = 7x - 1$	Solve the following pair of simultaneous equations: $4x^2 + xy - 6 = 0$ $y = 5x - 3$

Dr Frost 419c

Worked Example	Your Turn
Solve the following pair of simultaneous equations: $x^2 + y^2 = 9$ $y = x + 3$	Solve the following pair of simultaneous equations: $x^2 + y^2 = 9$ $y = x - 3$

Dr Frost 419d

Worked Example	Your Turn
Solve the following pair of simultaneous equations: $3x + 4y = 5$ $x^2 + y^2 = 17$	Solve the following pair of simultaneous equations: $4x - 5y = 1$ $x^2 + y^2 = 61$

Dr Frost 419e

Worked Example	Your Turn
Solve: $3y^2 - 2x^2 = 19$ $2y + 3x = 15$	Solve: $2y^2 - 3x^2 = 38$ $3y + 2x = 19$

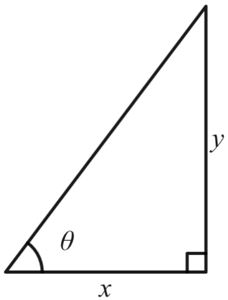
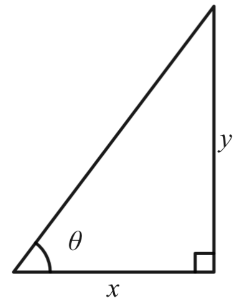
Worked Example	Your Turn
Solve the following pair of simultaneous equations: $\frac{12}{y} - \frac{4}{5x} + 1 = 0$ $y = 2x - 2$	Solve the following pair of simultaneous equations: $\frac{9}{2y} - \frac{3}{xy} = -1$ $y = 2x - 7$

Dr Frost 419f

Fill in the Gaps

Question	State $x =$/ $y =$ substitution	Substitute and rearrange to give quadratic equation	Solve the quadratic equation	Find corresponding y or x values
$y = x^2 - 5x + 3$ $y = 2x - 7$	$y = 2x - 7$	$2x - 7 = x^2 - 5x + 3$ $0 = x^2 - 7x + 10$	$(x - 2)(x - 5) = 0$ $x = 2$ or $x = 5$	
$x^2 + 2y = 13 - 4x$ $x + y = 5$	$y = 5 - x$	$x^2 + 2(5 - x) = 13 - 4x$ $x^2 + 10 - 2x = 13 - 4x$ $x^2 + 2x - 3 = 0$		
$x^2 + y^2 = 20$ $x - y = 2$	$x = y + 2$			
$y + 10 = x^2 + x$ $x - y - 1 = 0$				
$3x^2 - 2y = 7x - 8$ $3x = y - 2$				
$x^2 + y^2 + xy = 31$ $x + y + 1 = 0$				

Worked Example	Your Turn
A rectangle with length x cm and width y cm, where $x > y$, has a perimeter of 26 cm and an area of 40 cm^2 Find the values of x and y	A rectangle with length x cm and width y cm, where $x > y$, has a perimeter of 20 cm and an area of 24 cm^2 Find the values of x and y

Worked Example	Your Turn
A right-angled triangle is shown below with all lengths in centimetres.  Given that $\tan\theta = \frac{4}{3}$ and the area of the triangle is 24 cm², find the values of x and y	A right-angled triangle is shown below with all lengths in centimetres.  Given that $\tan\theta = \frac{5}{3}$ and the area of the triangle is 120 cm², find the values of x and y

Worked Example	Your Turn
A tennis club has 11 members. There are more men than women at the club. The total number of possible mixed doubles pairings is 5 more than the total number of men-only and women-only doubles pairings. Calculate the number of men and women who are members of the club.	A tennis club has 9 members. There are more women than men at the club. The total number of possible mixed doubles pairings is 8 less than the total number of men-only and women-only doubles pairings. Calculate the number of men and women who are members of the club.

Dr Frost 419g

Extra Notes

3 Advanced Sequences

Geometric Sequences

Worked Example	Your Turn
Generate the first 5 terms of the following geometric sequence: $4 \times 3^{n-1}$	Generate the first 5 terms of the following geometric sequence: $5 \times 4^{n-1}$

Dr Frost 204d

Worked Example	Your Turn
Write down the n^{th} term of the following geometric sequences: a) $4, 12, 36, 108$ b) $4, -12, 36, -108$ c) $108, 36, 12, 4$ d) $\sqrt{7}, 7, 7\sqrt{7}, 49$ e) $3p^4, 6p^4q^4, 12p^4q^8$	Write down the n^{th} term of the following geometric sequences: a) $5, 20, 80, 320$ b) $5, -20, 80, -320$ c) $320, 80, 20, 5$ d) $\sqrt{3}, 3, 3\sqrt{3}, 9$ e) $2x^4, \frac{8x^4}{y^4}, \frac{32x^4}{y^8}$

Dr Frost 370a, 370b, 370c, 370d, 370e, 370f and 370g

Worked Example	Your Turn
The second term of a geometric sequence is 78. The sixth term of the same sequence is $101{,}088$. Calculate the value of the common ratio.	A geometric sequence has second and fifth terms 108 and 4, respectively. Calculate the value of the common ratio.

Worked Example	Your Turn
A geometric sequence has first term $(x-3)$, second term $(x+1)$ and third term $(4x-2)$. Find the two possible values of x.	The first three terms of a geometric sequence are $4p, (3\mathrm{p}+15)$ and $(5p+20)$ respectively, where p is a positive constant. Find the value of p.

Quadratic Sequences

Worked Example	Your Turn
Generate the first 5 terms of the following quadratic sequence: $3n^2 + 2n - 5$	Generate the first 5 terms of the following quadratic sequence: $3n^2 - 2n + 5$

Dr Frost 204c

Worked Example	Your Turn
By comparison with the first four terms of the sequence n^2, find the nth term of the second sequence:	By comparison with the first four terms of the sequence n^2, find the nth term of the second sequence:

a)

First four terms				nth term
1	4	9	16	n^2
7	28	63	112	____

b)

First four terms				nth term
1	4	9	16	n^2
-1	2	7	14	____

Your Turn

a)

First four terms				nth term
1	4	9	16	n^2
4	7	12	19	____

b)

First four terms				nth term
1	4	9	16	n^2
-7	-28	-63	-112	____

Dr Frost 369a

Worked Example	Your Turn
Find the n^{th} term of the following sequence: 0, 11, 28, 51, 80	Find the n^{th} term of the following sequence: 6, 13, 26, 45, 70

Dr Frost 369h, 369b, 369c, 369d, 369e, 369f and 369g

Worked Example	Your Turn
Here are the first five terms of a quadratic sequence $6, -4, -22, -48, -82$ Find an expression, in terms of n, for the nth term of the sequence.	Here are the first five terms of a quadratic sequence $-14, -25, -38, -53, -70$ Find an expression, in terms of n, for the nth term of the sequence.

Dr Frost 369i

Worked Example	Your Turn
The nth term of a sequence is given by $an^2 + bn + c$ The second term is 23, the fourth term is 57 and the sixth term is 107. Find the values of a, b and c.	The nth term of a sequence is given by $an^2 + bn + c$ The fourth term is 34, the seventh term is 124 and the eleventh term is 328. Find the values of a, b and c.

Dr Frost 369j

Worked Example	Your Turn
A quadratic sequence has an nth term of $-3n^2 + 2n - 2$ A term in this sequence is equal to -343. Find the position of this term.	A sequence has an nth term of $-2n^2 - 5n + 1$ A term in this sequence is equal to -816. Find the position of this term.

Dr Frost 369k

Worked Example	Your Turn
Here are the first five terms of a sequence. $-11, -14, -13, -81$ An expression for the nth term of this sequence is $2n^2 - 9n - 4$. Find an expression for the nth term of a sequence whose first five terms are $-99, -126, -117, -729$	Here are the first five terms of a sequence. $-8, -5, 2, 13,28$ An expression for the nth term of this sequence is $2n^2 - 3n - 7$. Find an expression for the nth term of a sequence whose first five terms are $56, 35, -14, -91, -196$

Fill in the Gaps

Sequence	Type	n^{th} term	10th term	11th term	12th term	30th term	Is 60 in the sequence?
8, 11, 14, 17, …							
4, 11, 20, 31, …							
			67	74	81		
-4, -10, -16, -22, …							
0, 11, 28, 51, …							
		$n^2 + 12n - 4$					
3, 7, 15, 27, …							
		$4n - 8$					
		$4n^2 + n$					
-3, 0, 5, 12, …							
	Linear		56		66		
	Linear				70	178	

Fill in the Gaps

	u_1	u_2	u_3	u_4	...	u_k		
eg	-1	2	5	8	...	71	$u_n =$	$k =$
(a)	12	17	22	27	...	162	$u_n =$	$k =$
(b)	8	6	4	2	...	-96	$u_n =$	$k =$
(c)	3.5	6.5	9.5	12.5	...	123.5	$u_n =$	$k =$
(d)	-0.3	-0.1	0.1	0.3	...	2.7	$u_n =$	$k =$
(e)					...	430	$u_n = 8n - 2$	$k =$
(f)					...	-7.5	$u_n = 4 - 0.5n$	$k =$
(g)					...	$8\frac{1}{8}$	$u_n = \frac{1}{4}n + \frac{3}{8}$	$k =$
(h)					...	-194	$u_n = -3n - 2$	$k =$
(i)	5.8		7.4		...	20.2	$u_n =$	$k =$
(j)		-5.2		-15.6	...	-130	$u_n =$	$k =$

Extra Notes

4 Algebraic Proof

Fluency Practice

Forming Expressions

If n is any integer,
how can we form algebraic expressions to describe
these types, sequences, sums & products of numbers?

A number	
An even number	
An odd number	
Two consecutive numbers	
Two consecutive even numbers	
Two consecutive odd numbers	
The sum of two consecutive numbers	
The sum of two consecutive even numbers	
The sum of two consecutive odd numbers	
A number squared	
The square of an even number	
The square of an odd number	
The product of two consecutive numbers	
The product of two consecutive even numbers	
The product of two consecutive odd numbers	

Worked Example	Your Turn
A number is given as $5n - 8$ where n is an integer. Write down the expression for the next consecutive integer.	A number is given as $-2n + 13$ where n is an integer. Write down the expression for the next consecutive integer.

Dr Frost 454h

Worked Example	Your Turn
a) An odd number is given as $-2n+13$ where n is an integer. Write down the expression for the next consecutive odd number. b) An even number is given as $-2n-4$ where n is an integer. Write down the expression for the next consecutive even number.	a) An even number is given as $-2n+14$ where n is an integer. Write down the expression for the next consecutive even number. b) An odd number is given as $-2n-9$ where n is an integer. Write down the expression for the next consecutive odd number.

Dr Frost 454k

Worked Example	Your Turn
a) Given that n is an integer. Prove that $(2n-5)(4n-9)-10$ is always an odd number. b) Given that n is an integer. Prove that $(4n-3)^2+9$ is always an even number.	a) Given that n is an integer. Prove that $(4n+9)(4n-1)-3$ is always an even number. b) Given that n is an integer. Prove that $(2n-7)^2+2$ is always an odd number.

Dr Frost 454d and 454c

Worked Example	Your Turn
Given that n is a positive integer. Prove that $(2m+3)^2 - (2m+2)^2 - 1$ is always divisible by 4.	Given that n is a positive integer. Prove that $(2m+2)^2 - (2m-4)^2 - 12$ is always divisible by 24.

Dr Frost 454f

Worked Example	Your Turn
Prove that $(2x-7)(4x-7)-(2x-2)(2x-7)+1$ is a perfect square.	Prove that $(4y-7)(5y-1)-(2y+3)(2y-3)+7y$ is a perfect square.

Dr Frost 454q

Worked Example	Your Turn
Prove algebraically that the sum of any four consecutive integers is not divisible by 4.	Prove algebraically that the sum of any six consecutive integers is divisible by 3.

Dr Frost 454i

Worked Example	Your Turn
Prove algebraically that the sum of the squares of any three consecutive integers is always two more than a multiple of 3.	Prove algebraically that the sum of the squares of any four consecutive integers is always two more than a multiple of 4.

Dr Frost 454j

Worked Example	Your Turn
Prove algebraically that the sum of four consecutive even integers is always divisible by 4.	Prove algebraically that the sum of three consecutive odd integers is always divisible by 3.

Dr Frost 454l

Worked Example	Your Turn
a) Prove algebraically that the sum of the squares of two consecutive even integers is always divisible by 4. b) Prove algebraically that the sum of the squares of two consecutive odd integers is always 2 more than a multiple of 4.	a) Prove algebraically that the sum of the squares of three consecutive odd integers is always 1 less than a multiple of 12. b) Prove algebraically that the sum of the squares of three consecutive even integers always has a remainder of 8 when divided by 12.

Worked Example	Your Turn
a) Prove algebraically that the sum of any two odd integers is always even. b) Prove algebraically that the difference of any two even integers is always even.	a) Prove algebraically that the sum of any two even integers is always even. b) Prove algebraically that the difference of any two odd integers is always even.

Dr Frost 454o

Worked Example	Your Turn
Given that the difference of the squares of 2 consecutive even integers equals 68, find the value of the smallest integer.	Given that the difference of the squares of 2 consecutive odd integers equals 112, find the value of the smallest integer.

Worked Example	Your Turn
A sequence has the n^{th} term $n^2 - 6n + 10$. By completing the square, show that every term is positive.	A sequence has the n^{th} term $n^2 - 10n + 27$. By completing the square, show that every term is positive.

Worked Example	Your Turn
Show that for any integer n, $n^2 + n$ is always even.	Prove that $n(n-1)+1$ is odd for all integers n.

Worked Example	Your Turn
I think of a two-digit number. I then reverse the digits. Prove that the difference between the two numbers is a multiple of 9.	Prove that the sum of a four-digit number and its reverse is a multiple of 11.

Worked Example	Your Turn
Given that $4bx - 3a + 7 - 10ax \equiv -30x - 8$ Find the values of a and b.	Given that $ax + 5b - 8ax + 4bx \equiv -23x + 15$ Find the values of a and b.

Dr Frost 455a

Worked Example	Your Turn
Given that $3(4px - q) + 5(px + 3q) \equiv 68x - 60$ Find the values of p and q.	Given that $5(4ax + 3b) - 2(3ax + 2b) \equiv -84x + 66$ Find the values of a and b.

Dr Frost 455b

Worked Example	Your Turn
Given that $2x^2 - 4x + p \equiv (x-3)(qx+r) + 1$ where p, q and r are integers, find the values of p, q, and r	Given that $(x+3)(lx+m) + 9 \equiv 3x^2 + 5x + k$ where k, l and m are integers, find the values of k, l, and m

Dr Frost 455c

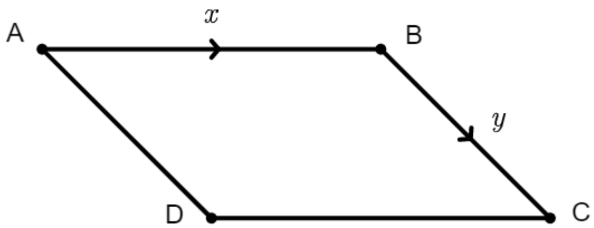
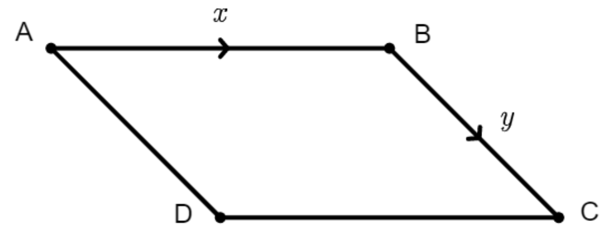
Worked Example	Your Turn
Given that $(2y-1)^2+ay+7=(2y+b)(2y+4)$ where a and b are integers, find the value of a and the value of b.	Given that $(2x+1)^2-12x+r=(2x+s)(2x-2)$ where r and s are integers, find the value of r and the value of s.

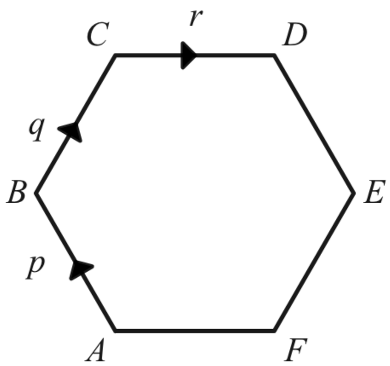
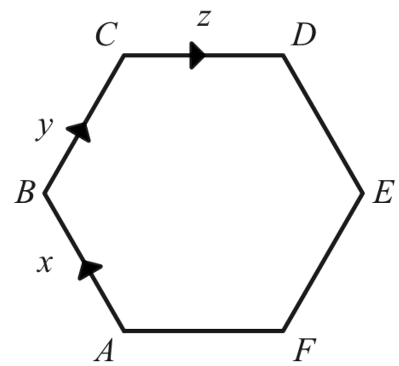
Dr Frost 455d

Worked Example	Your Turn
$3x^2 - 3bx + 16a \equiv 3(x-a)^2 + 5$ Work out the two possible pairs of values of a and b	$2x^2 - 2bx + 7a \equiv 2(x-a)^2 + 3$ Work out the two possible pairs of values of a and b

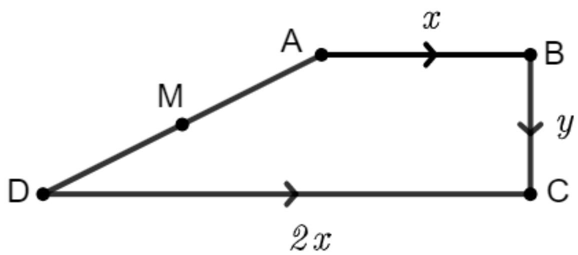
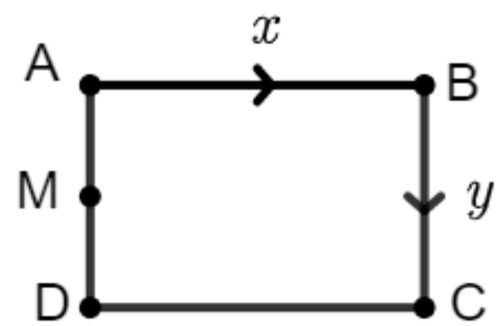
Extra Notes

5 Advanced Vectors

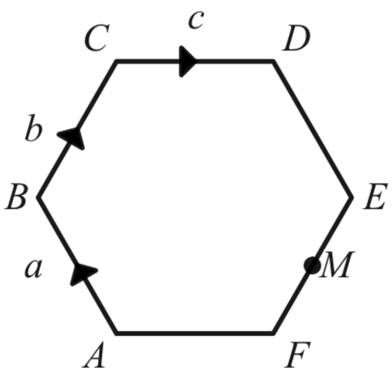
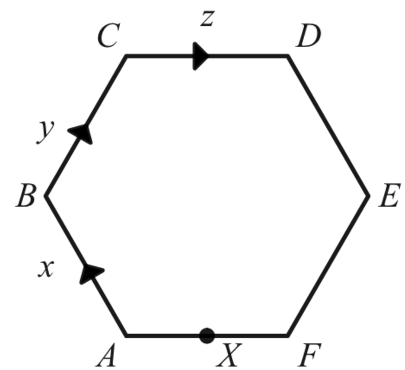
Worked Example	Your Turn
ABCD is a parallelogram. Express $\overrightarrow{DB}$ in terms of x and y.  	ABCD is a parallelogram. Express $\overrightarrow{CA}$ in terms of x and y. 

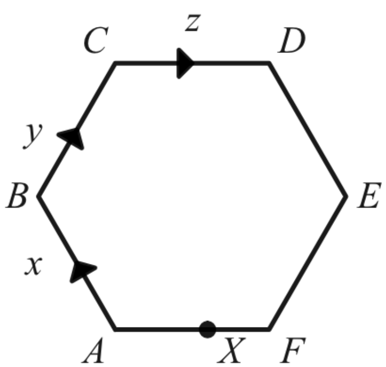
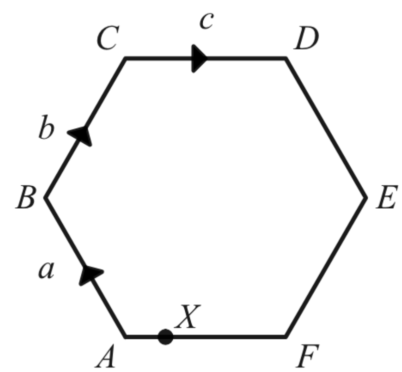
Worked Example	Your Turn
Express $\overrightarrow{DF}$ in terms of p, q and r. 	Express $\overrightarrow{BF}$ in terms of x, y and z. 

Dr Frost 473a

<table>
<tr><th>Worked Example</th><th>Your Turn</th></tr>
<tr><td>ABCD is a trapezium.
M is the midpoint of AD.
Find $\overrightarrow{MA}$ in terms of x and y.

</td><td>ABCD is a rectangle.
M is the midpoint of AD.
Find $\overrightarrow{MA}$ in terms of x and y.

</td></tr>
</table>

Dr Frost 419d

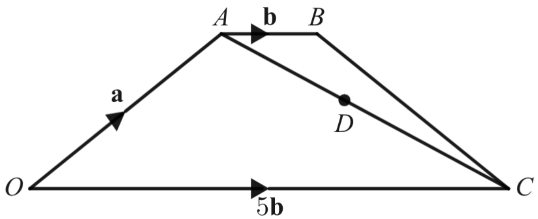
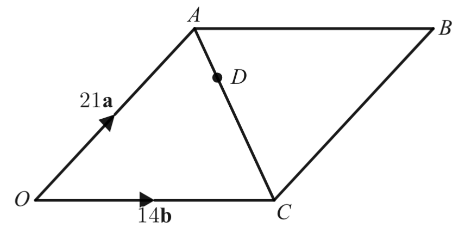
Worked Example	Your Turn
The point M is the midpoint of EF. Express $\overrightarrow{DM}$ in terms of a, b and c.  	The point x is the midpoint of FA. Express $\overrightarrow{EX}$ in terms of x, y and z. 

Worked Example	**Your Turn**
The point X shares the line segment FA in the ratio $2 : 3$. Express $\overrightarrow{EX}$ in terms of x, y and z.  	The point X shares the line segment FA in the ratio $3 : 1$. Express $\overrightarrow{CX}$ in terms of a, b and c. 

Fill in the Gaps

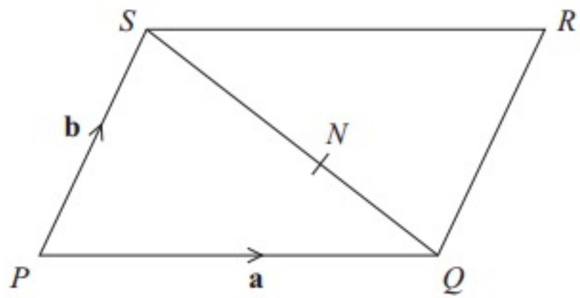
Point X divides the vector $\overrightarrow{AB}$ in the ratio given to create vectors $\overrightarrow{AX}$ and $\overrightarrow{XB}$.

$\overrightarrow{AB}$	Ratio $AX : XB$	$\overrightarrow{AX}$	$\overrightarrow{XB}$
$3\boldsymbol{a}$	$1:2$	$\boldsymbol{a}$	$2\boldsymbol{a}$
$3\boldsymbol{a}+3\boldsymbol{b}$	$2:1$	$2\boldsymbol{a}+2\boldsymbol{b}$	
$4\boldsymbol{a}-4\boldsymbol{b}$	$3:1$		
$5\boldsymbol{a}+10\boldsymbol{b}$	$3:2$		
$10\boldsymbol{a}-15\boldsymbol{b}$	$1:4$		
$\boldsymbol{a}$	$2:1$	$\frac{2}{3}\boldsymbol{a}$	
$\boldsymbol{a}+\boldsymbol{b}$	$1:2$		$\frac{2}{3}\boldsymbol{a}+\frac{2}{3}\boldsymbol{b}$
$\boldsymbol{a}-\boldsymbol{b}$	$3:1$		
$2\boldsymbol{a}+\boldsymbol{b}$	$4:1$		
$\boldsymbol{a}-4\boldsymbol{b}$	$3:2$		
	$1:3$	$\frac{1}{4}\boldsymbol{a}-\frac{1}{4}\boldsymbol{b}$	
$2\boldsymbol{a}-3\boldsymbol{b}$			$\frac{4}{3}\boldsymbol{a}-2\boldsymbol{b}$
		$\frac{6}{5}\boldsymbol{a}+\frac{3}{10}\boldsymbol{b}$	$\frac{4}{5}\boldsymbol{a}+\frac{1}{5}\boldsymbol{b}$

Worked Example	Your Turn
$OABC$ is a trapezium $\overrightarrow{OA} = a$ $\overrightarrow{AB} = b$ $\overrightarrow{OB} = 5b$ D is the point on AC such that $AD : DC = 3 : 4$  Find, in terms of a and b, the vector $\overrightarrow{OD}$	$OABC$ is a parallelogram $\overrightarrow{OA} = 21a$ $\overrightarrow{OB} = 14b$ D is the point on AC such that $AD : DC = 2 : 5$  Find, in terms of a and b, the vector $\overrightarrow{DB}$

Dr Frost 473e

Worked Example



PQRS is a parallelogram.
N is the point on *SQ* such that $SN : NQ = 3 : 2$
$\overrightarrow{PQ} = \mathbf{a}$ $\quad \overrightarrow{PS} = \mathbf{b}$

(a) Write down, in terms of **a** and **b**, an expression for $\overrightarrow{SQ}$.

(b) Express $\overrightarrow{NR}$ in terms of **a** and **b**.

Your Turn

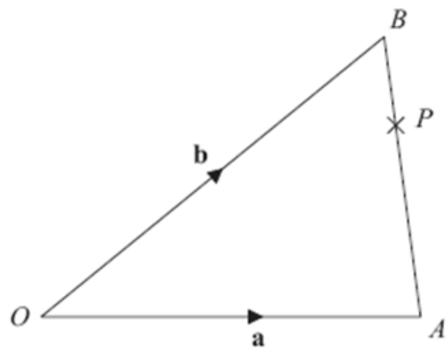


Diagram **NOT** accurately drawn

OAB is a triangle.

$\overrightarrow{OA} = \mathbf{a}$
$\overrightarrow{OB} = \mathbf{b}$

(a) Find $\overrightarrow{AB}$ in terms of $\mathbf{a}$ and $\mathbf{b}$.

....

(1)

P is the point on AB such that $AP : PB = 3 : 1$

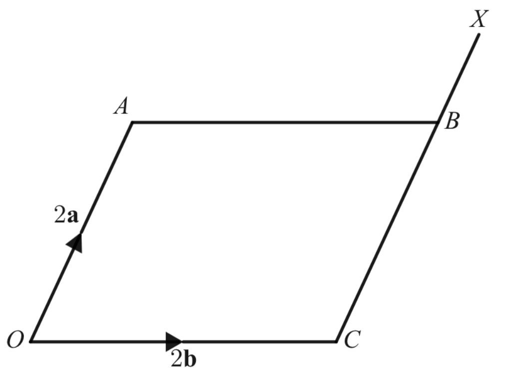
(b) Find $\overrightarrow{OP}$ in terms of $\mathbf{a}$ and $\mathbf{b}$.
Give your answer in its simplest form.

<table>
<tr><th>Worked Example</th><th>Your Turn</th></tr>
<tr><td>

$OABC$ is a parallelogram
$\overrightarrow{OA} = 2a$
$\overrightarrow{OB} = 2b$

CBX is a straight line
$CB : BX = 5 : 2$

The point Y is such that $\overrightarrow{CY} = 5\overrightarrow{AX}$



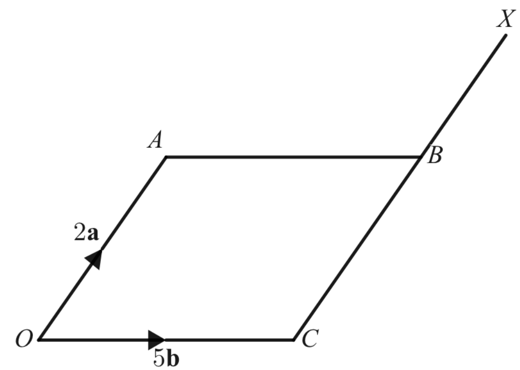
Find, in terms of a and b, the vector $\overrightarrow{OY}$

</td><td>

$OABC$ is a parallelogram
$\overrightarrow{OA} = 2a$
$\overrightarrow{OB} = 5b$

CBX is a straight line
$CB : BX = 3 : 2$

The point Y is such that $\overrightarrow{CY} = 4\overrightarrow{AX}$

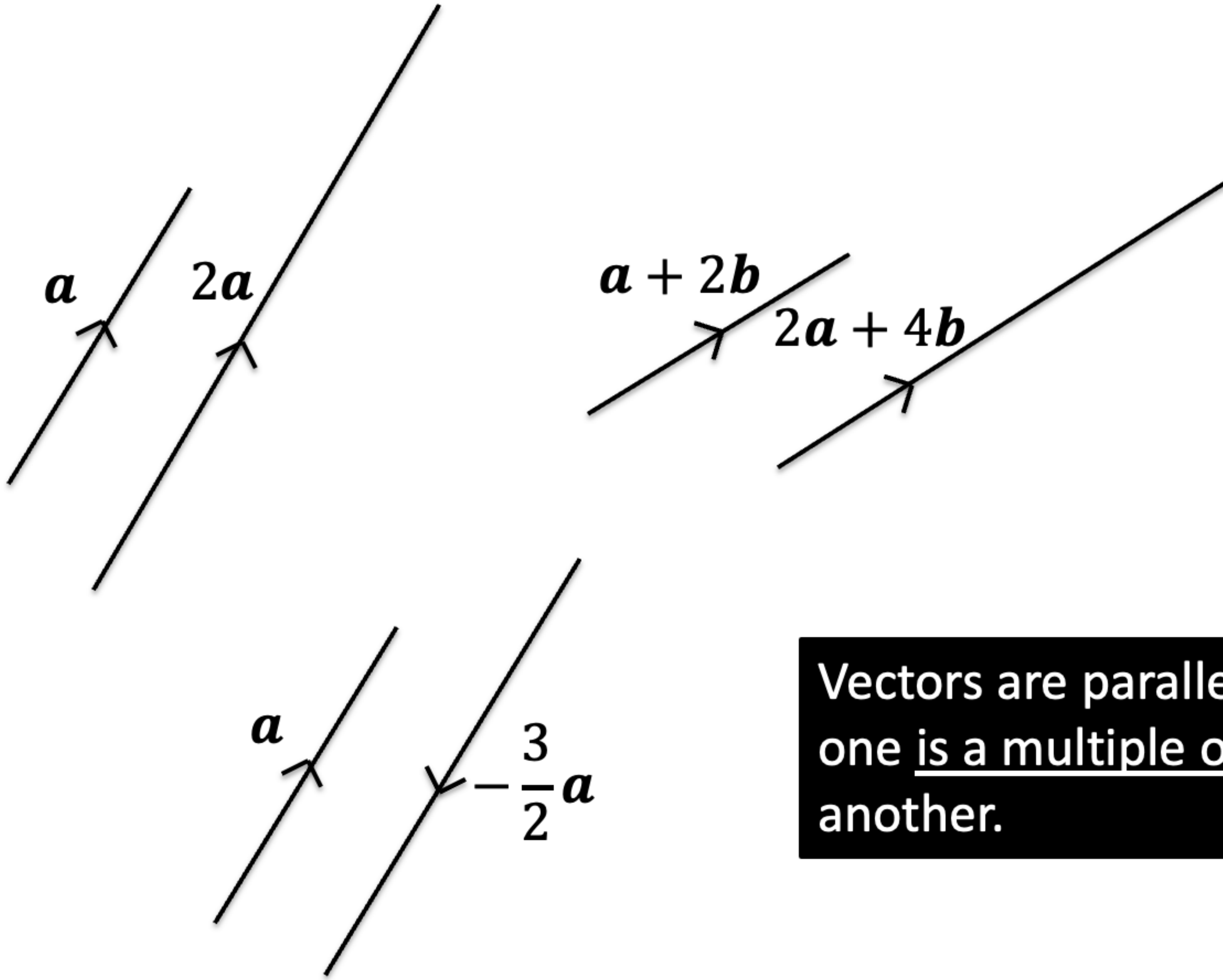


Find, in terms of a and b, the vector $\overrightarrow{OY}$

</td></tr>
</table>

Dr Frost 473f

Parallel Vectors



Vectors are parallel if one <u>is a multiple of</u> another.

Parallel Vectors

Two vectors are parallel if they are ***multiples*** of each other.

Vector 1	Vector 2	Parallel?	
a	-**a**	Yes	No
a + **b**	2**a** + 2**b**	Yes	No
a + **b**	**a** + 2**b**	Yes	No
$\frac{1}{2}$**a** + **b**	**a** + 2**b**	Yes	No
2**a** + 5**b**	4**a** + 10**b**	Yes	No
a + **b**	**a** - **b**	Yes	No
a + **b**	-**a** - **b**	Yes	No
a - **b**	-**a** + **b**	Yes	No
2**a** + 3**b**	$\frac{2}{3}$**a** + **b**	Yes	No

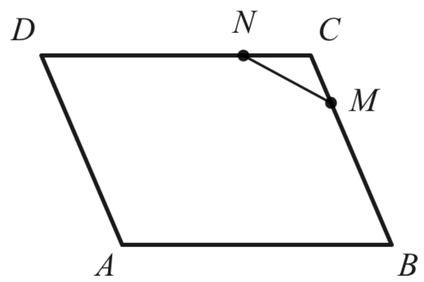
Dr Frost 474a

Worked Example	Your Turn
a) The vectors $-3a - b$ and $6a + nb$ are parallel. Given that a and b are not parallel, find the value of n b) Vector $p = \binom{3}{-4}$ and vector $q = \binom{n}{7}$ Vector $3p + q$ is parallel to $\binom{2}{-1}$ Find the value of n	a) The vectors $12p - 12q$ and $-6p + dq$ are parallel. Given that p and q are not parallel, find the value of d b) Vector $a = \binom{-3}{-4}$ and vector $b = \binom{l}{6}$ Vector $2a + b$ is parallel to $\binom{-2}{1}$ Find the value of l

Worked Example	Your Turn
D, E and F are three points on a straight line such that $\overrightarrow{DE} = 6x - 3y$ $\overrightarrow{EF} = 8x - 4y$ Find the ratio length of EF : length of DE Give your answer in its simplest form.	U, V and W are three points on a straight line such that $\overrightarrow{UV} = 7a - 3b$ $\overrightarrow{VW} = \frac{35}{2}a - \frac{15}{2}b$ Find the ratio length of UV : length of UW Give your answer in its simplest form.

Worked Example

The diagram shows parallelogram $ABCD$



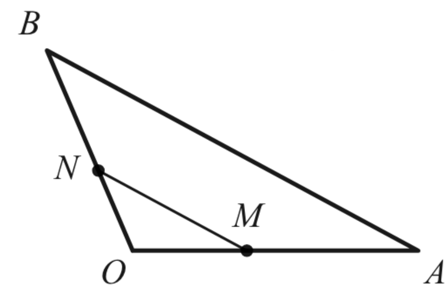
$\overrightarrow{AB} = a$
$\overrightarrow{AC} = b$

$BM : MC = 3 : 1$
$DN : NC = 3 : 1$

Use a vector method to prove that $\overrightarrow{MN}$ is parallel to $\overrightarrow{BD}$

Your Turn

The diagram shows triangle OAB

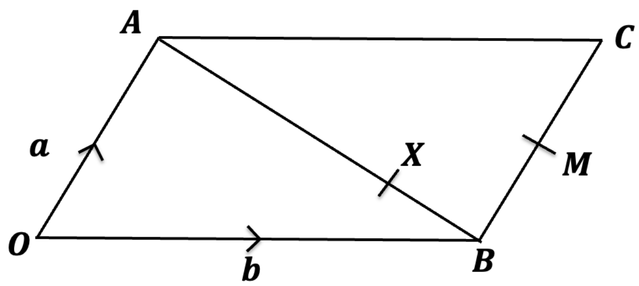


$\overrightarrow{OA} = a$
$\overrightarrow{OB} = b$

$OM : MA = 2 : 3$
$ON : NB = 2 : 3$

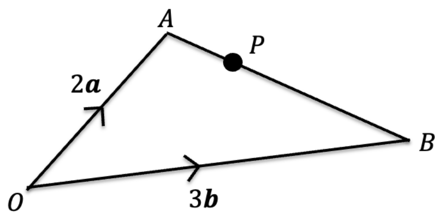
Use a vector method to prove that $\overrightarrow{MN}$ is parallel to $\overrightarrow{AB}$

Worked Example



X is a point on AB such that $AX\colon XB = 3\colon 1$. M is the midpoint of BC.
Show that $\overrightarrow{XM}$ is parallel to $\overrightarrow{OC}$.

Your Turn



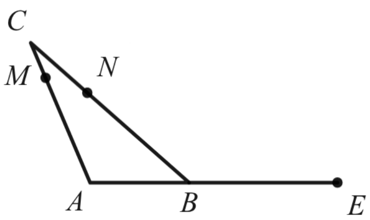
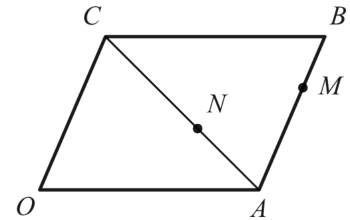
a) Find $\overrightarrow{AB}$ in terms of $\boldsymbol{a}$ and $\boldsymbol{b}$.

b) P is the point on AB such that $AP : PB = 2 : 3$.
Show that $\overrightarrow{OP}$ is parallel to the vector $\boldsymbol{a} + \boldsymbol{b}$.

Worked Example	Your Turn
The quadrilateral $OABC$ has vertices O, A, B, C where $\overrightarrow{OA} = 2a + b$, $\overrightarrow{OB} = 3b$ and $\overrightarrow{OC} = -4a + b$ By showing that $\overrightarrow{OA}$ and $\overrightarrow{BC}$ are parallel, prove that the quadrilateral $OABC$ is a trapezium.	The quadrilateral $OABC$ has vertices O, A, B, C where $\overrightarrow{OA} = a + b$, $\overrightarrow{OB} = 2b$ and $\overrightarrow{OC} = -3a - b$ By showing that $\overrightarrow{OA}$ and $\overrightarrow{BC}$ are parallel, prove that the quadrilateral $OABC$ is a trapezium.

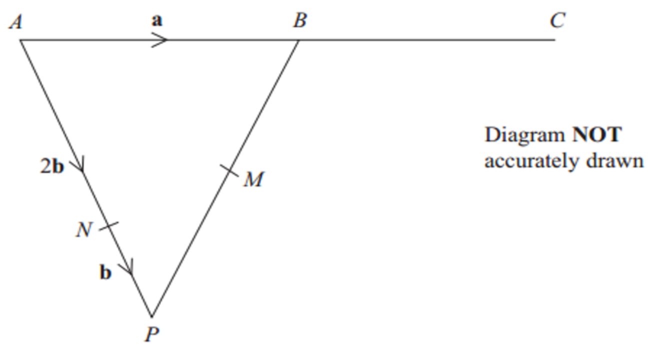
Dr Frost 474e

Straight Lines

Worked Example	Your Turn
The diagram shows triangle ABC The point E lies on the straight line through A and B  $\overrightarrow{AB} = a$ $\overrightarrow{AC} = b$ $\overrightarrow{AE} = \frac{5}{2}a$ $AM : MC = 3 : 1$ $BN : NC = 9 : 5$ Use a vector method to prove that M, N and E are collinear.	The diagram shows parallelogram $\text{O}ABC$  $\overrightarrow{OA} = 5a$ $\overrightarrow{OC} = 5b$ $AM : MB = 2 : 1$ $AN : NC = 2 : 3$ Use a vector method to prove that O, N and M are collinear.

Dr Frost 474f

Worked Example



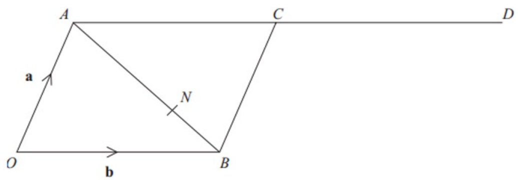
$$\overrightarrow{AN} = 2\boldsymbol{b}, \qquad \overrightarrow{NP} = \boldsymbol{b}$$

B is the midpoint of AC. M is the midpoint of PB.

a) Find $\overrightarrow{PB}$ in terms of $\boldsymbol{a}$ and $\boldsymbol{b}$.

b) Show that NMC is a straight line.

Your Turn



$\overrightarrow{OA} = a$ and $\overrightarrow{OB} = b$
D is the point such that $\overrightarrow{AC} = \overrightarrow{CD}$
The point N divides AB in the ratio $2:1$.

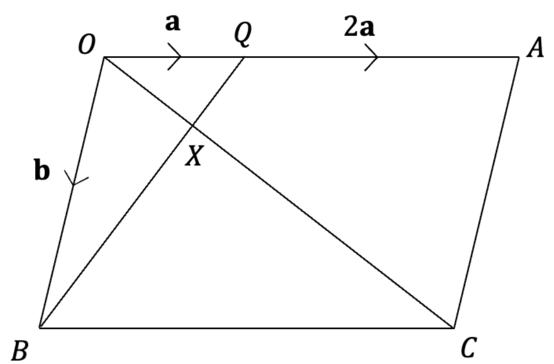
(a) Write an expression for $\overrightarrow{ON}$ in terms of $\boldsymbol{a}$ and $\boldsymbol{b}$.

(b) Prove that OND is a straight line.

Vector Proofs

Worked Example

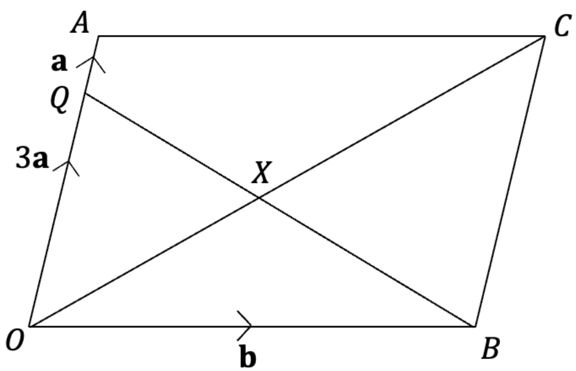
$OACB$ is a parallelogram. Given that OXC and BXQ are straight lines, determine the ratio $OX : XC$.



Dr Frost 475a

Your Turn

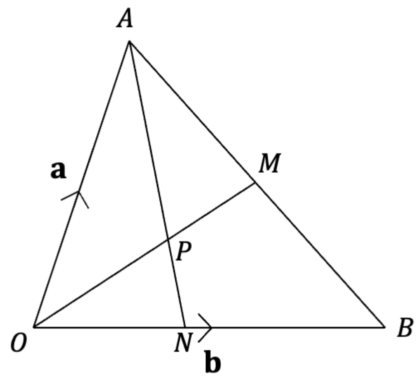
$OACB$ is a parallelogram. Given that OXC and BXQ are straight lines, determine the ratio $OX : XC$.



Worked Example

OAB is a triangle.
OPM and APN are straight lines.
M is the midpoint of AB.

$\overrightarrow{OA} = \mathbf{a}$
$\overrightarrow{OB} = \mathbf{b}$
$OP : PM = 3 : 2$
Work out the ratio $ON : NB$

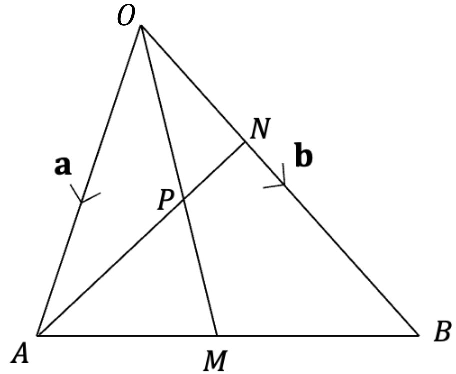


Dr Frost 475b

Your Turn

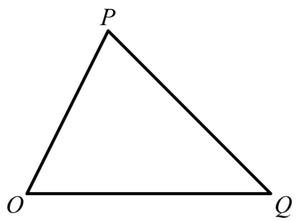
OAB is a triangle.
OPN and APN are straight lines.
M is the midpoint of OB.

$\overrightarrow{OA} = \mathbf{a}$
$\overrightarrow{OB} = \mathbf{b}$
$OP : PM = 5 : 3$
Work out the ratio $ON : NB$



Worked Example

The diagram below shows a sketch of triangle OPQ



The point R is such that $OP : PR = 1 : 2$
The point M is such that $PM : MQ = 2 : 3$

The straight line through R to M cuts OQ at the point N

Let $\overrightarrow{OP} = a$ and $\overrightarrow{OQ} = b$

By first finding $\overrightarrow{RM}$ in terms of a and b, and letting $\overrightarrow{RN} = \lambda\overrightarrow{RM}$, find $ON : NQ$

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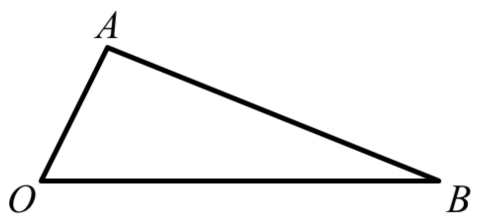
Your Turn

The diagram below shows a sketch of triangle OAB



The point C is such that $\overrightarrow{OC} = 2\overrightarrow{OA}$
The point M is such that $AM : MB = 3 : 2$

The straight line through C to M cuts OB at the point N

Let $\overrightarrow{OA} = a$ and $\overrightarrow{OB} = b$

By first finding $\overrightarrow{CM}$ in terms of a and b, and letting $\overrightarrow{CN} = \lambda\overrightarrow{CM}$, find $ON : NB$

Extra Notes