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VCE Mathematical Methods ½
Linear & Coordinate Geometry Exam Skills [1.2]
Workbook

Outline:

Section A: Recap of [1.1] – Linear and Coordinate Geometry

Definition

Linear equations

➤ **Definition:** Equations where the highest power of a variable is 1.

⟲ **Gradient-intercept form:**

$$y = mx + c$$

$$\text{where } m = gradient = \frac{rise}{run} =$$

$$\text{and } c =$$

➤ No singular solution for a linear equation in two variables.

⟲ All pairs of coordinates (x, y) that satisfy the equation lie on a **line.** (Hence, *linear* equations).

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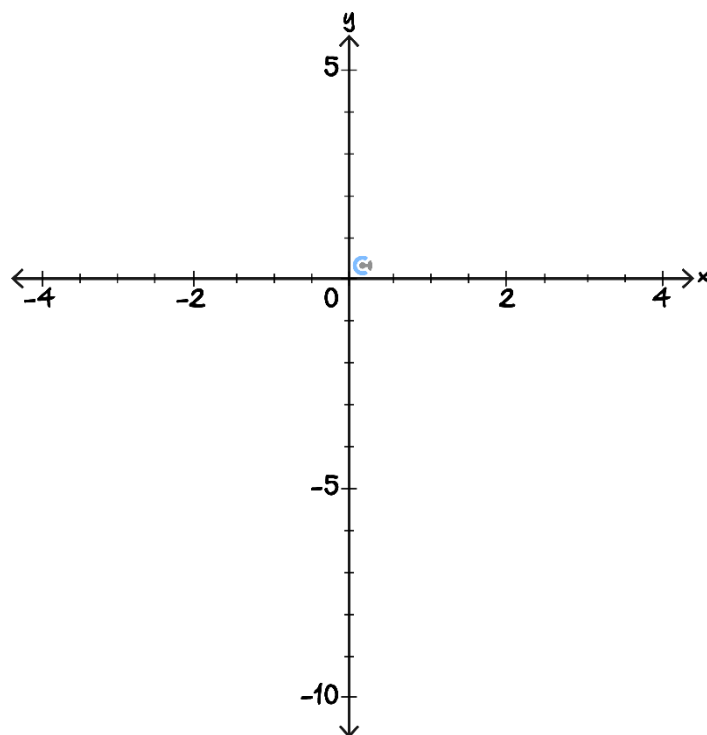
Sub-Section: Inequality

Inequalities rule

Definition

$$x > \frac{b}{a}, \text{ where } a < 0$$

➤ Multiplying both sides by a negative number _____ the inequality sign.

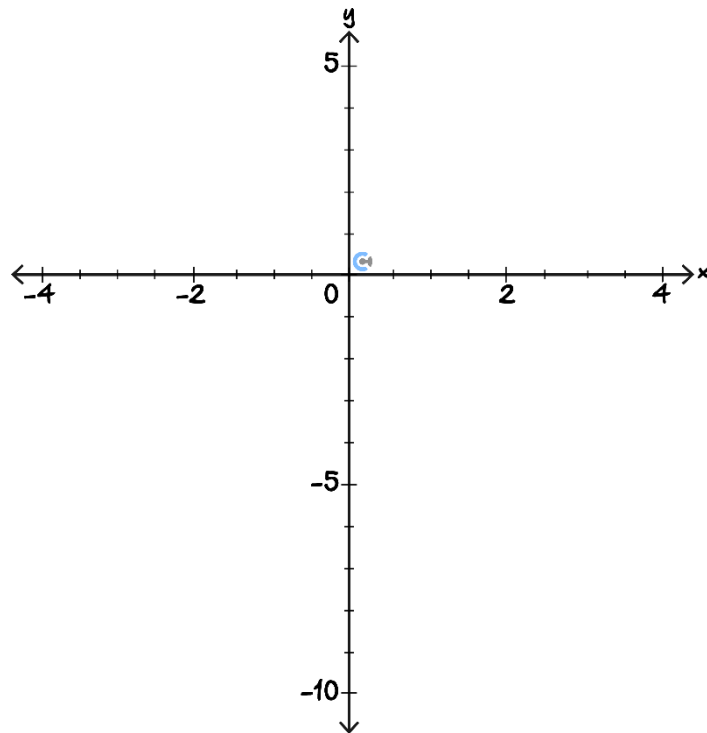**Question 1 Walkthrough.**

a. Sketch the graph of $y = 2x - 4$ on the axis below.

b. Solve the inequality: $-4x + 3 \geq 7$

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c. Sketch the region $4x - 2y < 4$ on the axis below.

Question 2

a. Sketch the graph of $y = 3x - 2$ on the axis below.

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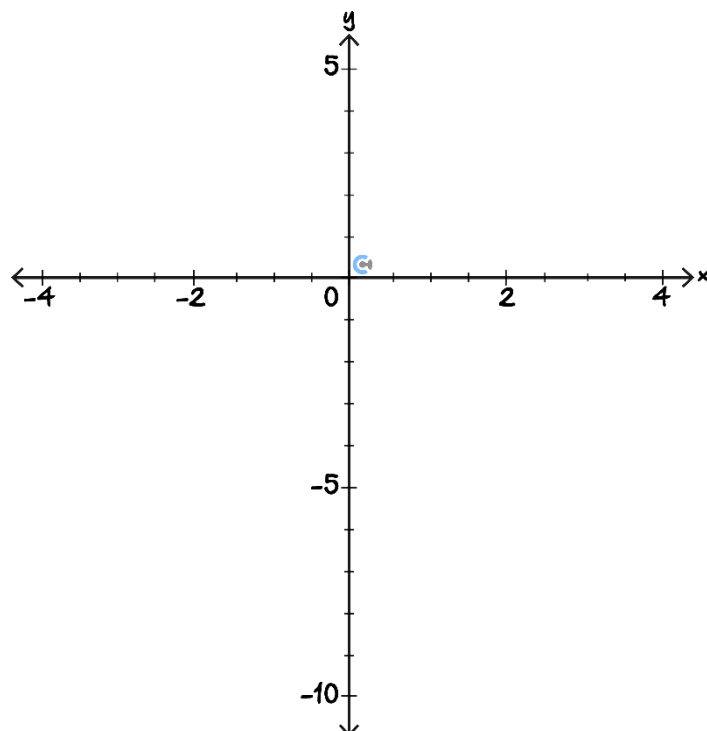
b. Solve the inequality: $-2x + 7 > 4$

c. Sketch the region $x - 2y > 4$ on the axis below.
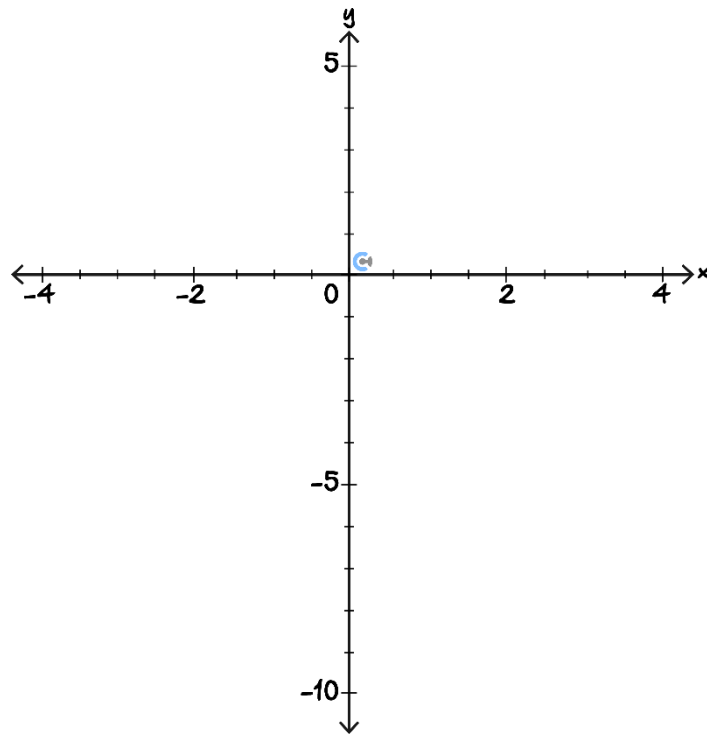
Question 3 Extension.

Solve the inequality: $\frac{x-4}{2x+3} > 2$

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Sub-Section: Midpoint

Definition

Midpoint

$$(x_2, y_2)$$

$$\left(\frac{x_1 + x_2}{2} , \frac{y_1 + y_2}{2} \right)$$

$$(x_1, y_1)$$

➤ **Definition:** The midpoint, M, of two points A and B is the point halfway between A and B.

$$M(x_m, y_m) = \left(\underline{\hspace{4cm}} \right)$$

➤ The midpoint can be found by taking the _____ of the x-coordinate and y-coordinate of the two points.

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Sub-Section: Distance Between Two Points

Definition

Distance between two points

➤ **Definition:** The distance between two points (x_1, x_2) and (y_1, y_2) can be found using Pythagoras' theorem:

$$\text{Distance} = \text{_____}$$

Question 4

Consider the line segment AB where $A(2,4)$ and $B(4,8)$.

a. Find the midpoint of a line segment AB.

b. Find the distance between the midpoint of AB and $(-1,4)$.

Question 5 Extension.

Find a point(s) on the line $y = 2x + 3$ which has a distance of 4 from the point $(4,3)$.

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Sub-Section: Vertical Distance Vs Horizontal Distance

Horizontal distance

$$\text{Horizontal Distance} = x_2 - x_1 \text{ where } \underline{\hspace{3cm}}$$

➤ Find the difference between their x-values.

Question 6

Find the horizontal distance between the two points $(1,9)$ and $(7,-4)$.

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What about vertical distance then?

Vertical distance
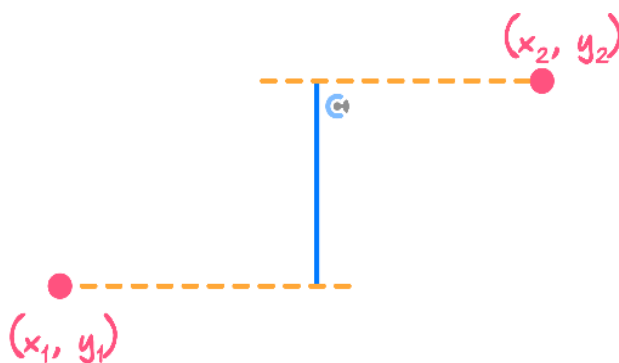
$$\text{Vertical Distance} = y_2 - y_1 \text{ where } y_2 > y_1$$
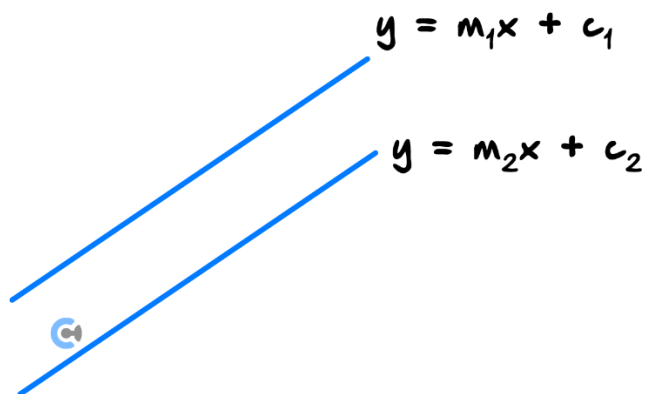
➤ Find the difference between their y-values.

Question 7

Find the vertical distance between the two points $(1, 9)$ and $(13, -8)$.

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Sub-Section: Parallel and Perpendicular Lines

Parallel lines

$y = m_1 x + c_1$

$y = m_2 x + c_2$

Definition

➤ Parallel lines have the _____ gradient.

$$m_1 = m_2$$

Perpendicular lines

$y = m_1 x + c_1$

$y = m_2 x + c_2$

Definition
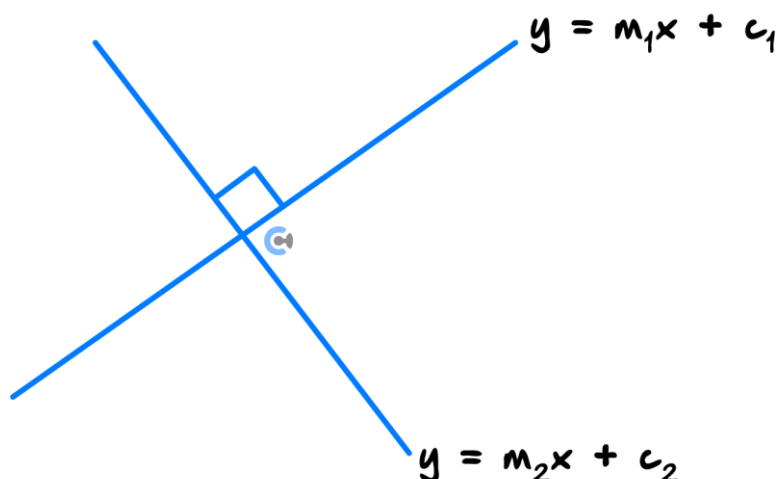
➤ A line that is perpendicular to another line has a gradient, which is the _____ of the gradient of the first line.

$$m_\perp = -\frac{1}{m}$$

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Question 8

a. Find a line that is parallel to $y = 3x - 1$ passing through the point $(-1,4)$.

b. Find a line which is perpendicular to $y = -3x + 4$ passing through the point $(3, -1)$.

Question 9 Extension.

Find the equation of the line that is a perpendicular bisector of the points $A(2,4)$ and $B(8,6)$.
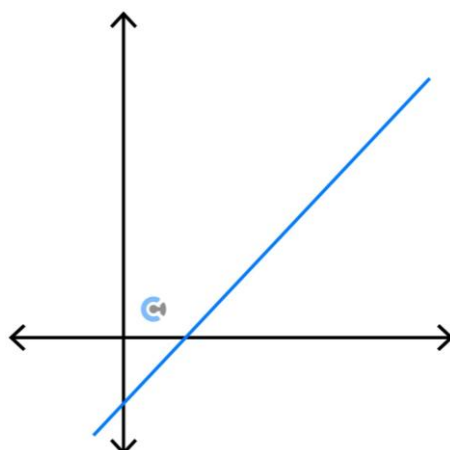
Sub-Section: Angle Between a Line and the x-axis

How do we find the angle between a line and the x-axis?

Angle between a line and the x-axis

➤ The angle between a line and the _____ **direction of the x-axis** (anticlockwise) is given by:

$$\tan(\theta) = m$$

Question 10 Tech-Active.

Find the angle made between the line $y = 3x - 6$ and the x-axis measured in the anticlockwise direction. Give your answer in degrees correct to two decimal places.

NOTE: Angles from the x-axis measured anticlockwise = _____ angles.

➤ Don't worry about it too much, it's just convention! (More on this in circular functions).

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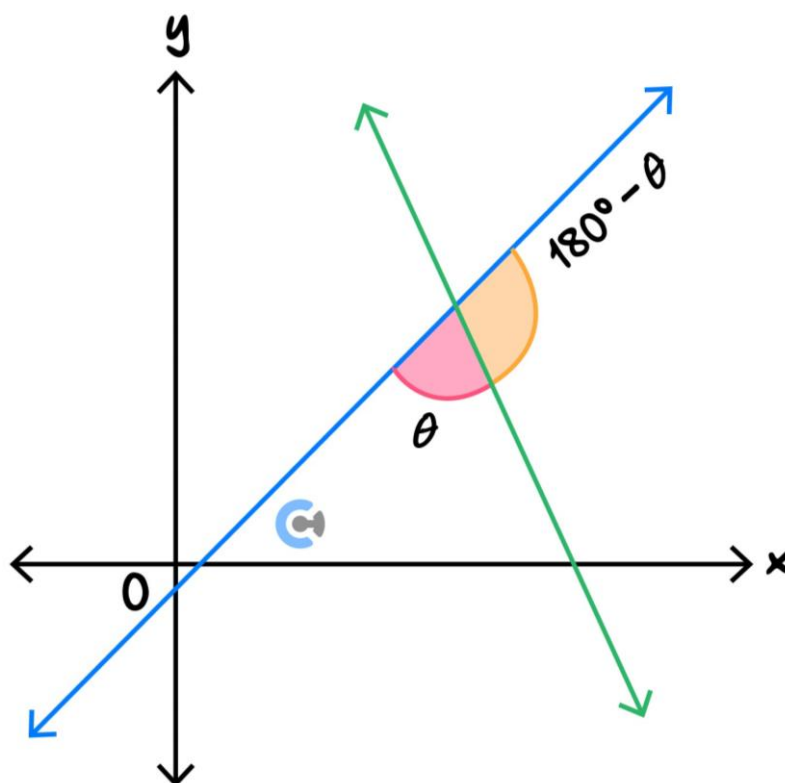## Sub-Section: Angle Between the Two Lines

Slightly more complicated now!
How about an angle between two lines?

Acute angle between two lines

$$\theta = \underline{\hspace{8cm}}$$

➤ Alternatively:

$$\tan(\theta) = \underline{\hspace{4cm}}$$

For your understanding, note that this formula is derived from the tan compound angle formula covered in SM12.

NOTE: $|x|$ just takes the positive value of x.

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Question 11 Tech-Active.

Find the acute angle between the lines $3x + 4y = 2$ and $y = x + 1$. Give your answer in degrees correct to two decimal places.

TIP: Make sure your CAS is in degrees.

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Sub-Section: Finding Simultaneous Equations for Two Variables

Simultaneous linear equations

1. Elimination method:

   ◉ Add or subtract one equation from the other in order to _____ one of the variables. Then have an equation in one variable that can be solved easily.

2. Substitution method:

   ◉ Make one of the variables the subject (generally x or y) and _____ that value into the other equation.

Question 12 Walkthrough.

Solve the following simultaneous linear equations using either elimination or substitution.

$$2x + 3y = 8 \text{ and } 4x - 4y = -4$$

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Question 13

Solve the following equation for x and y.

$$2x - 3y = 16 \text{ and } x + y = 3$$

Question 14 Extension.

Solve the following:

$$-6x + 2y = 10 \text{ and } -10 + y = 3x$$

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Sub-Section: Number of Solutions for Two Variables
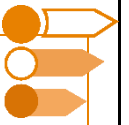
What does the geometry look like for each number of solutions?

Exploration: Geometry of the number of solutions between linear graphs

➤ Unique solution

$$m_1 \neq m_2$$

C They just need to have _____.

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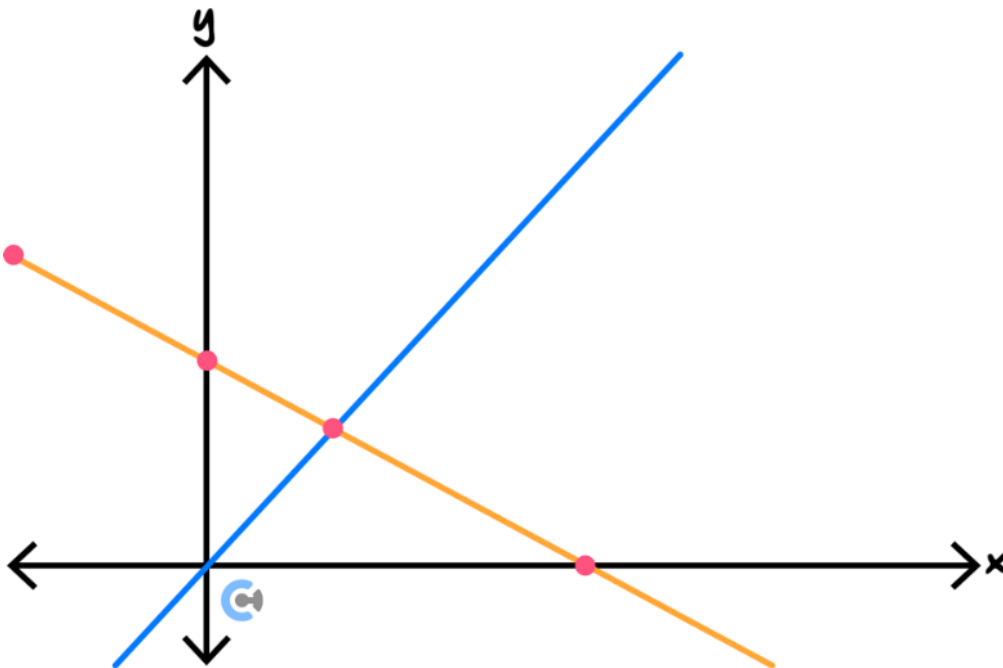
➢ **Infinite solutions**

$$m_1 = m_2 \text{ and } c_1 = c_2$$
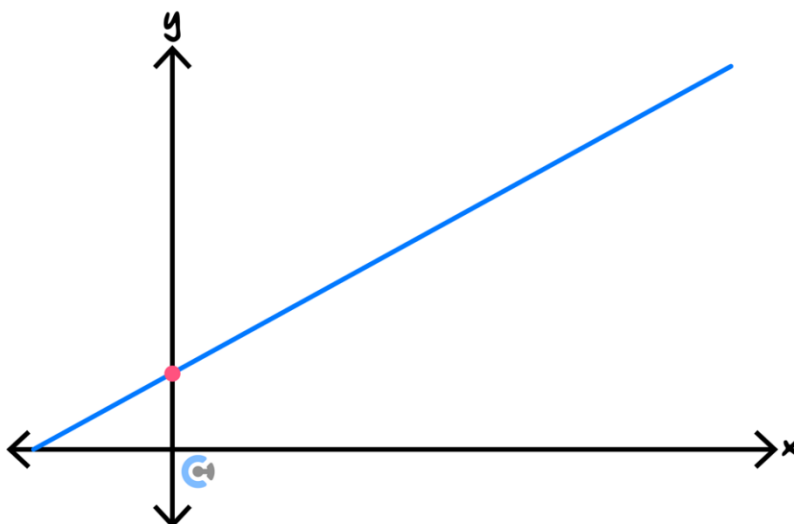
- They just need to have the same _____ and the same _____.

- In other words, they have to be the _____.

➢ **No solutions**

$$m_1 = m_2 \text{ and } c_1 \neq c_2$$

- They need to have the _____ but _____ $+c$.

- They have to be two different _____ lines.

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General solutions of simultaneous linear equations

➤ Two linear equations are either:
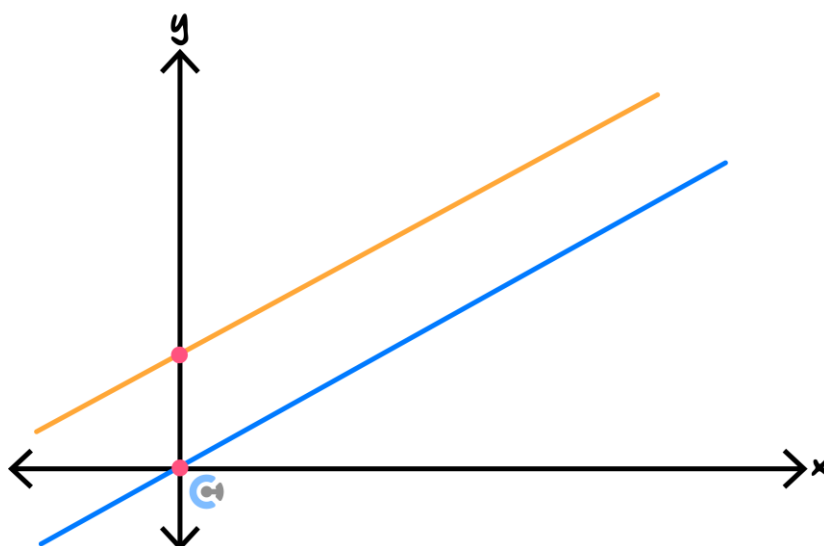
  ⊙ The same line is expressed in a different form. In this case, they have _____ solutions.

  ⊙ Unique lines which are parallel. In this case, they have _____ solutions.

  ⊙ Unique lines which are not parallel. In this case, they have _____ solution.

Question 15 Walkthrough.

Consider the following pair of simultaneous equations in terms of $k \in \mathbb{R}\backslash\{0\}$:

$$y = kx + 5$$

$$y = 2x - 5k$$

a. Find the value of k for which there are no solutions to the simultaneous equations.

b. Find the value(s) of k for which there is a unique solution to the simultaneous equations.

c. Find the value of k for which there are infinite solutions to the simultaneous equations.

TIP: It's a good idea to substitute your answer back into the equations to see if the criteria are met for each part.

Question 16

Consider the following pair of simultaneous equations in terms of $k \in \mathbb{R}\backslash\{0\}$:

$$-3x + y = -2k$$

$$-3kx + y = -2$$

a. Find the value(s) of k for which there is a unique solution to the simultaneous equations.

b. Find the value of k for which there are infinite solutions to the simultaneous equations.

c. Find the value of k for which there are no solutions to the simultaneous equations.

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Question 17 Extension.

Consider the following pair of simultaneous equations in terms of $a \in \mathbb{R}\backslash\{0\}$:

$$-2ax + 4y = 10$$

$$3x + (1-a)y = -5$$

a. Find the value(s) of a for which there are no solutions to the simultaneous equations.

b. Find the value(s) of a for which there is a unique solution to the simultaneous equations.

c. Find the value(s) of a for which there are infinite solutions to the simultaneous equations.

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Section B: Linear and Coordinate Geometry Exam Skills

Sub-Section: Finding the Equation of the Line
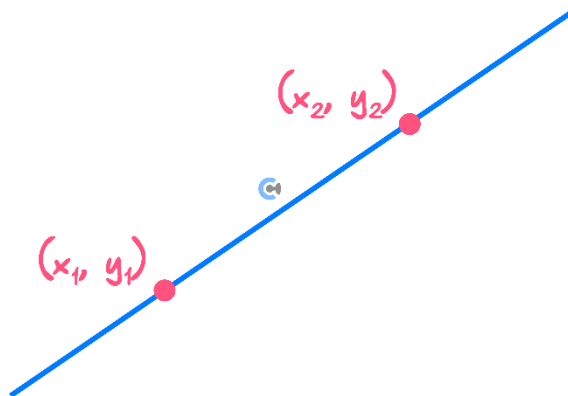
➤ m: Gradient

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

➤ $+c$: y-intercept

➤ Substitute in any point to $y = mx + c$ equation.

Question 18 Walkthrough.

Find the equation of the line joining the points $(1, 3)$ and $(5, 5)$.

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Question 19

Find the equation of the straight line shown on the graph below.

_____

_____

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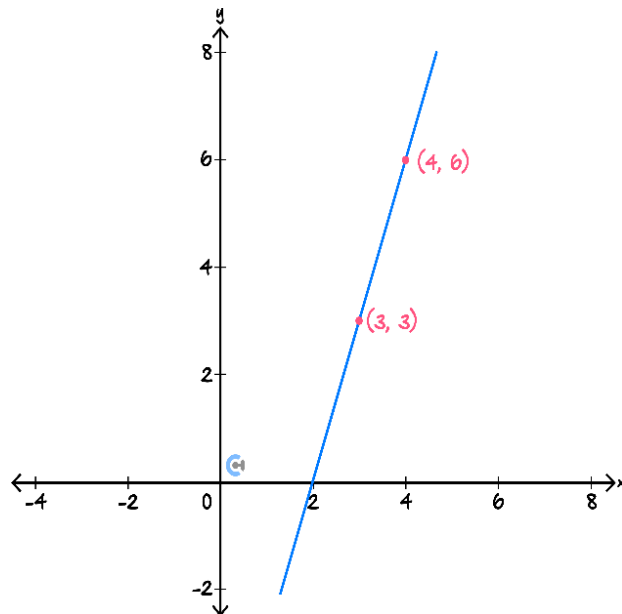
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Question 20 Extension.

Find the expression for the inequality shown on the graph below.

_____

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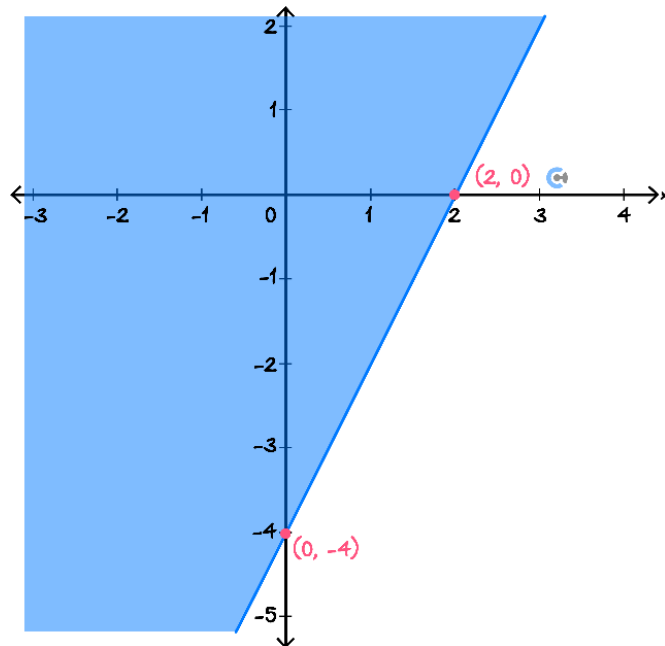
Sub-Section: Applying Midpoint to Find Reflected Points
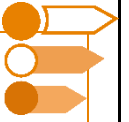
How can we use the idea of midpoint to find reflections?

Exploration: Finding reflections

➤ Consider a point reflected around $y = 3$.

• (x, 5)

——————————————————— y = 3

• (x, y)

➤ What do you notice about their midpoint?

➤ Hence, what should the average of two y-values equal to?

$$\frac{y + 5}{2} = \underline{\quad\quad}$$

➤ Find the reflected point!

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Finding reflections around horizontal and vertical axes

➤ **Horizontal axis**

$$\bullet\ (c, d)$$

$$\underline{\hspace{4cm}} \quad y = m$$

$$\bullet\ (a, b)$$
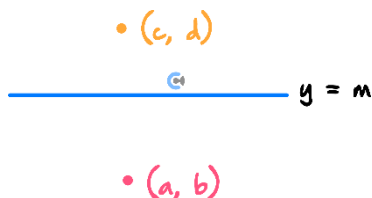
➤ The _____ changes for horizontal reflections.

$$\frac{b + d}{2} = m$$

➤ **Vertical axis**

$$x = m$$

$$(a, b) \quad\quad (c, d)$$
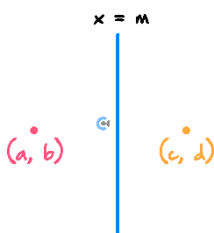
➤ The _____ changes for horizontal reflections.

$$\frac{a + c}{2} = m$$

Question 21 Walkthrough.

Find the reflection of $(3,1)$ around $x = 1$.

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Question 22

Find the reflection of (5,2) around $x = 3$.

Question 23 Extension.

Find the reflection of the point (a, b) around the line $y = c$.

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Sub-Section: Find Vertical Distance between Two Functions

Discussion: What can we call any point on the function, $f(x)$?

NOTE: That's why we say, $y = f(x)$.

Vertical Distance between Two Functions
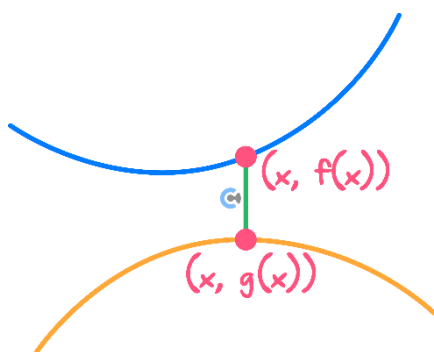
➤ Find the difference between the two y-values.

$$f(x) - g(x) \text{ where } f \text{ is above } g$$

Question 24 Walkthrough.

Find the vertical distance between the functions $f(x) = x^2 + 1$ and $g(x) = x - 1$ when $x = 2$.

Question 25

Find the vertical distance between the functions $f(x) = x^2 - 4$ and $g(x) = x + 1$ when $x = 2$.

Question 26 Extension.

When $x = a$, the vertical distance between the functions $f(x) = x^2 + 5$ and $g(x) = x + 4$ is 7.

Find the possible values of a.

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Sub-Section: Finding Distance between a Point And a Function

Active Recall: Point on a Function

$$Point\ on\ f : (x, _____)$$

Distance between a Function and a Point
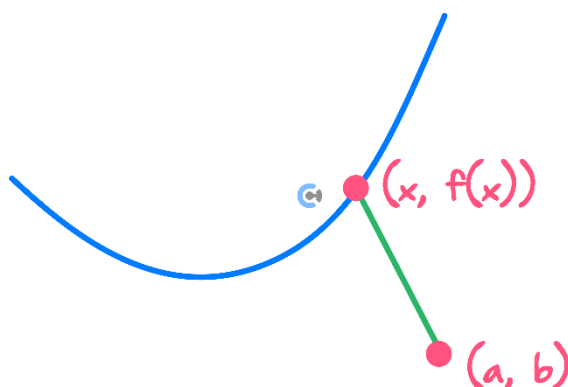
➤ Find the distance between the point and $(x, function)$.

$$Distance = \sqrt{(x-a)^2 + (f(x)-b)^2}$$

Question 27 Walkthrough.

Find the distance between the point $(1,2)$ and $f(x) = 3x - 4$ when $x = 3$.

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Question 28

Find the distance between the point $(3,2)$ and $f(x) = 2x - 3$ when $x = 4$.

Question 29 Extension.

The distance between the point $(3,5)$ and the function $f(x) = x + 1$ when $x = a$ is 1.

Find the possible value(s) of a.

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Section C: Exam 1 Questions (22 Marks)

INSTRUCTION: 22 Marks. 27.5 Minutes Writing.

Question 30 (5 marks)

a. Solve the linear equation, $2x - 7 = 4x + 8$. (1 mark)

_____

_____

_____

_____

b. Solve the linear inequality, $-2x + 3 \leq 4x + 5$. (2 marks)

_____

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_____

c. Sketch the inequality $4x - 8 + 6y < 0$ on the axis below. (2 marks)

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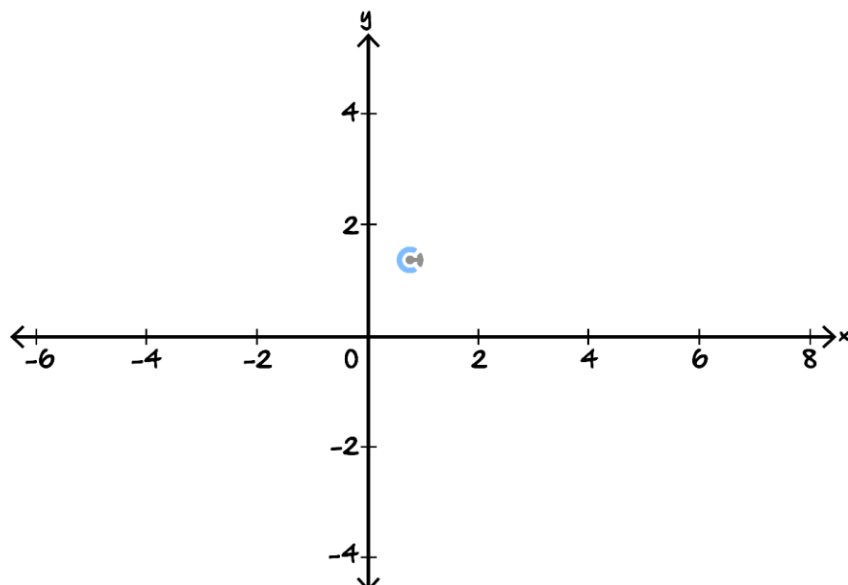
Question 31 (5 marks)

Consider the line segment AB with coordinates $A(2,4)$ and $B(6,6)$.

a. Find the midpoint of AB. (1 mark)

_____

_____

b. Find the equation of the line segment AB. (2 marks)

_____

_____

_____

_____

c. Find the perpendicular bisector of AB. (2 marks)

_____

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Question 32 (5 marks)

Consider the points $A(2,4)$ and $B(6,6)$.

a. Find the distance between points A and B. (1 mark)

_____

_____

_____

b. The distance between point A and a point $C(3,k)$ is 1. Find the value of k. (2 marks)

_____

_____

_____

_____

c. Find the coordinates of the point D obtained by reflecting A in the line $x = -1$. (1 mark)

_____

_____

d. Find the coordinates of the point E obtained by reflecting B in the line $y = 3$. (1 mark)

_____

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Question 33 (2 marks)

Richard buys 2 bags of brand X chips and 3 bags of brand Y chips for a total of $12. Brand X chips cost $1 more than brand Y chips. Find the cost of each chip brand.

$$2x + 3y = 12$$
$$x - y = 1$$

_____

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Question 34 (5 marks)

Consider the linear equations:

$$y - kx = -k$$
$$y - 2x = k$$

a. For what value(s) of k, will the system have a unique solution? (2 marks)

_____

_____

_____

b. For what value of k, will the system have no solution? (2 marks)

_____

_____

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c. Explain why the system can never have infinitely many solutions. (1 mark)

_____

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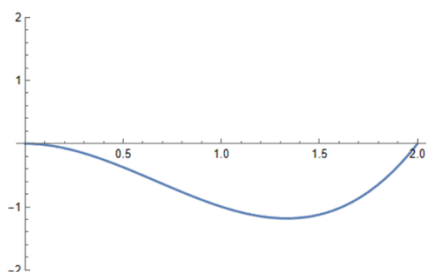## Section D: Tech Active Exam Skills

Calculator Commands: Graphing

➤ **Mathematica**

 ● Plot[function,{x,xmin,xmax}, PlotRange→{ymin, ymax}]

 ● PlotRange is optional but makes the scale appropriate for the question.

Plot[x^3 - 2 x^2, {x, 0, 2}, PlotRange → {-2, 2}]

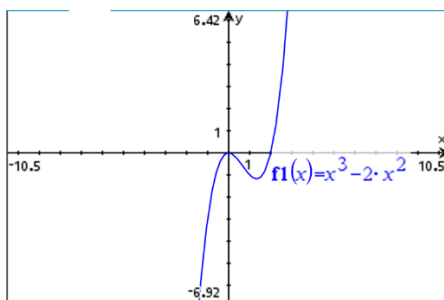 ● Menu→ 6 (Analyse) to find min/max x and y intercepts.

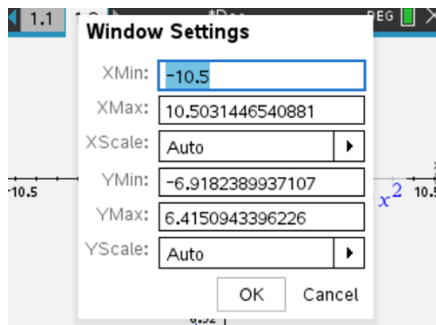 ● Restrict domain to $0 < x < 2$ use the bar can get it from ctrl+ =

$$f1(x)=x^3-2x^2|0<x<2$$

➤ **TI-Nspire**

 ● Open a graph page and plot your function.

$f1(x)=x^3-2\cdot x^2$

 ● Zoom settings: Menu→ 4 (window/zoom)→ 1 enter your x and y ranges.

Window Settings

XMin: -10.5
XMax: 10.5031446540881
XScale: Auto
YMin: -6.9182389937107
YMax: 6.4150943396226
YScale: Auto

OK   Cancel

 ● Can also click the axis numbers on the graph and alter them directly.

$f1(x)=x^3-2\cdot x^2$
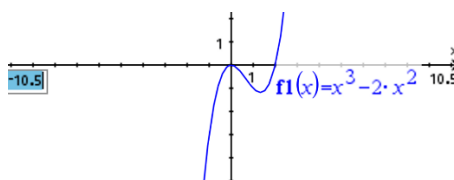
➤ **Casio Classpad**

 ● Click Graph & Table, and enter the function.

MENU ⚙

√α Main

eActivity   Statistics

Spread-sheet   Graph& Table

3D Graph   Geometry

Picture Plot   Interactive DiffCalc

Conics   DiffEq-Graph

⚙ Edit Zoom Analysis ◆

Y1:--
Y2:--   Box
Factor
Zoom In
Zoom Out
Auto
Original
Square
Round
Integer
Previous
Initialize
Quick

Deg   Real

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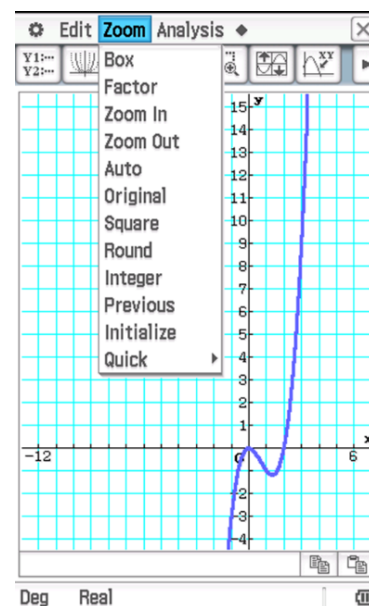
G Analysis→G-Solve to find intercepts.

G Use this button ⟨⟩ to set the view window.

View Window ✕

File Memory

☐ x-log ☐ y-log

xmin : -5
 max : 5
 scale: 1
 dot : 0.0324675324675325
ymin : -1.765
 max : 0.563
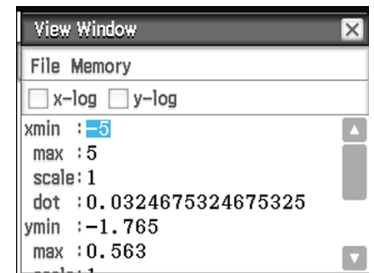
G Use | to restrict domain → find it in Math 3

☑ $y1 = x^3 - 2 \cdot x^2 \,|\, 0 < x < 2$

Question 35 Tech-Active.

Sketch the graph of $y = x^4 - 2x^3$ for $0 \le x \le \frac{9}{4}$.

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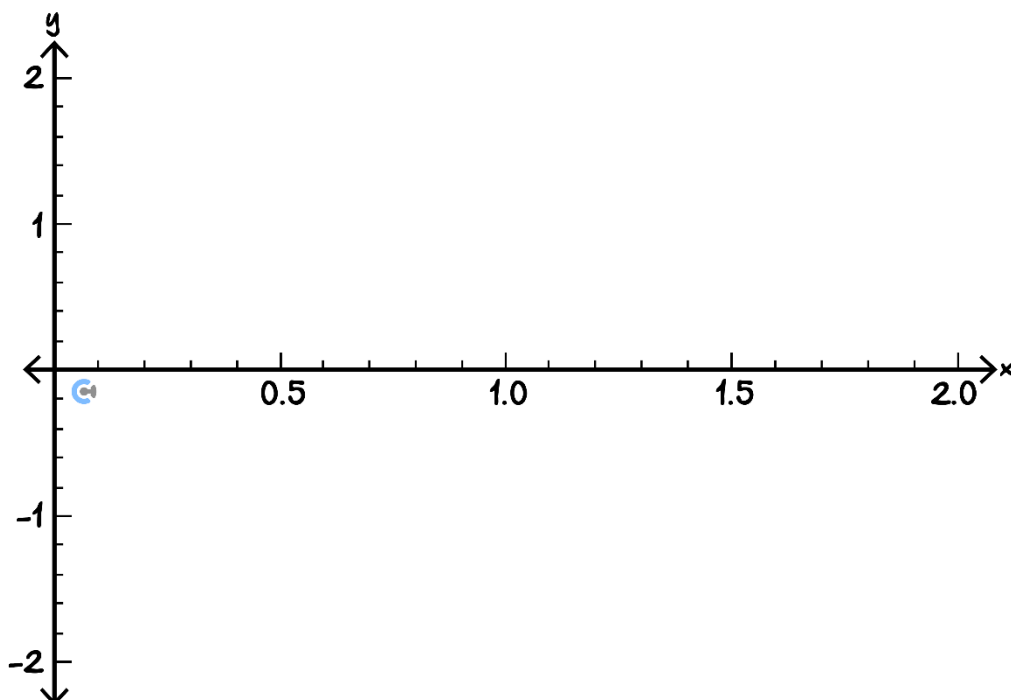
Calculator Commands: Solving Equations

➤ **TI-Nspire**

⊙ Menu→ 3 → 1

$$\text{solve}\left(x^2 - 4 \cdot x - 9 = 0, x\right)$$
$$x = -\left(\sqrt{13} - 2\right) \text{ or } x = \sqrt{13} + 2$$

➤ **Casio Classpad**

⊙ Action→Advanced→Solve

$$\text{solve}(x^2 - 4x - 9 = 0, x)$$
$$\{x = -\sqrt{13} + 2, x = \sqrt{13} + 2\}$$

In[122]:= **Solve[x^2 - 4 x - 9 == 0, x]**

Out[122]= $\left\{\left\{x \to 2 - \sqrt{13}\right\}, \left\{x \to 2 + \sqrt{13}\right\}\right\}$

Question 36 Tech-Active.

Solve $x^2 - 3x = 2x + 9$.

Calculator Commands: Finding the Angle between a Line and x-axis

➤ **Mathematica**

In[124]:= **ArcTan[2] / Degree // N**

Out[124]= 63.4349

➤ **TI-Nspire**

⊙ trig button. Check that you are in degrees.

$$\tan^{-1}(2) \qquad 63.4349$$

➤ **Casio Classpad**

⊙ Keyboard→Trig. Change to decimals and degrees.

$\tan^{-1}(2)$

63.43494882

Math1	Line	▦	√■	π	⇒
Math2	sin	cos	tan	i	∞
Math3	sin⁻¹	cos⁻¹	tan⁻¹	θ	t
Trig	sinh	cosh	tanh	°	ʳ
Var	sinh⁻¹	cosh⁻¹	tanh⁻¹	□■	
abc	←	🗐	🗐	ans	EXE
Alg	Decimal		Real	Deg	(▥)

Question 37 Tech-Active.

Find the angle between the line $y = 3x + 1$ and the positive x-axis.

Calculator Commands: Finding the Angle between Two Lines

➤ **Mathematica**	➤ **TI-Nspire**	➤ **Casio Classpad**
⊙ Use the Abs[] function.	⊙ Find the modulus sign.	⊙ Modulus sign under Math1.

Mathematica:

In[126]:= **Abs[ArcTan[2] – ArcTan[1]] / Degree // N**

Out[126]= 18.4349

TI-Nspire:
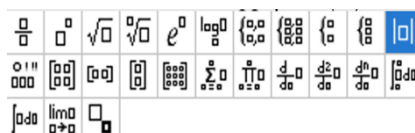
$|\tan^{-1}(2) - \tan^{-1}(1)|$ 18.4349

Casio Classpad:

$|\tan^{-1}(2) - \tan^{-1}(1)|$

18.43494882

Question 38 Tech-Active.

Find the angle between the lines $y = 3x - 2$ and $y = x + 1$.

Calculator Commands: Simultaneous Equations

Mathematica	TI-Nspire	Casio Classpad

➤ Mathematica

- ⊕ Just do && between

- ⊕ Solve[equation&&equation, {var1, var2}]

In[128]:= **Solve[2 x – 3 y = 16 && x + y = 3, {x, y}]**

Out[128]= {{x → 5, y → -2}}

➤ TI-Nspire

- ⊕ Menu 371

Solve a System of Equations

Number of equations: |2|

Variables: |x,y|

Enter variable names separated by commas

[OK]   [Cancel]

$$\text{solve}\left(\begin{cases} 2 \cdot x - 3 \cdot y = 16 \\ x + y = 3 \end{cases}, \{x, y\}\right) \qquad x=5 \text{ and } y=-2$$

➤ Casio Classpad

- ⊕ Math1 →click highlighted box→ enter equations and variables you are solving for

$$\begin{cases} 2x - 3y = 16 \\ x + y = 3 \end{cases} \bigg| x, y$$

$$\{x=5, y=-2\}$$

Math1	Line	▤	$\sqrt{\blacksquare}$	π	$\Rightarrow$
Math2	$\square^{\blacksquare}$	$e^{\blacksquare}$	ln	$\log_{\blacksquare}\square$	$\sqrt[\blacksquare]{\square}$
Math3	$|\blacksquare|$	x^2	x^{-1}	$\log_{10}(\blacksquare)$	solve(
Trig	$\blacksquare\square\square$	toDMS	$\{\blacksquare$	{ }	( )
Var					

Question 39 Tech-Active.

Solve simultaneous equations $2x + 3y = 5$ and $3x - y = 8$. (Give your answer correct to 2 decimal places.)

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Section E: Exam 2 Questions (21 Marks)

INSTRUCTION: 21 Marks. 5 Minutes Reading. 26 Minutes Writing.

Question 40 (1 mark)

The vertical distance between the function $f(x) = x^3 + 2$ and $g(x) = x - 2$ when $x = 1$ is:

A. 3

B. 4

C. 5

D. 6

Question 41 (1 mark)

It is known that the lines $y = mx + 4$ and $y = 2x - 2$ make an angle of 45° when they intersect. The possible values for m are:

A. $m = 3$ only.

B. $m = -\frac{1}{3}$ only.

C. $m = -3, \frac{1}{3}$

D. $m = -3, -\frac{1}{3}$

Question 42 (1 mark)

The angle that the line $y = -x + 4$ makes with the positive x-axis is:

A. 45°

B. 135°

C. 120°

D. 30°

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Question 43 (1 mark)

Solve the following simultaneous equations:

$$2x + 3y = 17$$
$$x - y = 1$$

A. $x = 2, y = 3$

B. $x = 4, y = 1$

C. $x = 4, y = 3$

D. $x = 3, y = 4$

Question 44 (1 mark)

The point $(2, k)$ has a vertical distance of 5 units from the line $y = 3x - 4$. A possible value of k is:

A. 6

B. 7

C. 8

D. 9

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Question 45 (16 marks)

Richard and David are playing volleyball. Richard stands at the point $A(2,1)$ and the middle of the net is at the point $B(4,7)$.

a. Find the equation of the line segment AB. (2 marks)

_____

_____

_____

_____

David stamds at the point Q such that B is the midpoint of the line segment AQ.

b.

    i. Find the coordinates of Q. (1 mark)

_____

_____

    ii. Find the distance between Richard and David. (1 mark)

_____

_____

c. The net runs perpendicular to the line segment AQ. Find the equation of the line that governs the net. (2 marks)

_____

_____

_____

_____

d. Hence, find the minimum distance between the line segment AB and the line $y = 3x + 4$. (3 marks)

_____

_____

_____

_____

_____

_____

e.

   i. Find the coordinates of the point C obtained from reflecting B in the line $y = 4$. (1 mark)

_____

_____

_____

   ii. Find the coordinates of the point D obtained from reflecting A in the line $x = 4$. (1 mark)

_____

_____

_____

f. Consider the triangle BAD.

   i. Find the area of the triangle BAD. (2 marks)

_____

_____

_____

_____

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ii. Find the angle ∠*ABD* correct to two decimal places. (3 marks)

_____

_____

_____

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Learning Objective: [1.1.1] – Solve and Graph Linear Equations and Inequalities

Key Takeaways

☐ Linear equations are in the form of $y = $ _____ where m is the _____ and c is the _____.

☐ The inequality sign _____ when you multiply by a negative.

Learning Objective: [1.1.2] – Find the Midpoint and Distance (Horizontal & Vertical) between Two Points or Functions

Key Takeaways

☐ Midpoint is simply the _____ of 2 points.

☐ Distance formula is derived from _____.

☐ Horizontal distance is the distance between ____ values.
.
☐ Vertical distance is the distance between _____ values.

Learning Objective: [1.1.3] – Find Parallel and Perpendicular Lines

Key Takeaways

☐ Parallel lines have the _____ gradient.

☐ Perpendicular lines have _____ gradient.

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Learning Objective: [1.1.4] – Find the Angle between a Line and x-axis or Two Lines

Key Takeaways

☐ To find the angle between a line and the x-axis, we can use equation $m =$ _____.

☐ To find the angle between two lines, we can use $\theta =$ _____ or

$\tan(\theta) =$ _____.

Learning Objective: [1.1.5] – Find the Unknown Value for Systems of Linear Equations

Key Takeaways

☐ Two linear equations have unique solutions if they have _____ gradients.

☐ Two linear equations have infinitely many solutions when they have _____ gradient and _____ constant.

☐ Two linear equations have no solution when they have _____ gradient and _____ constant.

Learning Objective: [1.2.1] – Applying Midpoint to Find Reflected Points

Key Takeaways

☐ The _____ changes for reflections about a horizontal line.

☐ The _____ changes for reflections about a vertical line.

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Learning Objective: [1.2.2] – Find the Vertical and Horizontal Distance between Functions

Key Takeaways

☐ The difference between two y-values is $f(x) = g(x)$ where f is _____ g.

Learning Objective: [1.2.3] – Finding the Distance between a Point and a Function

Key Takeaways

☐ A point on the function f is _____.

☐ The distance between a point (a, b) and a point on the function f is _____.

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