Grade 12 Calculus and Vectors Practice Final Exam with solutions

This document was composed and formatted by Annie Bernatchez.

The course material originated from www.jensenmath.ca

Practice Exam – Full Course

Instructions: There is a 3 hour maximum time limit for writing this exam. All questions are to be answered ON the exam paper.

Calculators are permitted. Use RADIAN mode for the Calculus portion and DEGREE mode for the Vectors portion.

Communicate your solutions clearly and **box all final answers**. Use exact values wherever possible. Round to 3 decimal places if you give an approximate answer.

Knowledge and Understanding	Application	Thinking	Communication
(30%)	(30%)	(20%)	(20%)

Sections	Points
Part 1: Derivatives and Applications	25
Part 2: Curve Sketching and Optimization	25
Part 3: Geometric and Algebraic Vectors	30
Part 4: Lines and Planes	20
Total	**/100**

Part 1: Derivatives and Applications [25]

1) Differentiate each of the following with respect to x. Fully simplify your answers. **[16]**

a) $y = 4x^3 - \frac{12}{x} + 71$

Rewrite $y = 4x^3 - 12x^{-1} + 71$

$y' = 12x^2 + 12x^{-2}$

$y' = 12x^2 + \frac{12}{x^2}$

b) $y = \frac{3x}{2x^2 + 4x - 1}$

Quotient rule, $u = 3x,\ v = 2x^2 + 4x - 1$:

$y' = \frac{3(2x^2 + 4x - 1) - 3x(4x + 4)}{(2x^2 + 4x - 1)^2}$

$y' = \frac{6x^2 + 12x - 3 - 12x^2 - 12x}{(2x^2 + 4x - 1)^2}$

$y' = \frac{-6x^2 - 3}{(2x^2 + 4x - 1)^2} = \frac{-3(2x^2 + 1)}{(2x^2 + 4x - 1)^2}$

c) $y = (x - 2)^3(x^2 + 9)^4$

Product rule, $u = (x - 2)^3,\ v = (x^2 + 9)^4$:

$y' = 3(x - 2)^2(x^2 + 9)^4 + (x - 2)^3 \cdot 8x(x^2 + 9)^3$

Factor out $(x - 2)^2(x^2 + 9)^3$:

$y' = (x - 2)^2(x^2 + 9)^3[3(x^2 + 9) + 8x(x - 2)]$

$y' = (x - 2)^2(x^2 + 9)^3(11x^2 - 16x + 27)$

d) $y = \sqrt{3x + 4}$

Chain rule, $y = (3x + 4)^{1/2}$:

$y' = \frac{1}{2}(3x + 4)^{-1/2} \cdot 3$

$y' = \frac{3}{2\sqrt{3x + 4}}$

e) $y = 2(6^x)$

Exponential rule:

$y' = 2(6^x)\ln 6$

f) $y = 3\tan x + 2$

$y' = 3\sec^2 x$

g) $f(x) = [\sin(2x)]e^{3x}$

Product rule, $u = \sin(2x),\ v = e^{3x}$:

$f'(x) = 2\cos(2x)e^{3x} + 3\sin(2x)e^{3x}$

$f'(x) = e^{3x}[2\cos(2x) + 3\sin(2x)]$

h) $f(x) = \cos^2(4x)$

Chain rule, $f(x) = [\cos(4x)]^2$:

$f'(x) = 2\cos(4x) \cdot [-\sin(4x)] \cdot 4 = -8\sin(4x)\cos(4x)$

Using $2\sin\theta\cos\theta = \sin(2\theta)$: $f'(x) = -4\sin(8x)$

Copyright © 2026 Annie Bernatchez—All rights reserved.

2) Determine the equation of the tangent to the curve $f(x) = \left(\frac{3x}{x-1}\right)^2$ at $x = -2$. **[3]**

Let $g(x) = \frac{3x}{x-1}$, so $f = g^2$ and $f' = 2gg'$.

$g'(x) = \frac{3(x-1) - 3x}{(x-1)^2} = \frac{-3}{(x-1)^2}$

$g(-2) = \frac{-6}{-3} = 2, \quad g'(-2) = \frac{-3}{9} = -\frac{1}{3}$

$f(-2) = 2^2 = 4$ (point $(-2, 4)$)

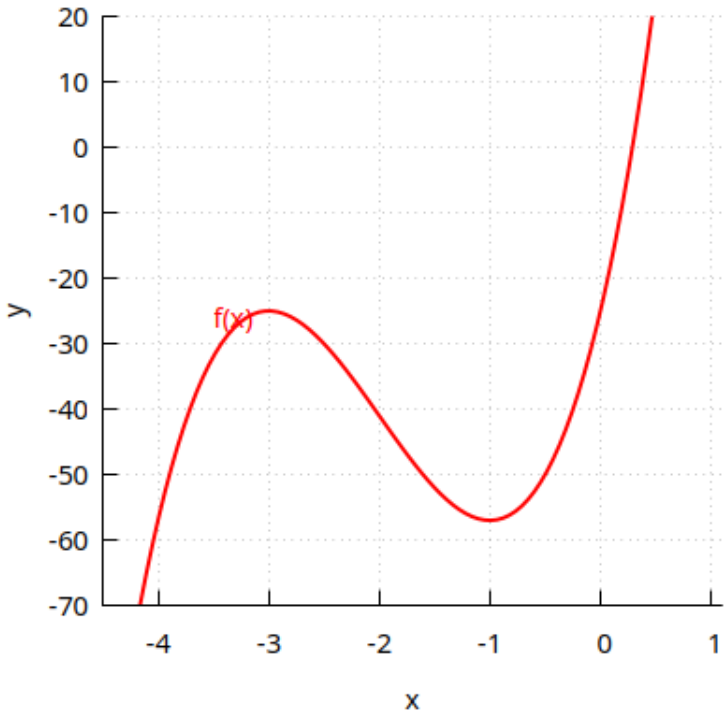
$f'(-2) = 2(2)\left(-\frac{1}{3}\right) = -\frac{4}{3}$

Point-slope: $y - 4 = -\frac{4}{3}(x+2)$

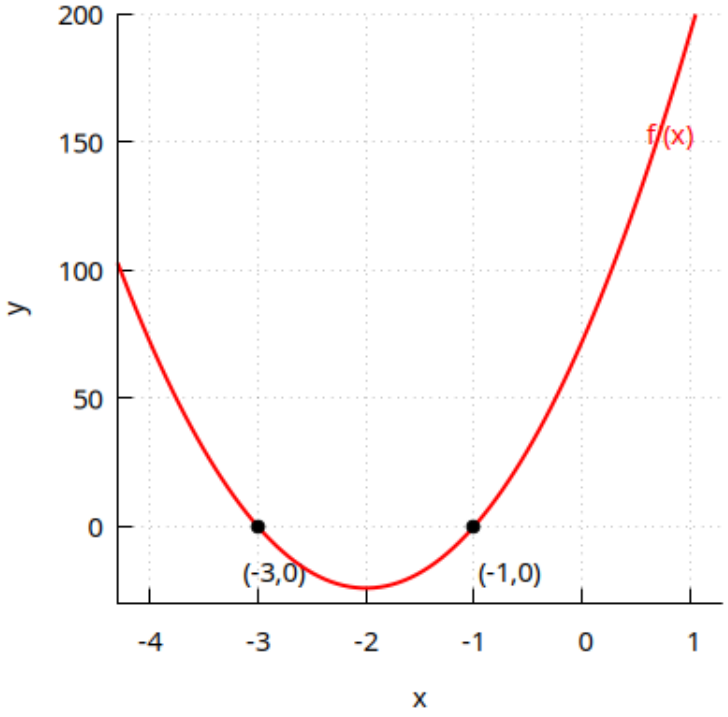
$y = -\frac{4}{3}x + \frac{4}{3}$

Copyright © 2026 Annie Bernatchez—All rights reserved.

3) Given the graph of $f(x)$, sketch a possible graph of $f'(x)$. **[1]**

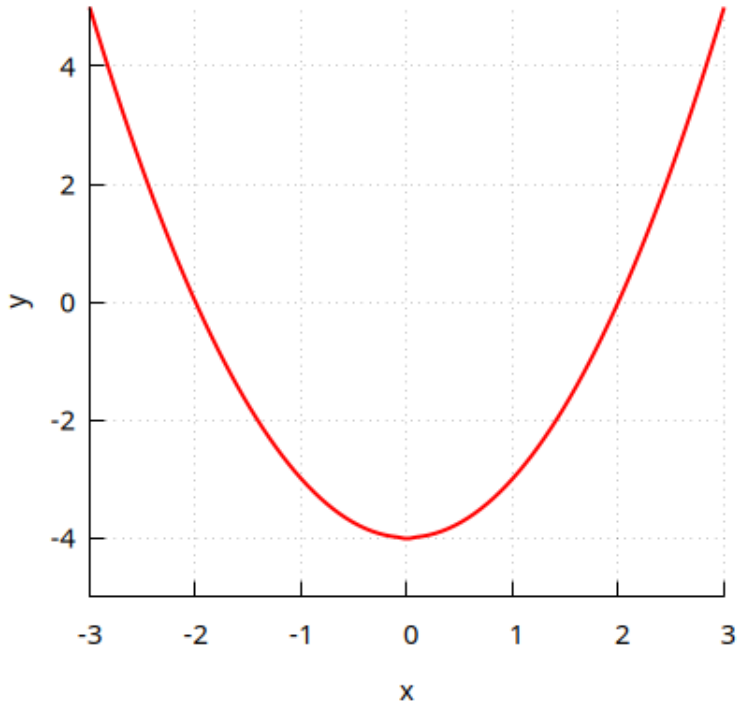


$f(x)$ has a local max near $x = -3$ and a local min near $x = -1$, so $f'(x)$ is a parabola (opening upward) that is zero at those two x-values, negative between them, and positive outside them.

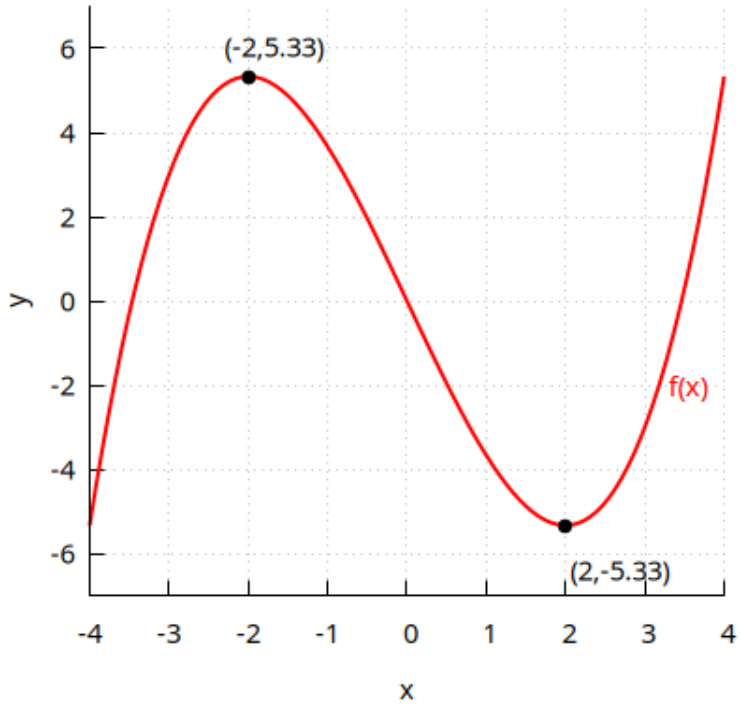


Copyright © 2026 Annie Bernatchez—All rights reserved.

4) Given the graph of $f'(x)$, sketch a possible graph of $f(x)$ **[1]**



$f'(x)$ is negative for $|x| < 2$ and positive for $|x| > 2$, so $f(x)$ decreases then increases with a local min at each of $x = \pm 2$. One possible antiderivative (choosing $C = 0$) is $f(x) = \frac{x^3}{3} - 4x$.



Copyright © 2026 Annie Bernatchez—All rights reserved.

5) Bob is on a diet. His original mass was 102 kg. His diet allows him to lose mass exponentially, so his mass is modelled by $W(t) = W_0e^{kt}$, where W_0 is his original mass, t is time in weeks, and k is a constant. After 3 weeks, his mass is 97 kg. **[4]**

a) Determine the value of k to five decimal places. $97 = 102e^{3k} \Rightarrow e^{3k} = \frac{97}{102}$ $3k = \ln\left(\frac{97}{102}\right) \Rightarrow k = \frac{1}{3}\ln\left(\frac{97}{102}\right)$ $k \approx -0.01675$	**b)** After 10 weeks, at what rate will his mass be changing? $W'(t) = W_0ke^{kt}$ $W'(10) = 102(-0.01675)e^{10(-0.01675)} \approx 102(-0.01675)(0.84575)$ $W'(10) \approx -1.446$ kg/week

Part 2: Curve Sketching and Optimization [25]

6) The function $f(x) = x^3 + bx^2 + c$ has a critical point at $(-2, 6)$ **[5]**

a) Find the constants b and c $f'(x) = 3x^2 + 2bx, \quad f'(-2) = 12 - 4b = 0 \Rightarrow b = 3$ $f(-2) = -8 + 4(3) + c = 6 \Rightarrow c = 2$ $b = 3,\ c = 2$ (so $f(x) = x^3 + 3x^2 + 2$)	**b)** Determine ALL of the critical points for $f(x)$ and classify them using the second derivative test. $f'(x) = 3x^2 + 6x = 3x(x+2) = 0 \Rightarrow x = 0, -2$ $f''(x) = 6x + 6$ $f''(-2) = -6 < 0 \Rightarrow$ local max at $(-2, 6)$ $f''(0) = 6 > 0 \Rightarrow$ local min at $(0, 2)$

7) For the function $y = x^3(2)^x$, find the critical point(s), and then use a derivative test to classify it/them as local max, local min, or neither. **[4]**

Product rule, $u = x^3,\ v = 2^x$:

$y' = 3x^2(2^x) + x^3(2^x)\ln 2 = x^2(2^x)(3 + x\ln 2)$

$y' = 0$ when $x = 0$ (double factor) or $x = -\frac{3}{\ln 2} \approx -4.328$

At $x = 0$: since $x^2 \geq 0$ never changes sign and $(3 + x\ln 2) > 0$ nearby, y' does not change sign across $x = 0$ – **neither** a max nor a min.

For $x < -4.328 : y' < 0; \quad$ for $-4.328 < x < 0 : y' > 0$

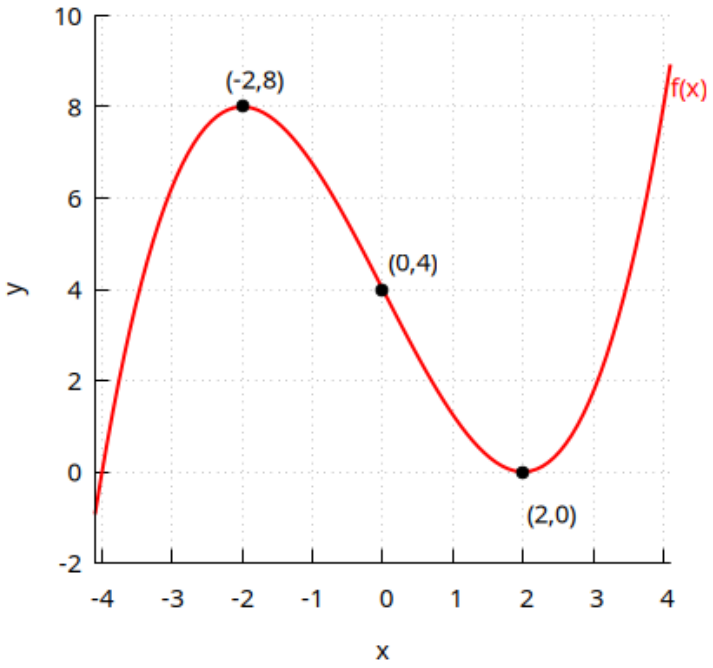
y' changes negative → positive, so $x \approx -4.328$ is a **local minimum**, with $y \approx (-4.328)^3(2^{-4.328}) \approx -4.038$.

Copyright © 2026 Annie Bernatchez—All rights reserved.

8) Sketch a continuous curve $f(x)$ with the following properties **[2]**

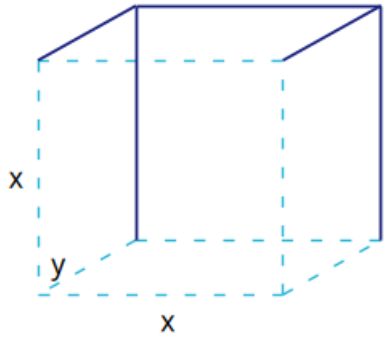
- $f(-2) = 8,\ \ f(0) = 4,\ \ f(2) = 0$
- $f'(2) = f'(-2) = 0$
- $f'(x) > 0$ for $x > 2$ or $x < -2$
- $f'(x) < 0$ for $-2 < x < 2$
- $f''(x) < 0$ for $x < 0$
- $f''(x) > 0$ for $x > 0$

Local max at $(-2, 8)$, local min at $(2, 0)$, point of inflection at $(0, 4)$. (One cubic matching every condition exactly is $f(x) = \frac{x^3}{4} - 3x + 4$.)



Copyright © 2026 Annie Bernatchez—All rights reserved.

9) A net enclosure for practising golf shots is open at one end, as shown. Find the dimensions that will minimize the amount of netting needed and give a volume of 144 m^3. Netting is required only on the sides, the top, and the far end (not the bottom or front). **[4]**



Netted area: two sides (xy each), the top (xy), and the far end (x^2):

$S = 3xy + x^2$

Volume constraint: $x^2y = 144 \Rightarrow y = \frac{144}{x^2}$

$S(x) = 3x\left(\frac{144}{x^2}\right) + x^2 = \frac{432}{x} + x^2$

$S'(x) = -\frac{432}{x^2} + 2x = 0 \Rightarrow 2x^3 = 432 \Rightarrow x^3 = 216 \Rightarrow x = 6$

$S''(x) = \frac{864}{x^3} + 2 > 0$ for $x > 0$, confirming a minimum.

$y = \frac{144}{6^2} = 4$

Dimensions: $x = 6$ m, $y = 4$ m (minimum netting $= 108$ m^2)

10) Use the algorithm for curve sketching to sketch the graph of $f(x) = x^3 + 6x^2 + 9x = x(x+3)^2$. Clearly label key points. **[10]**

1) Asymptotes or holes:

None – $f(x)$ is a polynomial.

2) Intercepts:	
x-int: $x(x+3)^2 = 0 \Rightarrow x = 0, -3$ y-int: $f(0) = 0$	

3) Critical points:	**4) Points of inflection:**
$f'(x) = 3x^2 + 12x + 9 = 3(x+1)(x+3) = 0 \Rightarrow x = -3, -1$ $f(-3) = 0,\ f(-1) = -1 + 6 - 9 = -4$ $f''(x) = 6x + 12;\ f''(-3) = -6 < 0$ (local max $(-3, 0)$); $f''(-1) = 6 > 0$ (local min $(-1, -4)$)	$f''(x) = 6x + 12 = 0 \Rightarrow x = -2$ $f(-2) = -8 + 24 - 18 = -2$ POI at $(-2, -2)$; concave down for $x < -2$, concave up for $x > -2$

5/6/7) Sign chart:

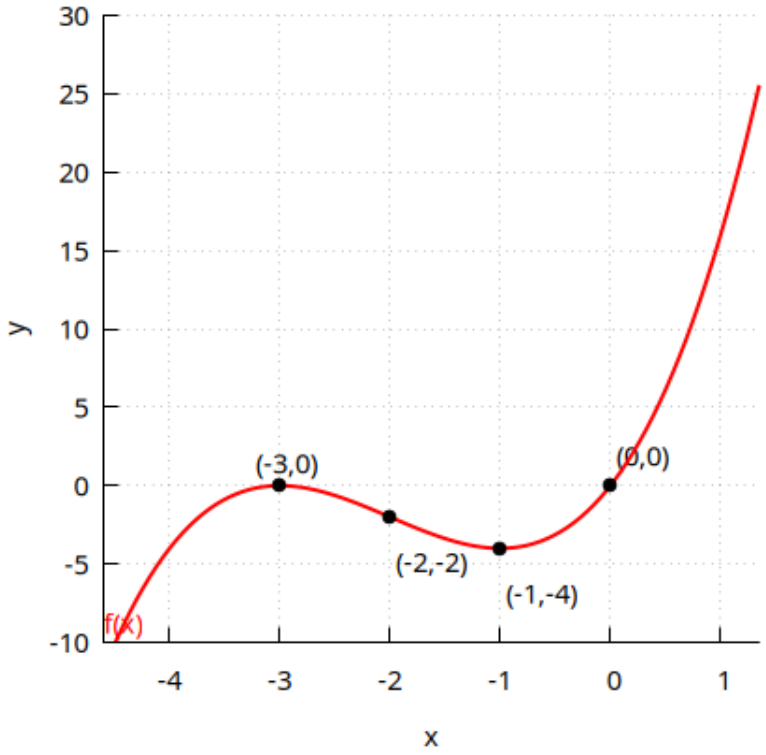
$f' > 0$ on $(-\infty, -3)$, $f' < 0$ on $(-3, -1)$, $f' > 0$ on $(-1, \infty)$

$f'' < 0$ on $(-\infty, -2)$, $f'' > 0$ on $(-2, \infty)$

Local max $(-3, 0)$, local min $(-1, -4)$, POI $(-2, -2)$

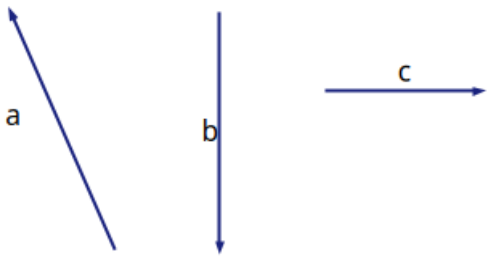
Copyright © 2026 Annie Bernatchez—All rights reserved.

8) Graph the function



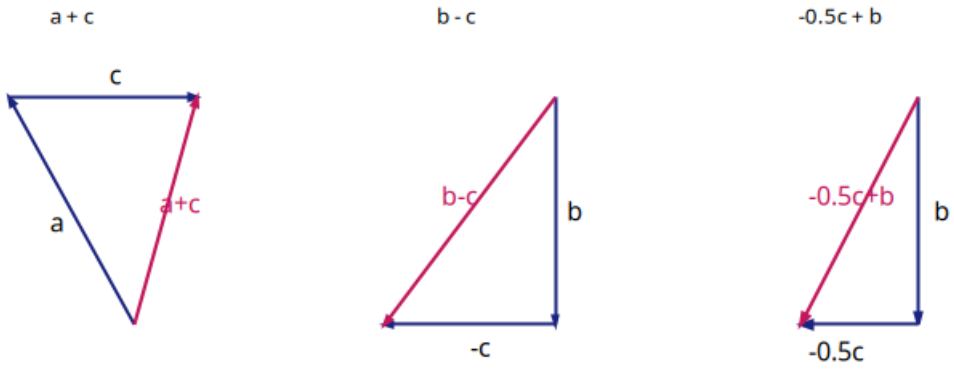
Part 3: Geometric and Algebraic Vectors [30]

11) Given vectors, sketch the following (illustrative values used below: $\vec{a} = [-2, 3]$, $\vec{b} = [0, -3]$, $\vec{c} = [3, 0]$) **[3]**

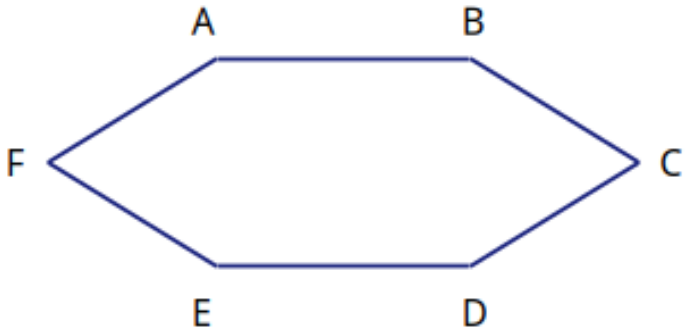


a) $\vec{a} + \vec{c}$ Tip-to-tail: $[-2, 3] + [3, 0] = [1, 3]$	**b)** $\vec{b} - \vec{c}$ $[0, -3] - [3, 0] = [-3, -3]$	**c)** $-0.5\vec{c} + \vec{b}$ $-1.5[1, 0] + [0, -3] = [-1.5, -3]$

Copyright © 2026 Annie Bernatchez—All rights reserved.



12) In hexagon ABCDEF, opposite sides are parallel and equal, and $\overrightarrow{FC} = 2\overrightarrow{AB}$. Let $\overrightarrow{AB} = \vec{u}$ and $\overrightarrow{FA} = \vec{v}$. Express each vector in terms of $\vec{u}$ and $\vec{v}$. **[4]**



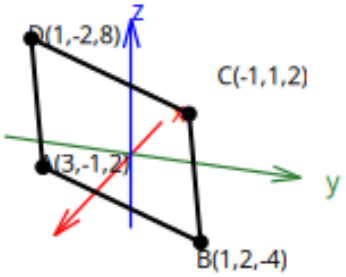
a) $\overrightarrow{CF}$ $\overrightarrow{CF} = -\overrightarrow{FC} = -2\vec{u}$	**b)** $\overrightarrow{FB}$ $\overrightarrow{FB} = \overrightarrow{FA} + \overrightarrow{AB} = \vec{u} + \vec{v}$
c) $\overrightarrow{BC}$ From $\overrightarrow{FC} = \overrightarrow{FA} + \overrightarrow{AB} + \overrightarrow{BC} \Rightarrow 2\vec{u} = \vec{v} + \vec{u} + \overrightarrow{BC} \Rightarrow \overrightarrow{BC} = \vec{u} - \vec{v}$	**d)** $\overrightarrow{DA}$ Opposite sides give $\overrightarrow{CD} = -\overrightarrow{FA} = -\vec{v}$, and $\overrightarrow{AD} = \overrightarrow{AB} + \overrightarrow{BC} + \overrightarrow{CD} = \vec{u} + (\vec{u} - \vec{v}) + (-\vec{v}) = 2\vec{u} - 2\vec{v}$, so $\overrightarrow{DA} = 2\vec{v} - 2\vec{u}$

13) Given vectors $\vec{a} = [4, -2, 1]$, $\vec{b} = [1, 5, 4]$, and $\vec{c} = [-1, -3, 0]$, calculate the following if possible. If not possible explain why. **[12]**

a) $\vec{b} - 2\vec{c}$ $[1, 5, 4] - 2[-1, -3, 0] = [1, 5, 4] - [-2, -6, 0]$ $= [3, 11, 4]$	**b)** $\lvert\text{proj}_{\vec{c}}\vec{b}\rvert$ $\vec{b} \cdot \vec{c} = (1)(-1) + (5)(-3) + (4)(0) = -16$ $\lvert\text{proj}_{\vec{c}}\vec{b}\rvert = \frac{\lvert\vec{b} \cdot \vec{c}\rvert}{\lvert\vec{c}\rvert} = \frac{16}{\sqrt{10}} \approx 5.060$
c) $\vec{a} \cdot \vec{c}$ $(4)(-1) + (-2)(-3) + (1)(0) = -4 + 6 + 0 = 2$	**d)** $(\vec{a})^2 + 4\vec{b}$ $(\vec{a})^2 = \vec{a} \cdot \vec{a} = \lvert\vec{a}\rvert^2 = 16 + 4 + 1 = 21$, a **scalar** – it cannot be added to the vector $4\vec{b}$, so this is **not possible**.
e) $\vec{a} \times \vec{c}$ $\vec{a} \times \vec{c} = [(-2)(0) - (1)(-3), (1)(-1) - (4)(0), (4)(-3) - (-2)(-1)]$ $= [3, -1, -14]$	**f)** Based on your previous answers, do $\vec{a}$ and $\vec{c}$ form a right angle? How do you know? **No** – from (c), $\vec{a} \cdot \vec{c} = 2 \neq 0$, so they are not perpendicular.

Copyright © 2026 Annie Bernatchez—All rights reserved.

14) Given the following parallelogram $A(3,\ -1,\ 2)$, $B(1,\ 2,\ -4)$, $C(-1,\ 1,\ 2)$, $D(1,\ -2,\ 8)$. **[6]**



a) calculate $|\overrightarrow{AB}|$

$\overrightarrow{AB} = [1-3,\ 2-(-1),\ -4-2] = [-2,\ 3,\ -6]$

$|\overrightarrow{AB}| = \sqrt{4+9+36} = \sqrt{49} = 7$

b) Find the area of the parallelogram.

$\overrightarrow{AD} = [1-3,\ -2-(-1),\ 8-2] = [-2,\ -1,\ 6]$

$\overrightarrow{AB}\times\overrightarrow{AD} = [3(6)-(-6)(-1),\ (-6)(-2)-(-2)(6),\ (-2)(-1)-3(-2)] = [12,\ 24,\ 8]$

Area $= |\overrightarrow{AB}\times\overrightarrow{AD}| = \sqrt{144+576+64} = \sqrt{784} = 28$ square units

c) Calculate the measure of angle A in degrees.

$\overrightarrow{AB}\cdot\overrightarrow{AD} = (-2)(-2)+3(-1)+(-6)(6) = 4-3-36 = -35$

$|\overrightarrow{AD}| = \sqrt{4+1+36} = \sqrt{41}$

$\cos A = \dfrac{-35}{7\sqrt{41}} = -\dfrac{5}{\sqrt{41}} \approx -0.78087$

$A \approx 141.343°$

15) A pilot flies on a heading of $N10°W$ with an airspeed of 260 km/h. Her actual ground velocity is 310 km/h at a bearing of $N20°E$. Find the magnitude and direction of the wind. **[3]**

Taking East as x and North as y: air velocity $\vec{v}_{air} = [-260\sin 10°,\ 260\cos 10°] \approx [-45.149,\ 256.050]$

$\vec{v}_{ground} = [310\sin 20°,\ 310\cos 20°] \approx [106.026,\ 291.305]$

Wind $= \vec{v}_{ground} - \vec{v}_{air} \approx [151.175,\ 35.255]$

$|\vec{v}_{wind}| \approx \sqrt{151.175^2 + 35.255^2} \approx 155.233$ km/h

Bearing $= \arctan\left(\dfrac{151.175}{35.255}\right) \approx 76.9°$ east of north

The wind is approximately **155.233 km/h at a bearing of** $N76.9°E$

16) Given that $|\vec{u}| = 10$ and $|\vec{v}| = 6$ and the angle between $\vec{u}$ and $\vec{v}$ is $40°$ determine an expression for a unit vector in the direction of $\vec{u}+\vec{v}$ **[2]**

Placing $\vec{u}$ along the positive x-axis: $\vec{u} = [10,\ 0]$, $\vec{v} = [6\cos 40°,\ 6\sin 40°]$

$\vec{u}+\vec{v} = [10+6\cos 40°,\ 6\sin 40°] \approx [14.596,\ 3.857]$

$|\vec{u}+\vec{v}| = \sqrt{|\vec{u}|^2+|\vec{v}|^2+2|\vec{u}||\vec{v}|\cos 40°} \approx 15.097$

Unit vector $\approx \dfrac{1}{15.097}[14.596,\ 3.857] \approx [0.967,\ 0.256]$

Copyright © 2026 Annie Bernatchez—All rights reserved.

Part 4: Lines and Planes [20]

17) Find the vector equation of each of the following lines **[4]**

a) the line passing through the points $P(2,\ 5,\ 4)$ and $Q(-3,\ 1,\ 5)$

$\vec{m} = \overrightarrow{PQ} = [-5,\ -4,\ 1]$

$[x,\ y,\ z] = [2,\ 5,\ 4] + t[-5,\ -4,\ 1]$

b) With the same x-intercept as $[x,\ y,\ z] = [3,\ 0,\ 0] + t[4,\ -4,\ 1]$ and the same z-intercept as $[x,\ y,\ z] = [6,\ -2,\ -3] + t[3,\ -1,\ 8]$

Line 1's x-intercept: set $y = 0 \Rightarrow t = 0$, giving $(3,\ 0,\ 0)$ (the given point itself).

Line 2's z-intercept: $x = 0 \Rightarrow 6 + 3t = 0 \Rightarrow t = -2;\ y = -2 - (-2) = 0$ ✓; $z = -3 + 8(-2) = -19$

New line through $(3,\ 0,\ 0)$ and $(0,\ 0,\ -19)$: $[x,\ y,\ z] = [3,\ 0,\ 0] + t[-3,\ 0,\ -19]$

18) Find the vector and scalar equation of each of the following planes **[4]**

a) the plane passing through the points $P(4,\ -2,\ 2)$, $Q(-1,\ 6,\ 8)$, and $R(-2,\ -2,\ 14)$.

$\overrightarrow{PQ} = [-5,\ 8,\ 6],\quad \overrightarrow{PR} = [-6,\ 0,\ 12]$

$[x,\ y,\ z] = [4,\ -2,\ 2] + s[-5,\ 8,\ 6] + t[-6,\ 0,\ 12]$

$\vec{n} = \overrightarrow{PQ} \times \overrightarrow{PR} = [96,\ 24,\ 48] = 24[4,\ 1,\ 2]$

$4x + y + 2z + D = 0,\ 4(4) - 2 + 2(2) + D = 0 \Rightarrow D = -18$

$4x + y + 2z - 18 = 0$

b) the plane parallel to the xy-plane and through the point $P(4,\ -2,\ 7)$.

$[x,\ y,\ z] = [4,\ -2,\ 7] + s[1,\ 0,\ 0] + t[0,\ 1,\ 0]$

$z - 7 = 0$

19) Solve the following systems of equations. If it is an inconsistent system, give proof and explain how you know.

a) $\ell_1 : [x,\ y,\ z] = [-2,\ 0,\ -3] + s[5,\ 1,\ 3]$, $\ell_2 : [x,\ y,\ z] = [5,\ 8,\ -6] + t[-1,\ 2,\ -3]$ **[4]**

$-2 + 5s = 5 - t,\quad s = 8 + 2t,\quad -3 + 3s = -6 - 3t$

From the first and third equations: $5s + t = 7$ and $s + t = -1$. Substituting $s = 8 + 2t$ into $s + t = -1$ gives $t = -3,\ s = 2$, which also satisfies $5s + t = 7$.

$x = -2 + 5(2) = 8,\ y = 0 + 2 = 2,\ z = -3 + 3(2) = 3$

The lines **intersect** (consistent system) at $(8,\ 2,\ 3)$.

b) $\pi_1 : x - 5y + 2z - 10 = 0$, $\pi_2 : x + 7y - 2z + 6 = 0$, $\pi_3 : 8x + 5y + z - 20 = 0$ **[4]**

$\pi_1 : x = 10 + 5y - 2z;$ sub into $\pi_2 \Rightarrow 12y - 4z + 16 = 0 \Rightarrow z = 3y + 4$

sub both into $\pi_3 \Rightarrow 60 + 45y - 15z = 0 \Rightarrow z = 3y + 4$ (identical to the relation above)

π_3 is dependent on π_1, π_2 – the three planes share a **line of intersection**, not a single point.

Let $y = t:\ z = 3t + 4,\ x = 10 + 5t - 2(3t + 4) = 2 - t$

Line of intersection: $[x,\ y,\ z] = [2,\ 0,\ 4] + t[-1,\ 1,\ 3]$ (this is a **consistent** system)

20) Find the distance between the point $P(7,\ -3,\ 2)$, and the plane $2x + 4y - 3z - 9 = 0$. **[4]**

$$d = \frac{|2(7) + 4(-3) - 3(2) - 9|}{\sqrt{2^2 + 4^2 + (-3)^2}} = \frac{|-13|}{\sqrt{29}}$$

$d = \frac{13}{\sqrt{29}} \approx 2.414$ units

Answer Key

1)a) $12x^2 + \frac{12}{x^2}$ **b)** $\frac{-3(2x^2+1)}{(2x^2+4x-1)^2}$ **c)** $(x-2)^2(x^2+9)^3(11x^2-16x+27)$ **d)** $\frac{3}{2\sqrt{3x+4}}$ **e)** $2(6^x)\ln 6$ **f)** $3\sec^2 x$ **g)** $e^{3x}[2\cos(2x) + 3\sin(2x)]$ **h)**

Copyright © 2026 Annie Bernatchez—All rights reserved.

$-4\sin(8x)$ **2)** $y = -\frac{4}{3}x + \frac{4}{3}$ **3)** parabola through $(-3, 0)$ and $(-1, 0)$ **4)** cubic-shaped curve with local extrema at $x = \pm 2$ **5)a)** $k \approx -0.01675$ **b)** ≈ -1.446 kg/week **6)a)** $b = 3$, $c = 2$ **b)** local max $(-2, 6)$, local min $(0, 2)$ **7)** $x = 0$ neither; $x \approx -4.328$ local min **8)** local max $(-2, 8)$, inflection $(0, 4)$, local min $(2, 0)$ **9)** $x = 6$ m, $y = 4$ m **10)** local max $(-3, 0)$, POI $(-2, -2)$, local min $(-1, -4)$, intercepts $(0, 0)$, $(-3, 0)$ **11)a)** $[1, 3]$ **b)** $[-3, -3]$ **c)** $[-1.5, -3]$ **12)a)** $-2\vec{u}$ **b)** $\vec{u} + \vec{v}$ **c)** $\vec{u} - \vec{v}$ **d)** $2\vec{v} - 2\vec{u}$ **13)a)** $[3, 11, 4]$ **b)** ≈ 5.060 **c)** 2 **d)** not possible (scalar + vector) **e)** $[3, -1, -14]$ **f)** no **14)a)** 7 **b)** 28 square units **c)** $\approx 141.343°$ **15)** ≈ 155.233 km/h at $N76.9°E$ **16)** $\approx [0.967, 0.256]$ **17)a)** $[x, y, z] = [2, 5, 4] + t[-5, -4, 1]$ **b)** $[x, y, z] = [3, 0, 0] + t[-3, 0, -19]$ **18)a)** $4x + y + 2z - 18 = 0$ **b)** $z - 7 = 0$ **19)a)** intersect at $(8, 2, 3)$ **b)** line of intersection $[x, y, z] = [2, 0, 4] + t[-1, 1, 3]$ **20)** $\frac{13}{\sqrt{29}} \approx 2.414$ units

Copyright © 2026 Annie Bernatchez—All rights reserved.