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Chapter 3 Review

For each type of question, the achievement level is indicated. Showing work is an important strategy in communicating your knowledge and ideas so please be thorough.

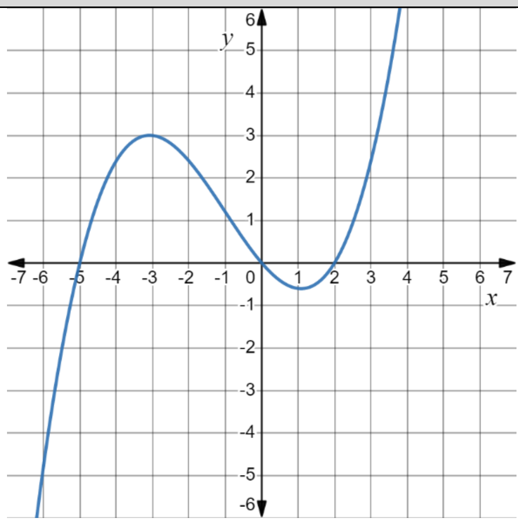
Learning Goal 3.1	Graphing and the characteristics of a graph (ex. Degree, extrema, zeros, end – behaviour)

1. Use the partial graph of the polynomial to determine the following information.

- Polynomial Type
- End Behaviour
- Domain
- Range
- Number of $x-$ intercepts
- Value(s) of $x-$ intercepts
- $y-$ intercept
- Max/Min values

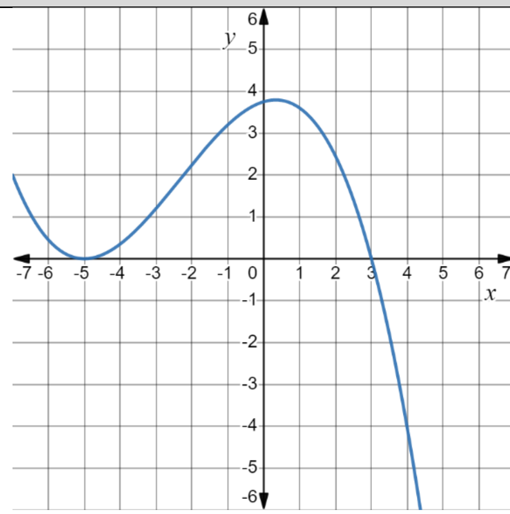
Developing

a.



Type	Cubic/Degree 3
End Behaviour	$\lim_{x\to-\infty} P(x) = -\infty$ $\lim_{x\to\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y \in \mathbb{R}\}$
# of $x-$ int.	3
Values	$x = -5, 0, 2$
$y-$ int	$y = 0$
Max/Min	Global/Absolute: $y = \pm\infty$ Local Max: $y = 3$ Local Min: $y \approx -0.5$

b.



Type	Cubic/Degree 3
End Behaviour	$\lim_{x\to-\infty} P(x) = \infty$ $\lim_{x\to\infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y \in \mathbb{R}\}$
# of $x-$ int.	2
Values	$x = -5, 3$
$y-$ int	$y \approx 3.6$
Max/Min	Global/Absolute: $y = \pm\infty$ Local Max: $y \approx 3.8$ Local Min: $y = 0$

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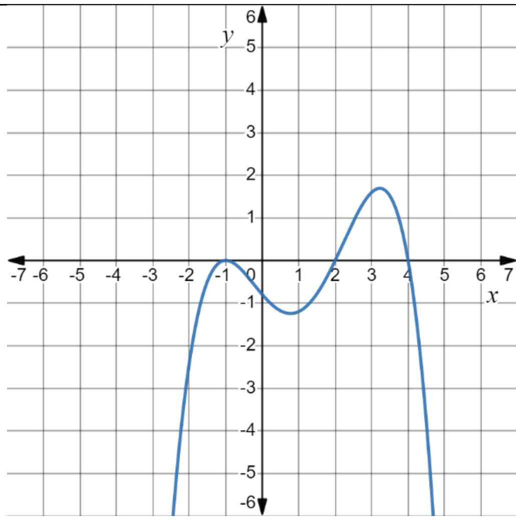
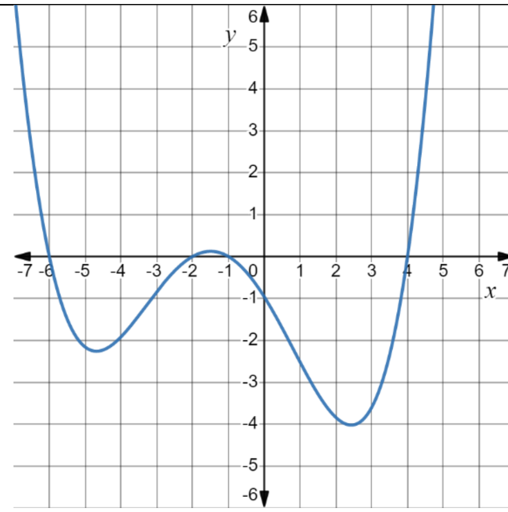
c.



Type	Quadric/Degree 4
End Behaviour	$\lim_{x \to \pm\infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y < 1.6, y \in \mathbb{R}\}$
# of $x -$ int.	3
Values	$x = -1, 2, 4$
$y -$ int	$y \approx -1.7$
Max/Min	Global/Absolute Min: $y = -\infty$ Global/Absolute Max: $y \approx 1.6$ Local Max: $y = 0$ Local Min: $y \approx -1.3$

d.



Type	Quadric/Degree 4
End Behaviour	$\lim_{x \to \pm\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y > -4, y \in \mathbb{R}\}$
# of $x -$ int.	4
Values	$x = -6, -2, -1, 4$
$y -$ int	$y = -1$
Max/Min	Global/Absolute Max: $y = \infty$ Global/Absolute Min: $y = -4$ Local Max: $y \approx 0.1$ Local Min: $y \approx -2.3$

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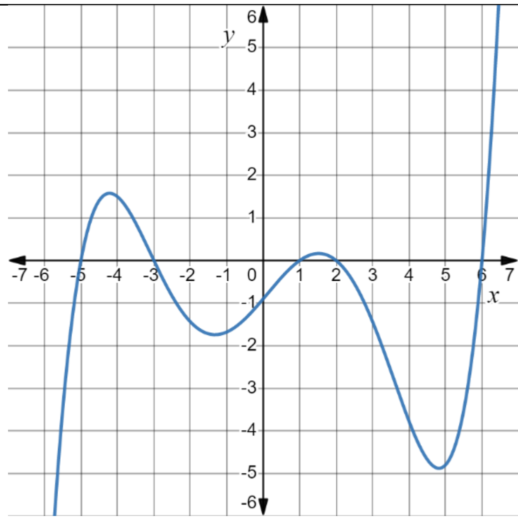
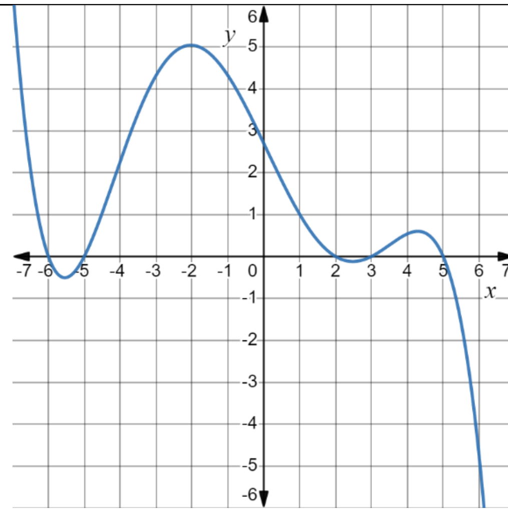
e.



Type	Qunitic/Degree 5
End Behaviour	$\lim_{x\to-\infty} P(x) = -\infty$ $\lim_{x\to\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y \in \mathbb{R}\}$
# of $x -$ int.	5
Values	$x = -5, -3, 1, 2, 6$
$y -$ int	$y = -1$
Max/Min	Global/Absolute: $y = \pm\infty$ Local Max: $y \approx 0.2, 1.5$ Local Min: $y \approx -1.7, -4.9$

f.



Type	Qunitic/Degree 5
End Behaviour	$\lim_{x\to-\infty} P(x) = \infty$ $\lim_{x\to\infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
Range	$\{y \mid y \in \mathbb{R}\}$
# of $x -$ int.	5
Values	$x = -6, -5, 2, 3, 5$
$y -$ int	$y \approx 2.6$
Max/Min	Global/Absolute: $y = \pm\infty$ Local Max: $y \approx 0.5, 5$ Local Min: $y \approx -0.1 - 0.5$

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2. Using the equation of the polynomial, determine the following information.

- Polynomial Type
- End Behaviour
- $y -$ intercept
- Domain
- Number of $x -$ intercepts

Proficient

a. $P(x) = x^2 - 6x - 8$

Type	Quadratic/Degree 2
End Behaviour	$\lim_{x \to \pm\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$0, 1,$ or 2
$y -$ int	$y = -8$

b. $P(x) = -3x + x^2 + 5$

Type	Quadratic/Degree 2
End Behaviour	$\lim_{x \to \pm\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$0, 1,$ or 2
$y -$ int	$y = 5$

c. $P(x) = -x^3 + 2x^2 - 10x$

Type	Cubic/Degree 3
End Behaviour	$\lim_{x \to -\infty} P(x) = \infty$ $\lim_{x \to \infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$1, 2$ or 3
$y -$ int	$y = 0$

d. $P(x) = 2x + 5x^3 - 7 + 12x^2$

Type	Cubic/Degree 3
End Behaviour	$\lim_{x \to -\infty} P(x) = -\infty$ $\lim_{x \to \infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$1, 2$ or 3
$y -$ int	$y = -7$

Extending

e. $P(x) = 6x^4 - 3x^3 - 2x^2 + 12x - 1$

Type	Quadric/Degree 4
End Behaviour	$\lim_{x \to \pm\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$0, 1, 2, 3$ or 4
$y -$ int	$y = -1$

f. $P(x) = x^3 - 4x^2 - 5x^4 + 12 - 2x$

Type	Quadric/Degree 4
End Behaviour	$\lim_{x \to \pm\infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$0, 1, 2, 3$ or 4
$y -$ int	$y = 12$

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g. $P(x) = 6x^5 - 7x^3 - x - 9$

Type	Quintic/Degree 5
End Behaviour	$\lim_{x\to-\infty} P(x) = \infty$ $\lim_{x\to\infty} P(x) = -\infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$1, 2, 3, 4$ or 5
$y -$ int	$y = 9$

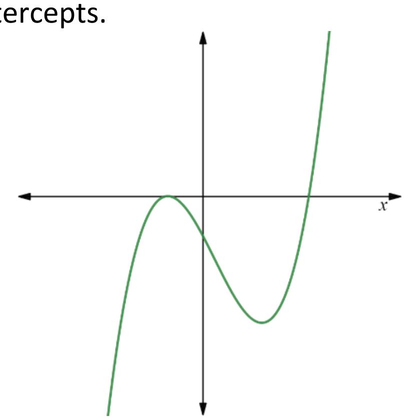
h. $P(x) = x^3 - x^4 - x^5$

Type	Quintic/Degree 5
End Behaviour	$\lim_{x\to-\infty} P(x) = -\infty$ $\lim_{x\to\infty} P(x) = \infty$
Domain	$\{x \mid x \in \mathbb{R}\}$
# of $x -$ int.	$1, 2, 3, 4$ or 5
$y -$ int	$y = 0$

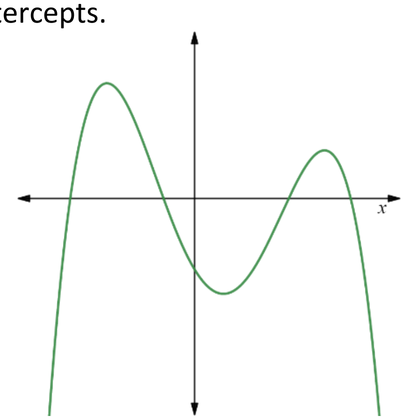
3. On a grid, sketch a polynomial function with the following characteristics.

Extending

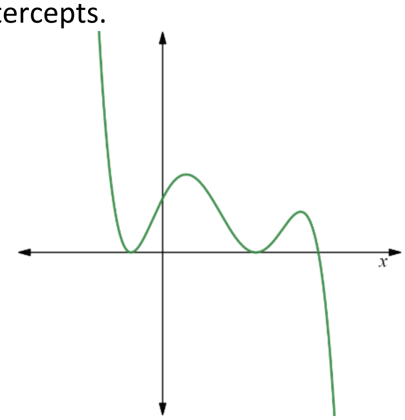
a. A polynomial function with degree 3, a positive leading coefficient and 2 $x -$ intercepts.



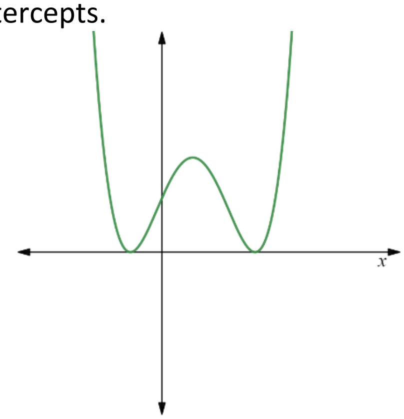
b. A polynomial function with degree 4, a negative leading coefficient, and 4 $x -$ intercepts.



a. A polynomial function with degree 5, a negative leading coefficient and 3 $x -$ intercepts.



b. A polynomial function with degree 4, a positive leading coefficient, and 2 $x -$ intercepts.



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Chapter 3 Review

Extending		
4. A skateboard manufacturer determines that it's profit P, in dollars, can be modelled by the function $P(x) = 1000x + 1.25x^4 - 3200$, where x represents the number, in hundreds, of skateboards sold. a. What is the degree of the function $P(x)$? b. What are the leading coefficient and the constant of this function? What does the constant represent in this context? c. Describe the end behaviour of the graph of this function. d. What are the restrictions on the domain of this function? Explain how you determined those restrictions. e. What do the $x -$ intercept(s) of the graph represent in this context? f. What is the profit from the sale of 1200 skateboards?		
a. four	b. $1.25/-3200$	c. $\lim_{x \to \pm\infty} P(x) = \infty$
d. $\{x \mid x > 0, x \in \mathbb{R}\}$	e. When the company breaks even.	f. none.
5. By analyzing the effect of growing economic conditions, the predicted population P of a town in t years from now can be modelled by the function $P(t) = 6t^4 - 6t^3 + 200t + 1\,200$. Assume this model can be used for the next 15 years. a. What are the key features of the graph of the function? b. What is the current population of this town? c. What will be the population 10 years from now? d. When will the population of the town be approximately 175 000?		
a.	b. 1 200	c. 57 200
d. $t \approx 13$ years		

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Chapter 3 Review

For each type of question, the achievement level is indicated. Showing work is an important strategy in communicating your knowledge and ideas so please be thorough.

Learning Goal 3.2	Factoring, including the factor theorem and the remainder theorem.

1. Use long division or synthetic division to find a division statement for the following problems. Verify the remainder using the remainder theorem. Identify any restrictions on the variable.

Developing	
a. $x^4 + 3x^3 - x^2 - 2x + 1$ by $x + 2$ $= (x + 2)(x^3 + x^2 - 3x + 4) - 7$ $x \neq -2$	b. $P(x) = 2x + 5x^3 - 7 + 12x^2$ by $x + 1$ $= (x \mp 1)(5x^2 + 7x - 5) - 2$ $x \neq -1$
c. $2x^3 - 3x^2 + 9x - 12$ by $x - 4$ $= (x - 4)(2x^2 + 5x + 29) + 104$ $x \neq 4$	d. $3x^4 - 2x^3 + 5x^2 - 7x + 10$ by $x - 5$ $= (x - 5)(3x^3 + 13x^2 + 70x + 443) + 2225$ $x \neq 5$
e. $2x^3 + x^2 - 27x - 36$ by $x - 1$ $= (x - 1)(2x^2 + 3x - 24) - 50$ $x \neq 1$	f. $3x^4 - 2x^3 + 5x^2 - 7x + 10$ by $x + 2$ $= (x + 2)(3x^3 - 8x^2 + 21x - 49) + 109$ $x \neq -2$
g. $2x^3 + x^2 - 27x - 36$ by $x + 1$ $= (x + 1)(2x^2 + x - 28) - 8$ $x \neq -1$	h. $4x^4 - 10x^3 + 13x^2 - 2x + 15$ by $x + 2$ $= (x + 2)(4x^3 - 18x^2 + 49x - 100) + 215$ $x \neq -2$
Proficient	
i. $P(x) = -x^3 + 2x^2 - 10x$ by $x - 3$ $= (x - 3)(-x^2 - x - 13) - 39$ $x \neq 3$	j. $9x + 4x^3 - 12$ by $x - 2$ $= (x - 2)(4x^2 + 8x + 25) + 38$ $x \neq 2$
k. $P(x) = -x^4 + 2x^2 - 10x$ by $x - 3$ $= (x - 3)(-x^3 - 3x^2 - 7x - 31) - 93$ $x \neq 3$	l. $x^3 - x^4 + x^2 - x + 1$ by $x - 1$ $= (x - 1)(x - x^3) + 1$ $x \neq 1$
m. $3x^4 - x^3 - 5$ by $x - 3$ $= (x - 3)(3x^3 + 8x^2 + 24x + 72) + 221$ $x \neq 3$	n. $x^3 - x - 10$ by $x + 4$ $= (x + 4)(x^2 - 4x + 15) - 70$ $x \neq -4$

2. For each dividend, determine the value of k if the remainder is -2.

Developing	
a. $(2x^3 - 5x^2 - 4x + k) \div (x + 1)$ $k = 1$	b. $(x^3 - 4x^2 + kx + 10) \div (x - 3)$ $k = -1$
c. $(3x^3 + kx^2 - 13x + 4) \div (x + 2)$ $k = -2$	d. $(kx^3 - 4x^2 - 5x + 8) \div (x - 2)$ $k = 2$

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Proficient
3. For what value of m will the polynomial $P(x) = x^3 + 6x^2 + mx - 4$ have the same remainder when it is divided by $x - 1$ and $x + 2$? $m = 3$
4. Given that $x + 3$ is a factor of the polynomial $P(x) = x^4 + 3x^3 + cx^2 - 7x + 6$, determine the value of c. $c = -3$
5. Determine the value of k so that $x + 3$ is a factor of $x^3 + 4x^2 - 2kx + 3$ $k = -2$
6. For what value of b will the polynomial $P(x) = 4x^3 - 3x^2 + bx + 6$ have the same remainder when it is divided by both $x - 1$ and $x + 3$? $b = -34$

7. State all possible integer factors of the following polynomials, then factor fully.

Proficient	
a. $x^3 - 4x^2 + x + 6$ $\pm1, \pm2, \pm3, \pm6$ $= (x-2)(x-3)(x+1)$	b. $-4x^3 - 4x^2 + 16x + 16$ $\pm1, \pm2, \pm4, \pm8, \pm16$ $= -4(x-2)(x+2)(x+1)$
c. $x^3 + 4x^2 + 5x + 2$ $\pm1, \pm2$ $= (x+2)(x+1)^2$	d. $x^3 - 13x^2 + 12$ $\pm1, \pm2, \pm3, \pm4, \pm6, \pm12$ $= (x-1)(x^2 - 12x - 12)$
e. $-x^3 + 6x^2 - 9x$ $\pm1, \pm3, \pm9$ $= -x(x-3)^2$	f. $x^3 - 3x^2 + x + 5$ $\pm1, \pm5$ $= (x+1)(x^2 - 4x + 5)$
g. $x^3 + 3x^2 - 10x - 24$ $\pm1, \pm2, \pm3, \pm4, \pm6, \pm8, \pm12, \pm24$ $= (x-3)(x+2)(x+4)$	h. $x^3 - 21x + 20$ $\pm1, \pm2, \pm4, \pm5, \pm10, \pm20$ $= (x+5)(x-1)(x-4)$
i. $x^3 - 7x - 6$ $\pm1, \pm2, \pm3, \pm6$ $= (x-3)(x+2)(x+1)$	j. $x^3 - x^2 - 4x + 4$ $\pm1, \pm2, \pm4$ $= (x-2)(x+2)\ (x-1)$
k. $x^3 - 2x^2 - 4x + 8$ $\pm1, \pm2, \pm4, \pm8$ $= (x-2)^2(x+2)$	l. $x^3 + 3x^2 + 3x + 1$ ±1 $= (x+1)^3$
m. $x^3 + 2x^2 - 9x - 18$ $\pm1, \pm2, \pm3, \pm6, \pm9, \pm18$ $(x+2)(x-3)(x+3)$	n. $4x^3 - 8x^2 + x + 3$ $\pm1, \pm3$ $= (x-1)(2x+1)(2x-3)$
o. $6x^3 + x^2 - 31x + 10$ $\pm1, \pm2, \pm5, \pm10$ $= (x-2)(2x+5)(3x-1)$	p. $3x^3 - 5x^2 - 26x - 8$ $\pm1, \pm2, \pm4, \pm8$ $= (x-4)(x+2)(3x+1)$

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q. Extending	
r. $x^4 - 4x^3 - x^2 + 16x - 12$ $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12$ $(x-1)(x-2)(x-3)(x+2)$	s. $x^5 - 3x^4 - 5x^3 + 27x^2 - 32x + 12$ $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12$ $= (x+3)(x-1)^2(x-2)^2$
t. $-x^4 + 8x^2 - 16$ $\pm 1, \pm 2, \pm 4, \pm 8, \pm 16$ $= -(x-2)^2(x+2)^2$	u. $x^4 + 2x^3 - x - 2$ $\pm 1, \pm 2$ $= (x-1)(x+2)(x^2+x+1)$
v. $x^4 + x^3 - 13x^2 - 25x - 12$ $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12$ $= (x+1)^2(x+3)(x-4)$	w. $5x^4 + 12x^3 - 101x^2 + 48x + 36$ $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 9, \pm 12, \pm 18, \pm 36$ $= (x-3)(x-1)(x+6)(5x+2)$
x. $2x^4 + 5x^3 - 8x^2 - 20x$ 0 $= x(x-2)(x+2)(2x+5)$	y. $x^5 + 2x^4 - 11x^3 - 40x^2 - 44x - 16$ $\pm 1, \pm 2, \pm 4, \pm 8, \pm 16$ $= (x+1)^2(x-4)(x+2)^2$

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Chapter 3 Review

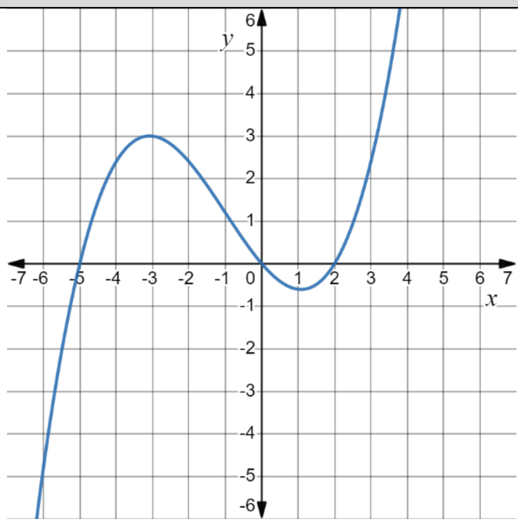
For each type of question, the achievement level is indicated. Showing work is an important strategy in communicating your knowledge and ideas so please be thorough.

Learning Goal 3.3	Solving equations algebraically and graphically.

1. For each graph, state the $x-$ intercepts, the interval(s) where the function is positive and negative and the multiplicity of each zero.

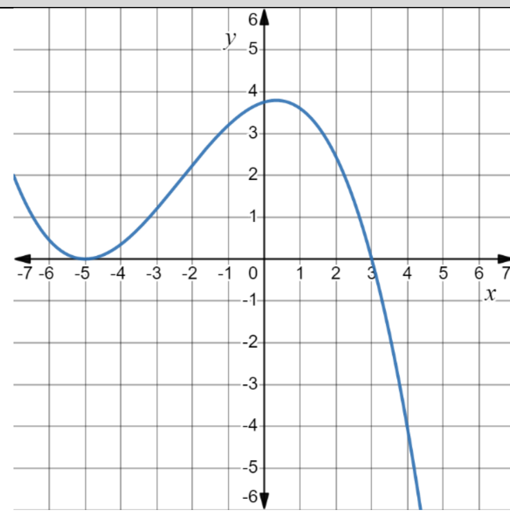
Developing

a.



$x-$ int	$x=-5,0,2$
+ve interval(s)	$\{x\mid -5<x<0, x>2, x\in\mathbb{R}\}$
−ve interval(s)	$\{x\mid -5>x, 0<\ x<2, x\in\mathbb{R}\}$
Multiplicity	all are 1

b.



$x-$ int	$x=-5,3$
+ve interval(s)	$\{x\mid x<3, x\in\mathbb{R}\}$
−ve interval(s)	$\{x\mid x>3, x\in\mathbb{R}\}$
Multiplicity	$x=-5$ has multiplicity 2 (even) $x=3$ has multiplicity 1

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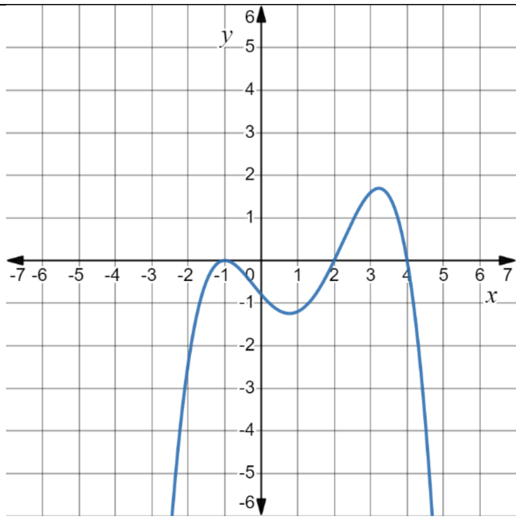
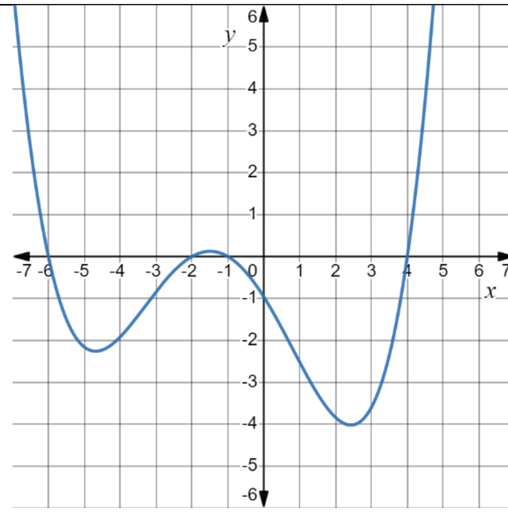
c.



$x -$ int	$x = -1, 2, 4$
+ve interval(s)	$\{x \mid 2 < x < 4, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < 2, x > 4, x \in \mathbb{R}\}$
Multiplicity	$x = -1$ has multiplicity 2 (even) $x = 2$ has multiplicity 1 $x = 4$ has multiplicity 1

d.



$x -$ int	$x = -6, -2, -1, 4$
+ve interval(s)	$\{x \mid x < -6, -2 < x < -1,$ $x > 4, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -6 < x < -2,$ $-2 < x < 4, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.

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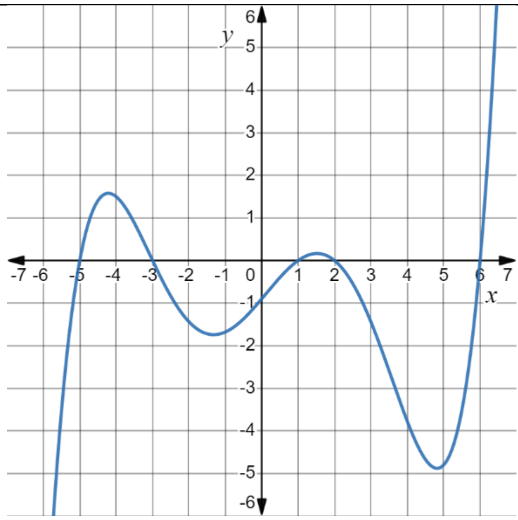
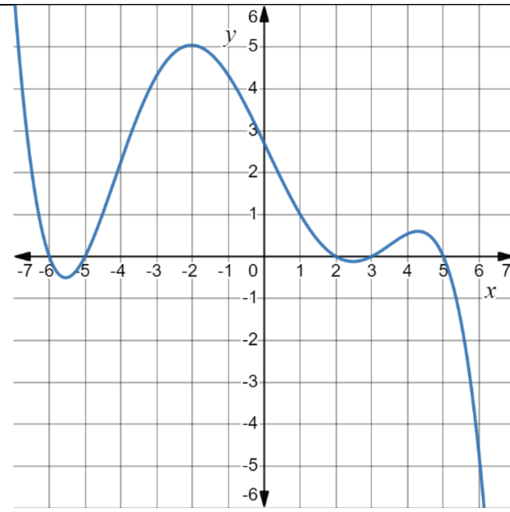
e.



$x -$ int	$x = -5, -3, 1, 2, 6$
+ve interval(s)	$\{x \mid -5 < x < -3, x < x < 2,$ $x > 6, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -3 < x < 1, 2 < x < 6,$ $x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.

f.



$x -$ int	$x = -6, -5, 2,3, 5$
+ve interval(s)	$\{x \mid x < -6, -5 < x < 2,$ $3 < x < 5, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -6 < x < -5, 2 < x < 3,$ $x > 5, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.

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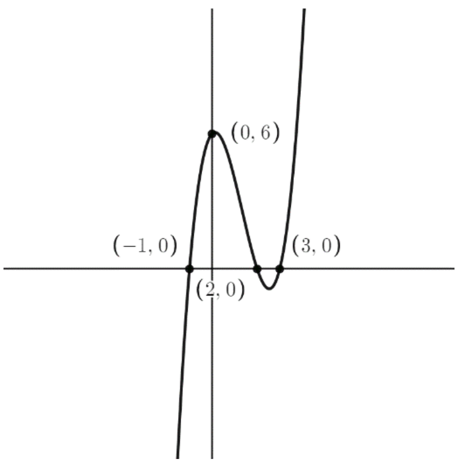
Chapter 3 Review

2. For each equation, state the $x -$ intercepts, the interval(s) where the function is positive and negative and the multiplicity of each zero. Sketch a graph.

Proficient

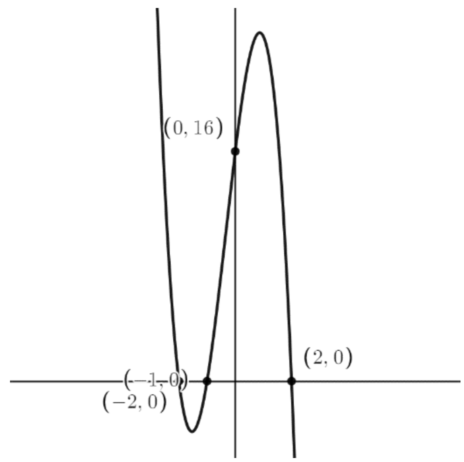
a. $x^3 - 4x^2 + x + 6$
$= (x-2)(x-3)(x+1)$

$x -$ int	$x = 2, 3, -1$
+ve interval(s)	$\{x \mid x - 1 < x < 2, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -1, 2 < x < 3,$ $x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



b. $-4x^3 - 4x^2 + 16x + 16$
$= -4(x-2)(x+2)(x+1)$

$x -$ int	$x = -2, -1, 2$
+ve interval(s)	$\{x \mid x < -2, -1 < x < 2, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -2 < x < -1, x > 2, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



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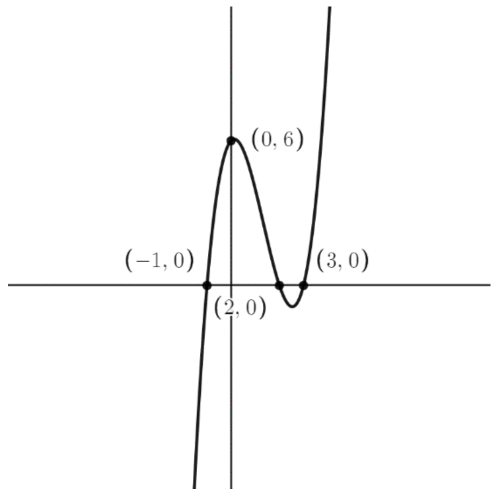
Chapter 3 Review

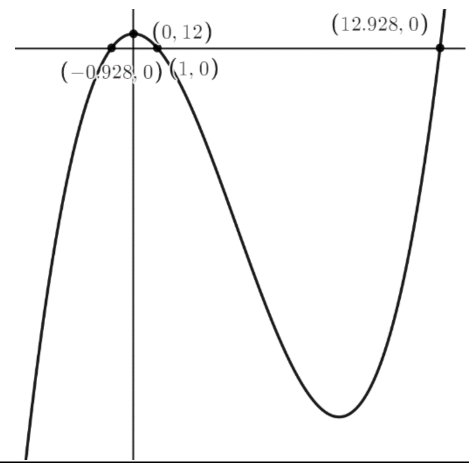
c. $x^3 + 4x^2 + 5x + 2$
$= (x + 2)(x + 1)^2$

$x -$ int	$x = 2, 3, -1$
+ve interval(s)	$\{x \mid -1 < x < 2, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -1, 2 < x < 3, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



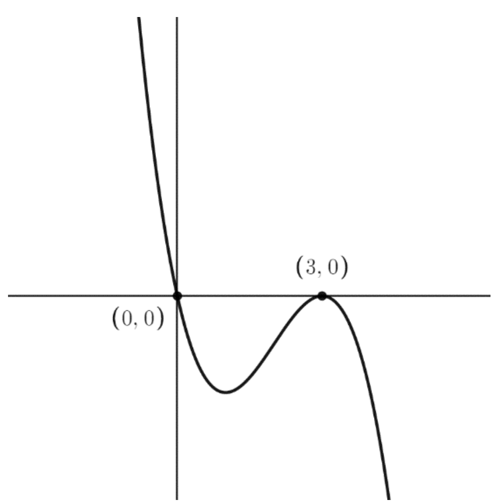
d. $x^3 - 13x^2 + 12$
$= (x - 1)(x^2 - 12x - 12)$

$x -$ int	$x = -1, 6 \pm 4\sqrt{3}$
+ve interval(s)	$\{x \mid 6 - 4\sqrt{3} < x < 1,$ $x > 6 + 4\sqrt{3}, \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < 6 - 4\sqrt{3},$ $1 < x < 6 + 4\sqrt{3}, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



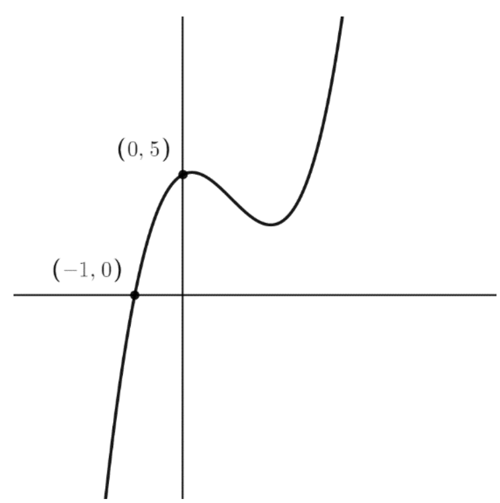
e. $-x^3 + 6x^2 - 9x$
$= -x(x - 3)^2$

$x -$ int	$x = 0, 3$
+ve interval(s)	$\{x \mid x < 0, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x > 0, x \in \mathbb{R}\}$
Multiplicity	$x = 3$ has multiplicity 2 (even) $x = 0$ has multiplicity 1



f. $x^3 - 3x^2 + x + 5$
$= (x + 1)(x^2 - 4x + 5)$

$x -$ int	$x = -1$
+ve interval(s)	$\{x \mid x > -1, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -1, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



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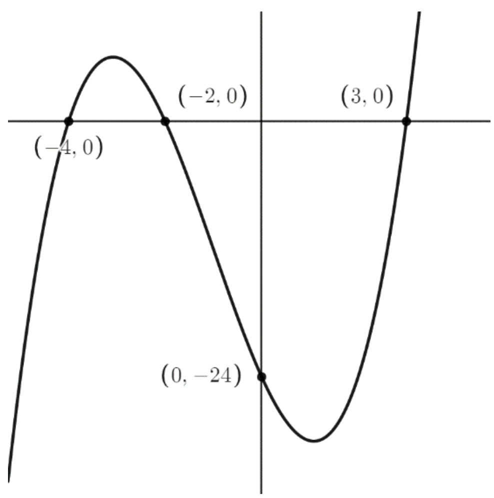
Chapter 3 Review

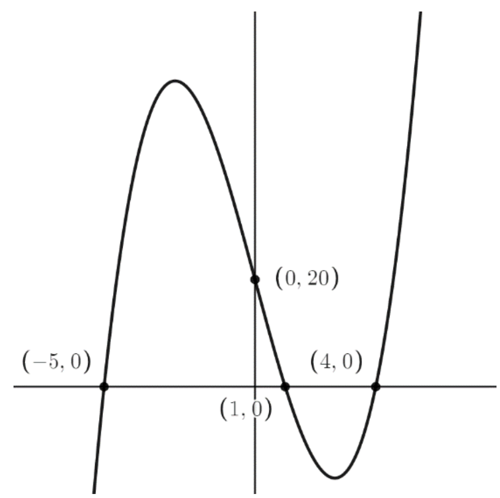
g. $x^3 + 3x^2 - 10x - 24$
$= (x-3)(x+2)(x+4)$

$x -$ int	$x = -4, -2, 3$
+ve interval(s)	$\{x \mid -4 < x < -2, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -4, -2 < x < 3, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



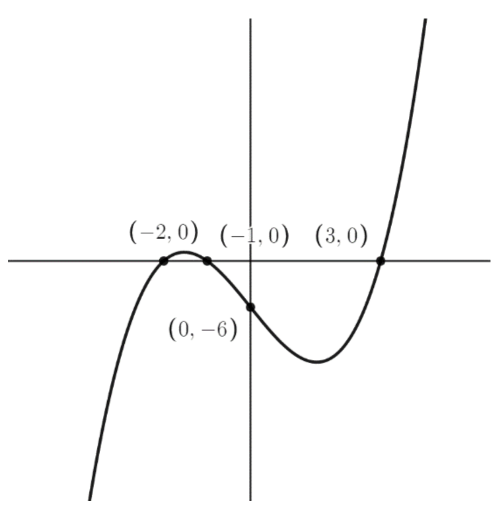
h. $x^3 - 21x + 20$
$= (x+5)(x-1)(x-4)$

$x -$ int	$x = -5, 1, 4$
+ve interval(s)	$\{x \mid -5 < x < 1, x > 4, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -5, 1 < x < 4, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



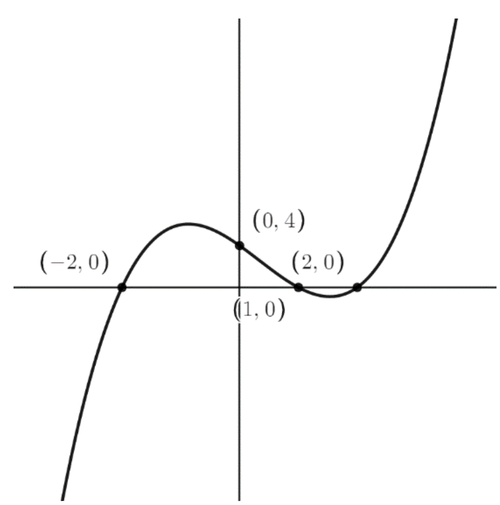
i. $x^3 - 7x - 6$
$= (x-3)(x+2)(x+1)$

$x -$ int	$x = -2, -1, 3$
+ve interval(s)	$\{x \mid -2 < x < -1, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -2, -1 < x < 3, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



j. $x^3 - x^2 - 4x + 4$
$= (x-2)(x+2)\,(x-1)$

$x -$ int	$x = \pm 2, 1$
+ve interval(s)	$\{x \mid x < -2, 1 < x < 2, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -2 < x < 1, x > 2, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



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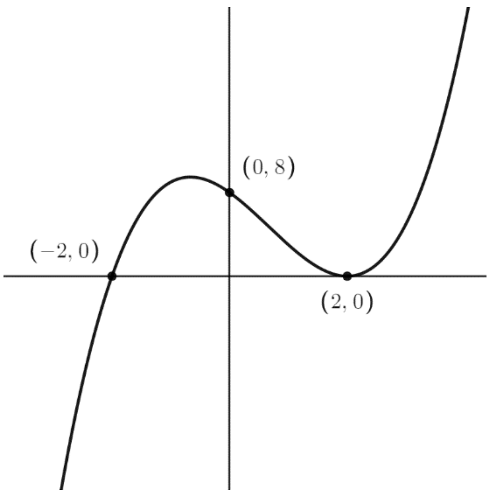
Chapter 3 Review

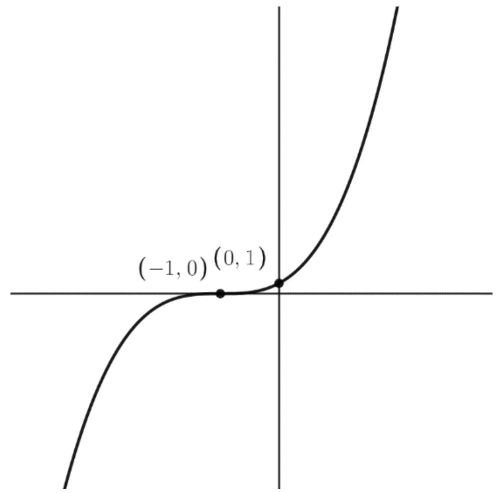
k. $x^3 - 2x^2 - 4x + 8$
$= (x-2)^2(x+2)$

$x -$ int	$x = -2, 2$
+ve interval(s)	$\{x \mid x > -2, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -2, x \in \mathbb{R}\}$
Multiplicity	$x = 2$ has multiplicity 2 $x = -2$ has multiplicity 1



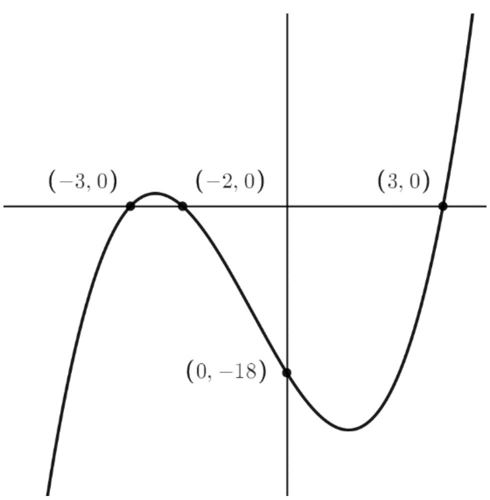
l. $x^3 + 3x^2 + 3x + 1$
$= (x+1)^3$

$x -$ int	$x = -1$
+ve interval(s)	$\{x \mid x > -1, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -1, x \in \mathbb{R}\}$
Multiplicity	$x = -1$ has multiplicity 3



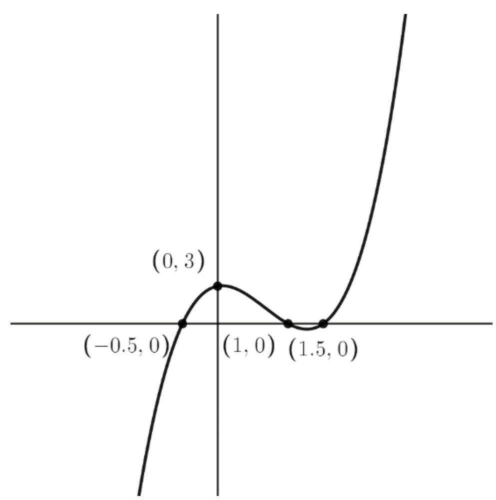
m. $x^3 + 2x^2 - 9x - 18$
$(x+2)(x-3)(x+3)$

$x -$ int	$x = -3, -2, 3$
+ve interval(s)	$\{x \mid -3 < x < -2, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -3, -2 < x < 3, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



n. $4x^3 - 8x^2 + x + 3$
$= (x-1)(2x+1)(2x-3)$

$x -$ int	$x = -{}^{1}/_{2}, 1, {}^{3}/_{2}$
+ve interval(s)	$\{x \mid -{}^{1}/_{2} < x < 1, x > {}^{3}/_{2}, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -{}^{1}/_{2}, 1 < x < {}^{3}/_{2}, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



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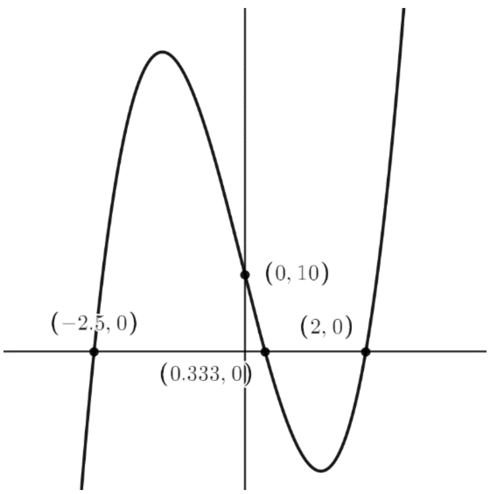
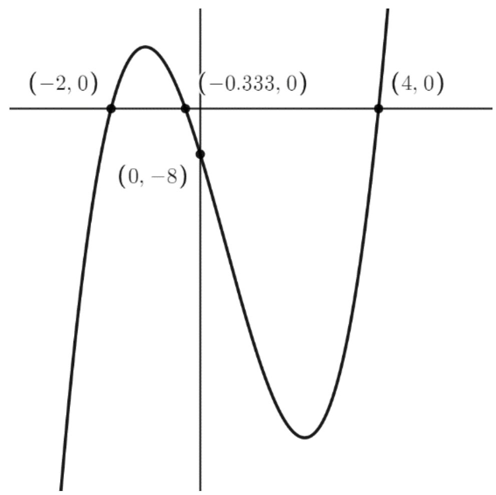
o. $6x^3 + x^2 - 31x + 10$
$= (x-2)(2x+5)(3x-1)$

$x -$ int	$x = -{}^5/_2, {}^1/_3, 2$
+ve interval(s)	$\{x \mid -{}^5/_2 < x < {}^1/_3, x > 2, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -{}^5/_2, {}^1/_3 < x < 2, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



p. $3x^3 - 5x^2 - 26x - 8$
$= (x-4)(x+2)(3x+1)$

$x -$ int	$x = -2, -{}^1/_3, 4$
+ve interval(s)	$\{x \mid -2 < x < -{}^1/_3, x > 4, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -2, -{}^1/_3 < x < 4, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



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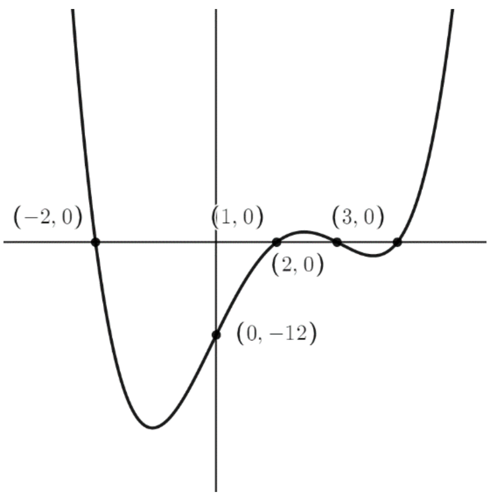
Chapter 3 Review

Extending

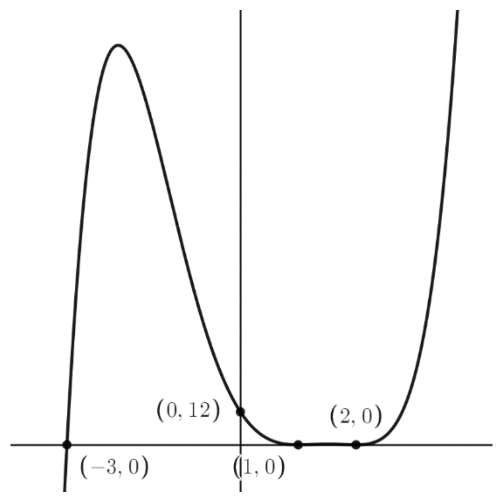
q. $x^4 - 4x^3 - x^2 + 16x - 12$
$(x-1)(x-2)(x-3)(x+2)$

$x-$ int	$x = -2, 1, 2, 3$
+ve interval(s)	$\{x \mid x < -2, 1 < x < 2, x > 3, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -2 < x < 1, 2 < x < 3, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



r. $x^5 - 3x^4 - 5x^3 + 27x^2 - 32x + 12$
$= (x+3)(x-1)^2(x-2)^2$

$x-$ int	$x = -3, 1, 2$
+ve interval(s)	$\{x \mid -3 < x, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid x < -3\}$
Multiplicity	$x = -3$ has multiplicity 1 $x = 1$ has multiplicity 2 $x = 2$ has multiplicity 2



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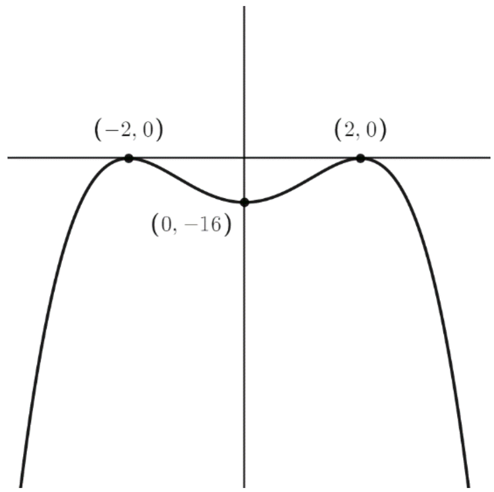
Chapter 3 Review

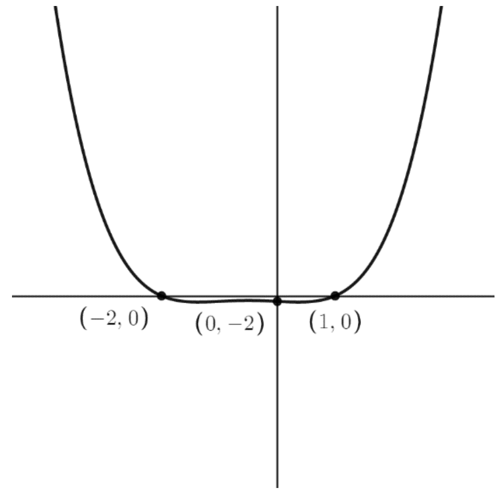
s. $-x^4 + 8x^2 - 16$
$= -(x-2)^2(x+2)^2$

x − int	$x = \pm 2$
+ve interval(s)	none
−ve interval(s)	$\{x \mid x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 2.



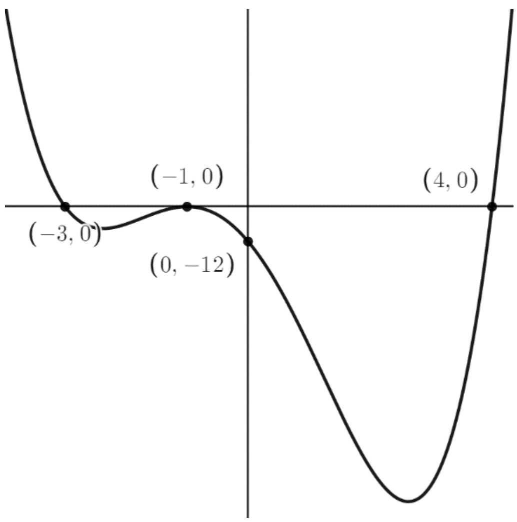
t. $x^4 + 2x^3 - x - 2$
$= (x-1)(x+2)(x^2+x+1)$

x − int	$x = -2, 1$
+ve interval(s)	$\{x \mid x < -2, x < 1, x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -2 < x < 1, x \in \mathbb{R}\}$
Multiplicity	all zeros have multiplicity 1.



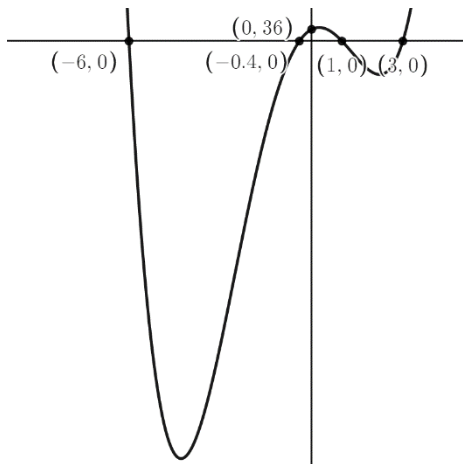
u. $x^4 + x^3 - 13x^2 - 25x - 12$
$= (x+1)^2(x+3)(x-4)$

x − int	$x = -1, -3, 4$
+ve interval(s)	$\{x \mid x < -3, x > 4\ x \in \mathbb{R}\}$
−ve interval(s)	$\{x \mid -3 < x < 4, x \in \mathbb{R}\}$
Multiplicity	$x = -3$ has multiplicity 2 $x = -3, 4$ has multiplicity 1



v. $5x^4 + 12x^3 - 101x^2 + 48x + 36$
$= (x-3)(x-1)(x+6)(5x+2)$

x − int	$x = -6, -{}^{2}/_{5}, 1, 3$
+ve interval(s)	$\left\{x \middle\| x < -6, -{}^{2}/_{5} < x < 1, x > 3\ x \in \mathbb{R}\right\}$
−ve interval(s)	$\left\{x \middle\| -6 < x < -{}^{2}/_{5}, 1 < x < 3, x \in \mathbb{R}\right\}$
Multiplicity	all zeros have multiplicity 1.



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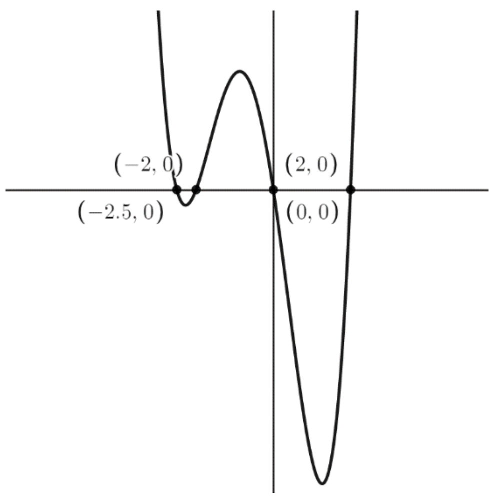
w. $2x^4 + 5x^3 - 8x^2 - 20x$
$= x(x-2)(x+2)(2x+5)$

$x - \text{int}$	$x = 0, -2, -{}^{5}\!/_{2}, 2$
+ve interval(s)	$\left\{x \middle\| x < -{}^{5}\!/_{2}, -2 < x < 0, x > 2\ x \in \mathbb{R}\right\}$
−ve interval(s)	$\left\{x \middle\| -{}^{5}\!/_{2} < x < -2, 0 < x < 2, x \in \mathbb{R}\right\}$
Multiplicity	all zeros have multiplicity 1.



x. $x^5 + 2x^4 - 11x^3 - 40x^2 - 44x - 16$
$= (x+1)^2(x-4)(x+2)^2$

$x - \text{int}$	$x = -1, -2, 4$
+ve interval(s)	$\{x\|\ x > 4\ x \in \mathbb{R}\}$
−ve interval(s)	$\{x\| < 4, x \in \mathbb{R}\}$
Multiplicity	$x = 4$ has multiplicity 1 $x = -1, -2$ has multiplicity 2