10. $\dfrac{3x^4 + x^3 - 4x^2 + 9x - 3}{x + 5}$

$= 3x^3 - 14x^2 + 66x - 321 + \dfrac{1602}{x + 5}$

−5⌋	3	1	−4	9	−3
		−15	70	−330	1605
	3	−14	66	−321	1602

11. $\dfrac{5x^4 - 3x + 1}{4 - x}$

$= -5x^3 - 20x^2 - 80x - 317 + \dfrac{-1269}{4 - x}$

4⌋	−5	0	0	3	−1
		−20	−80	−320	−1268
	−5	−20	−80	−317	−1269

12. $\dfrac{x^8 - 1}{x + 2}$

$= x^7 - 2x^6 + 4x^5 - 8x^4 + 16x^3 - 32x^2 + 64x - 128 + \dfrac{255}{x + 2}$

−2⌋	1	0	0	0	0	0	0	0	−1
		−2	4	−8	16	−32	64	−128	256
	1	−2	4	−8	16	− 32	64	−128	255

13. The remainder is $f(2) = 3$.

14. The remainder is $f(1) = -4$.

15. The remainder is $f(-3) = -43$.

16. The remainder is $f(-2) = 2$.

17. The remainder is $f(2) = 5$.

18. The remainder is $f(-1) = 23$.

19. Yes: 1 is a zero of the second polynomial.

20. Yes: 3 is a zero of the second polynomial.

21. No: When $x = 2$, the second polynomial evaluates to 10.

22. Yes: 2 is a zero of the second polynomial.

23. Yes: -2 is a zero of the second polynomial.

24. No: When $x = -1$, the second polynomial evaluates to 2.

25. From the graph it appears that $(x + 3)$ and $(x - 1)$ are factors.

−3⌋	5	−7	−49	51
		−15	66	−51
1⌋	5	−22	−17	0
		5	−17	
	5	−17	0	

$f(x) = (x + 3)(x - 1)(5x - 17)$

26. From the graph it appears that $(x + 2)$ and $(x - 3)$ are factors.

−2⌋	5	−12	−23	42
		−10	44	−42
3⌋	5	−22	21	0
		15	−21	
	5	−7	0	

$f(x) = (x + 2)(x - 3)(5x - 7)$

27. $2(x + 2)(x - 1)(x - 4) = 2x^3 - 6x^2 - 12x + 16$

28. $2(x + 1)(x - 3)(x + 5) = 2x^3 + 6x^2 - 26x - 30$

29. $2(x - 2)\left(x - \frac{1}{2}\right)\left(x - \frac{3}{2}\right)$

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

$= 2x^3 - 8x^2 + \frac{19}{2}x - 3$

30. $2(x + 3)(x + 1)(x)\left(x - \frac{5}{2}\right)$

$= x(x + 3)(x + 1)(2x - 5)$

$= 2x^4 + 3x^3 - 14x^2 - 15x$

31. Since $f(-4) = f(3) = f(5) = 0$, it must be that $(x + 4)$, $(x - 3)$, and $(x - 5)$ are factors of f. So $f(x) = k(x + 4)(x - 3)(x - 5)$ for some constant k. Since $f(0) = 180$, we must have $k = 3$. So $f(x) = 3(x + 4)(x - 3)(x - 5)$.

32. Since $f(-2) = f(1) = f(5) = 0$, it must be that $(x + 2)$, $(x - 1)$, and $(x - 5)$ are factors of f. So $f(x) = k(x + 2)(x - 1)(x - 5)$ for some constant k. Since $f(-1) = 24$, we must have $k = 2$, so $f(x) = 2(x + 2)(x - 1)(x - 5)$.

33. Possible rational zeros: $\dfrac{\pm 1}{\pm 1, \pm 2, \pm 3, \pm 6}$, or $\pm 1, \pm\frac{1}{2}, \pm\frac{1}{3}, \pm\frac{1}{6}$; 1 is a zero.

34. Possible rational zeros: $\dfrac{\pm 1, \pm 2, \pm 7, \pm 14}{\pm 1, \pm 3}$, or $\pm 1, \pm 2, \pm 7, \pm 14, \pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{7}{3}, \pm\frac{14}{3}$; $\frac{7}{3}$ is a zero.

35. Possible rational zeros: $\dfrac{\pm 1, \pm 3, \pm 9}{\pm 1, \pm 2}$, or $\pm 1, \pm 3, \pm 9, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{9}{2}$; $\frac{3}{2}$ is a zero.

36. Possible rational zeros: $\dfrac{\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12}{\pm 1, \pm 2, \pm 3, \pm 6}$, or $\pm 1, \pm 2, \pm 3, \pm 4, \pm 6, \pm 12, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{1}{3}, \pm\frac{2}{3}, \pm\frac{4}{3}, \pm\frac{1}{6}$; $-\frac{4}{3}$ and $\frac{3}{2}$ are zeros.

37.

3⌋	2	−4	1	−2
		6	6	21
	2	2	7	19

Since all numbers in the last line are ≥ 0, 3 is an upper bound for the zeros of f.

38.

5⌋	2	−5	−5	−1
		10	25	100
	2	5	20	99

Since all values in the last line are ≥ 0, 5 is an upper bound for the zeros of $f(x)$.

39.

2⌋	1	−1	1	1	−12
		2	2	6	14
	1	1	3	7	2

Since all values in the last line are ≥ 0, 2 is an upper bound for the zeros of $f(x)$.

50. Possible rational zeros: $\pm 1, \pm 3, \pm 9$. The only rational zero is -3. Synthetic division (below) leaves $x^2 - 3$, so the irrational zeros are $\pm\sqrt{3}$.

$-3\rfloor$	1	3	−3	−9
		−3	0	9
	1	0	−3	0

51. Rational: -3; irrational: $1 \pm \sqrt{3}$

$-3\rfloor$	1	1	−8	−6
		−3	6	6
	1	−2	−2	0

52. Rational: 4; irrational: $1 \pm \sqrt{2}$

$4\rfloor$	1	−6	7	4
		4	−8	−4
	1	−2	−1	0

53. Rational: -1 and 4; irrational: $\pm\sqrt{2}$

$-1\rfloor$	1	−3	−6	6	8
		−1	4	2	−8
	1	−4	−2	8	0

$4\rfloor$	1	−4	−2	8
		4	0	−8
	1	0	−2	0

54. Rational: -1 and 2; irrational: $\pm\sqrt{5}$

$-1\rfloor$	1	−1	−7	5	10
		−1	2	5	−10
	1	−2	−5	10	0

$2\rfloor$	1	−2	−5	10
		2	0	−10
	1	0	−5	0

63. False. $x - a$ is a factor if and only if $f(a) = 0$. So $(x + 2)$ is a factor if and only if $f(-2) = 0$.

64. True. By the Remainder Theorem, the remainder when $f(x)$ is divided by $x - 1$ is $f(1)$, which equals 3.

65. The statement $f(3) = 0$ means that $x = 3$ is a zero of $f(x)$ and that 3 is an x-intercept of the graph of $f(x)$. And it follows that $x - 3$ is a factor of $f(x)$ and thus that the remainder when $f(x)$ is divided by $x - 3$ is zero. So the answer is A.

66. By the Rational Zeros Theorem, every rational root of $f(x)$ must be among the numbers $\pm 1, \pm 3, \pm \frac{1}{2}, \pm \frac{3}{2}$. The answer is E.

67. $f(x) = (x + 2)(x^2 + x - 1) - 3$ yields a remainder of -3 when divided by either $x + 2$ or $x^2 + x - 1$, from which it follows that $x + 2$ is not a factor of $f(x)$ and that $f(x)$ is not evenly divisible by $x + 2$. The answer is B.