1. Find all zeros of the polynomials. (Hint: try factors of the constant term.)

   (a) $P(x) = x^3 - 7x - 6$

   (b) $P(x) = x^3 - 3x^2 - 4x + 12$

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

   (d) $P(x) = x^3 - 3x^2 - x + 3$

   (e) $P(x) = x^4 - 2x^3 - 16x^2 + 2x + 15$

   (f) $P(x) = x^4 - 7x^3 - x^2 + 67x - 60$

   (g) $P(x) = x^4 - 2x^3 - 13x^2 + 38x - 24$

   (h) $P(x) = x^4 - 4x^3 - 7x^2 + 22x + 24$

   (i) $P(x) = x^4 + 11x^3 + 41x^2 + 61x + 30$

   (j) $P(x) = x^4 - 3x^3 - 11x^2 + 3x + 10$

2. Verify that $(x - c)$ is a factor of each polynomial. Then use the factor theorem and long division or synthetic division to factor completely.

   (a) $Q(x) = x^3 - 7\,x - 6$, $c = -1$

   (b) $Q(x) = x^3 - 3\,x^2 - 4\,x + 12$, $c = 2$

   (c) $Q(x) = x^3 + x^2 - 4\,x - 4$, $c = 2$

   (d) $Q(x) = x^3 - 3\,x^2 - x + 3$, $c = 1$

   (e) $Q(x) = x^3 - 2\,x^2 - 9\,x + 18$, $c = 2$

   (f) $Q(x) = x^3 - 4\,x^2 - 4\,x + 16$, $c = -2$

3. Factor completely.

   (a) $R(x) = x^3 - 10\,x^2 + 19\,x + 30$

   (b) $R(x) = x^3 - 5\,x^2 - 2\,x + 24$

   (c) $R(x) = x^3 - 8\,x^2 + 21\,x - 18$

   (d) $R(x) = x^3 - 2\,x^2 - 4\,x + 8$

   (e) $R(x) = x^3 + x^2 - 14\,x - 24$

   (f) $R(x) = x^3 + 9\,x^2 + 26\,x + 24$

   (g) $R(x) = x^4 + 6\,x^3 - 9\,x^2 - 94\,x - 120$

   (h) $R(x) = x^4 - 7\,x^3 + 6\,x^2 + 32\,x - 32$

   (i) $R(x) = x^4 + 5\,x^3 + 5\,x^2 - 5\,x - 6$

   (j) $R(x) = x^4 - x^3 - 46\,x^2 + 16\,x + 480$

   (k) $R(x) = x^4 - 4\,x^3 - 28\,x^2 + 64\,x + 192$

   (l) $R(x) = x^4 + 10\,x^3 + 28\,x^2 + 6\,x - 45$

Answers

1. (a) $-1, -2, 3$ (b) $3, 2, -2$ (c) $-1, 2, -2$ (d) $3, 1, -1$

   (e) $-1, 1, -3, 5$ (f) $1, 4, -3, 5$ (g) $1, 2, -4, 3$ (h) $-1, 4, -2, 3$

   (i) $-2, -1, -3, -5$ (j) $-1, -2, 1, 5$

2. (a) $(x+2)(x+1)(x-3)$ (b) $(x+2)(x-2)(x-3)$ (c) $(x+2)(x+1)(x-2)$

   (d) $(x+1)(x-1)(x-3)$ (e) $(x+3)(x-2)(x-3)$ (f) $(x+2)(x-2)(x-4)$

3. (a) $(x+1)(x-5)(x-6)$ (b) $(x+2)(x-3)(x-4)$

   (c) $(x-2)(x-3)^2$ (d) $(x+2)(x-2)^2$

   (e) $(x+3)(x+2)(x-4)$ (f) $(x+4)(x+3)(x+2)$

   (g) $(x+5)(x+3)(x+2)(x-4)$ (h) $(x+2)(x-1)(x-4)^2$

   (i) $(x+3)(x+2)(x+1)(x-1)$ (j) $(x+5)(x+4)(x-4)(x-6)$

   (k) $(x+4)(x+2)(x-4)(x-6)$ (l) $(x+5)(x+3)^2(x-1)$