CHAPTER 5 EXPONENTS AND POLYNOMIALS

Section 5.1 The Product Rule and Power Rules for Exponents

Objective 1 Use exponents.

Write the expression in exponential form and evaluate.

1. $3\cdot 3\cdot 3\cdot 3$
2. $10\cdot 10\cdot 10\cdot 10\cdot 10$
3. $(-1)(-1)(-1)(-1)(-1)(-1)$
4. $11\cdot 11\cdot 11$
5. $\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)\left(\frac{1}{4}\right)$
6. $\left(-\frac{2}{5}\right)\left(-\frac{2}{5}\right)\left(-\frac{2}{5}\right)$

Write the expression in exponential form.

7. $m\cdot m\cdot m\cdot m\cdot m\cdot m$
8. $(-2y)(-2y)(-2y)$
9. $(ef)(ef)(ef)(ef)$
9. $(0.2st)(0.2st)(0.2st)$

Evaluate the exponential expressions. Name the base and the exponent.

11. $(-4)^3$
12. -6^3
13. 3^4
14. $(-5)^2$
15. -8^2
16. $(-11)^3$

Objective 2 Use the product rule for exponents.

Use the product rule to simplify the expression, if possible. Write the answer in exponential form.

17. $3^3\cdot 3^4$
18. $(-7)^3\cdot(-7)^3$
19. $2^5\cdot 2\cdot 2^6$
20. $3^2\cdot 2^3$
21. $\left(\frac{1}{2}\right)^4\cdot\left(\frac{1}{2}\right)^3$
22. $\left(\frac{3}{4}\right)^6\cdot\left(\frac{3}{4}\right)$
23. $(-5)^9\cdot(-5)^3$
24. 8^2+8^3

Multiply.

25. $4p^4 \cdot 6p^2$

26. $2k \cdot 16k^3$

27. $6a \cdot 12a^5$

28. $13b\left(-13b^{10}\right)$

29. $\left(-3m^3\right)\cdot\left(-7m^5\right)$

30. $\left(-4x^3\right)\left(5x^{11}\right)$

In the following exercises, add the given terms. Then start over and multiply them.

31. $2y^2,\ 4y^2$

32. $x^4,\ -3x^4$

33. $5a^3,\ 6a^3,\ -a^3$

34. $t^2,\ 6t^2,\ -7t^2$

Objective 3 Use the rule $\left(a^m\right)^n = a^{mn}$.

Simplify the expression. Write the answer in exponential form.

35. $\left(3^2\right)^5$

36. $\left(11^3\right)^5$

37. $\left(9^2\right)^6$

38. $\left(12^7\right)^4$

39. $-\left(8^5\right)^4$

40. $\left(11^5\right)^9$

41. $\left[(-3)^3\right]^{11}$

42. $\left[(-5)^7\right]^3$

43. $-\left(13^2\right)^{14}$

44. $\left(14^5\right)^3$

45. $\left(17^{11}\right)^{10}$

46. $-\left(21^5\right)^7$

Objective 4 Use the rule $(ab)^m = a^m b^m$.

Simplify the expression.

47. $(2a)^2$
48. $(y^4 z)^2$
49. $(p^2 q^3)^5$
50. $(r^5 s^2)^3$
51. $4(ab^3)^2$
52. $(2w^2 z^7)^3$
53. $(5r^7 t^2)^4$
54. $(-3qr)^3$
55. $(-2r^2 s)^4$
56. $2(3c^2 d^3)^4$
57. $-3(rs^5)^6$
58. $(4c^3 d^4)^3$

Objective 5 Use the rule $\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$.

Simplify the expression. Assume all variables represent nonzero real numbers.

59. $\left(\frac{2}{5}\right)^3$
60. $\left(\frac{7}{9}\right)^2$
61. $\left(\frac{a}{b}\right)^5$
62. $\left(\frac{w}{3}\right)^4$
63. $\left(\frac{z}{10}\right)^3$
64. $\left(\frac{2}{3x}\right)^2$
65. $\left(\frac{xy}{z}\right)^4$
66. $\left(\frac{x^4 y^3}{z}\right)^3$
67. $\left(-\frac{2x}{5}\right)^2$
68. $\left(\frac{2a^2}{b^3}\right)^4$
69. $\left(-\frac{r}{s}\right)^3$
70. $\left(\frac{1}{k}\right)^3$

Objective 6 Use combinations of rules.

71. $(-3a^2)(-3a^3)^4$
72. $(5a^2 b^3 c)^3 (ab^3 c^2)^4$
73. $(z^3)^6 (z^2)^5$
74. $\left(\frac{5}{7}\right)^2 (5m)^3$
75. $\left(\frac{2}{3}\right)^3 (7x)^4$
76. $\left(\frac{1}{3}\right)^4 (4ab^2)^3$
77. $(z^4)^5 (z^2)^3$
78. $(5x^2 y^3)^3 (5xy^4)^2$

Mixed Exercises

Evaluate the exponential expression. Name the base and the exponent.

79. $(-2)^8$

80. -3^6

81. $(-1)^7$

82. -1^{11}

83. -5^3

84. $(-7)^3$

Simplify the expression. Write the answer in exponential form.

85. $\left(6^4\right)^5$

86. $\left(x^2y\right)^3$

87. $\left(2a^2b^3\right)^5$

88. $\left(\dfrac{3x}{5y}\right)^6 \quad (y \neq 0)$

89. $\left(7x^6y\right)^3$

90. $(9st)^5(9st)^2$

91. $\left(\dfrac{9wx^3}{y^2}\right)^4 \quad (y \neq 0)$

92. $\left(\dfrac{r^2st}{2n}\right)^2 \quad (n \neq 0)$

93. $(4m)^2(4m)^7$

94. $(-6q)^3(-6q)^6$

95. $\left(\dfrac{4}{11}\right)^3 \cdot 4^2$

96. $\left(\dfrac{6b^2}{17}\right)^7$

97. $\left(\dfrac{7a^2b^3}{2}\right)^5$

98. $\left(\dfrac{km^2p^3}{3n^4}\right)^2 \quad (n \neq 0)$

99. $(-2pq)^3(-2pq)^4$

100. $\left(7x^2yz^5\right)^2\left(x^4y\right)^3$

Writing/Conceptual Exercises

101. Explain how $(-3)^6$ and -3^6 are different.

102. Explain how $(2y)^5$ and $2y^5$ are different.

103. Explain why the product rule for exponents does not apply to the expression $3^5 \cdot 5^3$. Then evaluate the expression by finding the individual powers and multiplying the results.

104. An algebra student applied the product rule for exponents in the following way:

$$(3x^3)(5x^5) = 15x^{15}.$$

Explain to the student why this is not correct and show how to obtain the correct answer.

105. After listening to your explanation, the student in Exercise #104 said, "Now I understand. Let me try another one." This time the student applied the product rule in the following way:

$$(8x^3)(11x^6) = 19x^9.$$

Explain to the student why this is also incorrect, and then show how to obtain the correct answer.

106. Explain why $(3a^3b^4)^2$ is not equivalent to $(3 \cdot 2)a^6b^8$ or $6a^6b^8$.

107. Is $(5^3)^4$ equivalent to $(5^4)^3$? Explain your answer.

108. On a math test covering the material in this chapter, a student was asked to simplify the following expressions.

1. $\left(\dfrac{3a^5b^4}{c^3}\right)^2 \quad (c \neq 0)$
2. $(3a^5b^4c^3)^2$

She wondered why the first expression was written with restriction "$c \neq 0$," while the second was not, even though the expressions contain the same numbers and variables. Explain the reason for this.

Section 5.2 Integer Exponents and the Quotient Rule

Objective 1 Use 0 as an exponent.

Evaluate the expression.

109. 3^0

110. $(-6)^0$

111. -10^0

112. $\left(\frac{1}{3}\right)^0$

113. $5^0 + 6^0$

114. $7^0 - (-7)^0$

115. $\left(\frac{2}{3}\right)^0 + \left(\frac{1}{3}\right)^0$

116. $(-5)^0 + (-5)^0$

117. $-11^0 + (-11)^0$

118. $-25^0 - (-25)^0$

119. $-w^0 \quad (r \neq 0)$

120. $\frac{0^5}{5^0}$

Objective 2 Use negative numbers as exponents.

Evaluate the expression.

121. 5^{-2}

122. 12^{-1}

123. $(-4)^{-2}$

124. $(-2)^{-4}$

125. $\left(\frac{3}{4}\right)^{-2}$

126. $\left(\frac{4}{7}\right)^{-1}$

127. $2^{-1} + 3^{-1}$

128. $10^{-2} + 5^{-2}$

129. $8^{-1} - 4^{-1}$

Simplify by using the definition of negative exponents. Write the expression with only positive exponents. Assume all variables represent nonzero real numbers.

130. r^{-3}

131. y^{-8}

132. $\frac{2}{r^{-3}}$

133. $\frac{r^{-4}}{6}$

134. $\frac{2x^{-3}}{3y^{-2}}$

135. $\frac{5^{-2}}{4^{-2}}$

Objective 3 Use the quotient rule for exponents.

Use the quotient rule to simplify the expression. Write answers with only positive exponents. Assume that all variables represent nonzero real numbers.

136. $\dfrac{3^5}{3^2}$

137. $\dfrac{4^{11}}{4^5}$

138. $\dfrac{(-2)^{10}}{(-2)^3}$

139. $\dfrac{(-4)^{-4}}{(-4)^3}$

140. $\dfrac{7^4 \cdot x^2}{7^5 \cdot x^5}$

141. $\dfrac{4k^7 m}{8km^5}$

142. $\dfrac{12x^3 y^4}{12^4 x^3 y^5}$

143. $\dfrac{3^{-2}}{3^{-7}}$

144. $\dfrac{12^{-3}}{12^{-2}}$

145. $\dfrac{x^{13}}{x^{-3}}$

146. $\dfrac{3^{-1} m^{-2} p^5}{3^4 m^{-1} p^{-2}}$

147. $\dfrac{5b^{-3} c^{-3}}{5^{-4} b^{-7} c^{-3}}$

148. $\dfrac{1}{q^{-1}}$

149. $\dfrac{e^3 f^4}{e^{-3} f^{-4}}$

150. $\dfrac{5^{-3} x^{-2} y^0}{5^2 x^{-3} y^{-2}}$

Objective 4 Use combinations of rules.

Use a combination of the rules for exponents to simplify the expression. Write answers with only positive exponents. Assume that all variables represent nonzero real numbers.

151. $\dfrac{\left(7^2\right)^4}{7^8}$

152. $\dfrac{\left(9^3\right)^2}{9^5}$

153. $8^7 \cdot 8^{-1} \cdot 8^{-6}$

154. $a^{-3} \cdot a^3 \cdot a^7$

155. $\left(5^{-3}\right)^4$

156. $\left(3^2 x^{-4} y\right)^2$

157. $\left(5w^2 y^2\right)^{-2} \left(4wy^{-3}\right)^2$

158. $\left(2r^{-3} s^2\right)^2 \left(4r^4 s^{-1}\right)^{-1}$

159. $\dfrac{(5m)^{-4}}{(2m)^{-3}}$

160. $(9xy)^5 (9xy)^{-6}$

161. $\dfrac{\left(t^{-3}\right)^{3}\left(t^{5}\right)^{2}}{\left(t^{-6}\right)^{-2}}$

162. $\dfrac{\left(q^{-2}\right)^{-4}\left(q^{0}\right)^{5}}{\left(q^{5}\right)^{-3}}$

163. $\left(\dfrac{x^{-4}y^{2}}{x^{6}y^{-2}}\right)^{-2}$

164. $\left(\dfrac{k^{-2}t^{2}}{k^{2}t^{-3}}\right)^{-2}$

Mixed Exercises

Evaluate the expression.

165. $9^{0}+(-9)^{0}$

166. 5^{-2}

167. $-4^{0}+(-4)^{0}$

168. $\left(4^{-3}\right)^{0}$

169. $\left(3^{0}\right)^{-8}$

170. $\left(4^{0}\right)^{0}$

171. $\left(\dfrac{2}{3}\right)^{-4}$

172. $\left(-\dfrac{4}{3}\right)^{-4}$

173. $6^{-1}+6^{-2}$

Simplify the expression. Write answers with only positive exponents. Assume that all variables represent nonzero real numbers.

174. $\dfrac{13^{-8}}{13^{-9}}$

175. $\dfrac{a^{-8}}{a^{2}}$

176. $\dfrac{\left(2^{5}\right)^{2}}{2^{6}}$

177. $\dfrac{\left(6^{3}\right)^{-2}}{6^{-1}}$

178. $\left(\dfrac{2}{5}\right)^{-2}\cdot\left(\dfrac{5}{2}\right)$

179. $\dfrac{\left(5k^{-1}\right)^{2}}{5k^{3}}$

180. $\dfrac{\left(2xy^{-1}\right)^{3}}{2^{3}x^{-3}y}$

181. $\dfrac{x^{3}\cdot x^{-1}}{x^{4}\cdot x^{-4}}$

182. $\left(\dfrac{2x^{-3}}{5x^{2}}\right)^{-1}$

183. $\dfrac{\left(z^{3}\right)^{2}\left(z^{2}\right)^{4}z^{-8}}{\left(z^{4}\right)^{-3}}$

184. $\dfrac{\left(3y^{-1}z^{4}\right)^{-1}\left(3y^{-3}\right)}{\left(y^{3}z^{2}\right)^{-2}}$

185. $\dfrac{\left(2^{-1}m^{-1}n^{-1}p\right)^{-2}}{\left(p^{2}m^{-1}\right)^{-3}}$

Writing/Conceptual Exercises

Decide whether the expression is positive, negative, or zero.

186. $(-2)^{3}$

187. 5^{-3}

188. $(-3)^{2}$

189. -7^{-2}

190. $\left(\dfrac{1}{6}\right)^{-2}$

191. $\left(-\dfrac{1}{5}\right)^{-2}$

192. $7^{0}-13^{0}$

193. $(-5)^{3}+5^{3}$

194. 10^{-10}

195. -10^{-10}

196. If one side of a square measures $5x^{3}$ centimeters, what is the area of the square?

197. If one edge of a cube measures $2y^{4}$ feet, what is the volume of the cube?

198. On an algebra quiz, a student evaluated the expression $2^{-1}+2^{-3}$ as follows:

$$2^{-1}+2^{-3}=2^{-4}=\frac{1}{2^{4}}=\frac{1}{16}.$$

Explain why this is incorrect and show the correct solution.

Section 5.3 An Application of Exponents: Scientific Notation

Objective 1 Express numbers in scientific notation.

Write the number in scientific notation.

199. 756

200. 3295

201. 30,054

202. 609,906

203. 5.8

204. 11,502,000

205. 0.03

206. 0.176

207. 0.00007

208. 0.00402

209. –93,572

210. –0.00021

Objective 2 Convert numbers in scientific notation to numbers without exponents.

Write the numbers without exponents.

211. 4.3×10^{3}

212. 7.02×10^{3}

213. -2.75×10^{5}

214. -2.073×10^{0}

215. 2×10^{6}

216. 1.5×10^{8}

217. 4.8×10^{-2}

218. 7.55×10^{-4}

219. 2.001×10^{-1}

220. 4.931×10^{-4}

221. -6.05×10^{0}

222. -9.99×10^{-3}

Objective 3 Use scientific notation in calculations.

Perform the indicated operations with the numbers in scientific notation, and then write the answer without exponents.

223. $\left(4\times10^{3}\right)\left(7\times10^{2}\right)$

224. $\left(3.2\times10^{3}\right)\times\left(2.1\times10^{-2}\right)$

225. $\left(2.3\times10^{-4}\right)\times\left(3.1\times10^{-2}\right)$

226. $\left(4\times10^{-2}\right)\left(2\times10^{-1}\right)\left(3\times10^{6}\right)$

227. $\dfrac{5.2\times10^{4}}{1.3\times10^{-2}}$

228. $\dfrac{7.2\times10^{3}}{4\times10^{5}}$

229. $\dfrac{1.02\times10^{-5}}{1.7\times10^{-9}}$

230. $\dfrac{4.6\times10^{-3}}{2.3\times10^{-1}}$

231. $\left(3\times10^{4}\right)\times\left(4\times10^{3}\right)\times\left(2\times10^{4}\right)$

232. $\left(6\times10^{4}\right)\times\left(3\times10^{5}\right)\div\left(9\times10^{7}\right)$

233. $\dfrac{\left(4.8\times10^{4}\right)\times\left(2.1\times10^{-3}\right)}{\left(7\times10^{-6}\right)\times\left(1.6\times10^{6}\right)}$

234. $\dfrac{\left(7.5\times10^{6}\right)\times\left(4.2\times10^{-5}\right)}{\left(6\times10^{4}\right)\times\left(2.5\times10^{-3}\right)}$

Mixed Exercises

If a number is written without exponents, rewrite it in scientific notation. If a number is written in scientific notation, rewrite it without exponents.

235. 4,905,000

236. 46

237. 0.5

238. 0.0075

239. –7.04

240. –0.0000906

241. 3.42×10^{8}

242. 2.71×10^{-6}

243. -3.06×10^{5}

244. -9.24×10^{-7}

245. 1.236×10^{4}

246. -7.049×10^{-2}

247. 8×10^{6}

248. -7×10^{-5}

Perform the indicated operations with the numbers in scientific notation, and write the answer without exponents.

249. $\left(3.4\times10^{6}\right)\left(1.6\times10^{-3}\right)$

250. $\left(2.5\times10^{-7}\right)\times\left(5.6\times10^{4}\right)$

251. $\dfrac{5\times10^{-5}}{5\times10^{-6}}$

252. $\dfrac{9\times10^{3}}{3\times10^{-2}}$

253. $\dfrac{8\times10^{-4}}{2\times10^{-7}}$

254. $\dfrac{7\times10^{-3}}{5\times10^{-7}}$

255. $\dfrac{\left(4\times10^{2}\right)\times\left(3\times10^{4}\right)}{2\times10^{3}}$

256. $\dfrac{\left(6\times10^{5}\right)\times\left(3\times10^{5}\right)}{\left(9\times10^{6}\right)}$

257. $\dfrac{\left(6\times10^{3}\right)\times\left(4\times10^{-7}\right)}{\left(8\times10^{2}\right)\times\left(3\times10^{-5}\right)}$

258. $\dfrac{\left(4\times10^{-5}\right)\left(3\times10^{4}\right)}{\left(6\times10^{-2}\right)\left(2\times10^{-1}\right)}$

259. $\dfrac{\left(7.2\times10^{-5}\right)\left(3.8\times10^{6}\right)}{\left(1.8\times10^{3}\right)\left(9.5\times10^{-5}\right)}$

260. $\dfrac{\left(12.5\times10^{3}\right)\left(4.9\times10^{-4}\right)}{\left(7\times10^{-8}\right)\left(2.5\times10^{5}\right)}$

Writing/Conceptual Exercises

Determine whether the given number is written in scientific notation, as defined in the textbook. If it is not, write it as such.

261. 3.804×10^{3}

262. 200

263. 8532

264. 0.0005

265. 92×10^{3}

266. 7.1×10^{-6}

267. 0.3×10^{4}

268. 0.039×10^{2}

269. Explain in your own words some reasons why you think scientists prefer to work with numbers that are in scientific notation rather than numbers written without exponents.

270. Why do you think that 10 was chosen as the base for all numbers written in scientific notation?

Section 5.4 Adding and Subtracting Polynomials; Graphing Simple Polynomials

Objective 1 Identify terms and coefficients.

For the polynomial, determine the number of terms and name the coefficients of the terms.

271. $7b$

272. $-6y^{2}$

273. $a^{5}-a$

274. $-2f^{3}+f^{2}-f$

275. $8x^{3}-6x^{2}-5x+2$

276. $3-7w$

277. $\frac{1}{2}x+y-1$

278. $-\frac{4}{7}z^{2}+\frac{2}{5}z$

279. $0.75x-0.25y$

280. $0.10a^{2}-0.20b^{2}$

Objective 2 Add like terms.

In the polynomial, add like terms whenever possible. Write the result in descending powers of the variable.

281. $-6s^3+8s^3$

282. $2t^6+\left(-7t^6\right)$

283. $4x^2-6x^3+3x^2+5x^3$

284. $-5y^3-y^4+y^3+y^2$

285. $0.3m^5-0.9m^5$

286. $3.2r^2-5.8r-6.5r-9.7r^2$

287. $8c^3+11c^2-c^2-10c^2-5c-5+2c^3$

288. $4y^4-3y^2+2-7y^3+6y^4-2y^2-y$

289. $8a^2-3a^3+5a^2-7a^2$

290. $-14x^3-2x^2+6x-x^3$

291. $-\frac{1}{2}r^3-\frac{1}{3}r+\frac{1}{4}r^3+\frac{1}{3}r$

292. $-\frac{2}{3}m^2+\frac{1}{10}m^3-\frac{1}{3}m^2+\frac{4}{5}m^3$

Objective 3 Know the vocabulary for polynomials.

Choose one or more of the following descriptions for each expression: (a) polynomial, (b) polynomial written in descending order, (c) not a polynomial.

293. $-6w^3+7w^2+2w-11$

294. x^5+x^9

295. $4y^3-3y+\frac{2}{y}$

296. $8a^5+4a^3-6a^{-1}+10$

297. $-k^{-2}$

298. f^6-f^4+3f-2

Simplify the polynomial, if possible, and write the resulting polynomial in descending powers of the variable. Then give the degree of this polynomial, and tell whether it is a *monomial,* a *binomial*, a *trinomial*, or *none of these*.

299. $6y^2+2y-3$

300. $8m^2-4m-m^5$

301. $z^4+3z^3-2z^3$

302. $-p^3+p^5-2p^5$

303. $n^8-n^7+4n^8$

304. $x^2-4x^5+5x^2$

305. $\frac{7}{8}x^2-\frac{3}{4}x-\frac{1}{4}x^2-\frac{1}{2}x$

306. $\frac{5}{6}y^2+\frac{1}{3}-\frac{5}{6}y-\frac{1}{3}y+\frac{1}{6}-\frac{2}{3}y^2$

Objective 4 Evaluate polynomials.

Find the value of the polynomial when (a) $x = 3$ and (b) $x = -2$.

307. $5x - 13$

308. $5x + 7$

309. $3x^2 - 4x + 3$

310. $x^2 - 3x + 8$

311. $-x^2 - 4x + 2$

312. $-x^2 + 5x - 9$

313. $2x^3 + 4x^2 - 7x + 3$

314. $x^3 + 4x^2 - 8x - 2$

315. $5x^4 - 2x^2 + 8x - 1$

316. $3x^4 + x^3 - 6x + 11$

Objective 5 Add and subtract polynomials.

Add.

317. $3x^2 + 6x + 1$
$\underline{2x^2 - 2x + 3}$

318. $8y^3 - 2y^2 + 5$
$\underline{2y^3 - 3y^2 + 11}$

319. $6m^3 + 2m^2 - m - 4$
$\underline{-4m^3 - 12m^2 - 2m + 4}$

320. $w^4 + 3w^2 - 2w + 6$
$\underline{4w^4 - 2w^2 + 8w + 4}$

321. $5x^5 + 2x^2 - 3x - 1$
$\underline{-6x^5 + x + 1}$

322. $2y^4 - 3y^3 + 6y - 9$
$\underline{3y^3 - 5y + 1}$

323. $7p^4 + 2p^2 - 3p - 11$
$\underline{5p^4 - 3p^3 - 8p^2 - 3p + 4}$

324. $-8z^5 - 2z^4 - 12z^3 - 5z^2 + z$
$\underline{8z^5 - 4z^4 + 9z^3 + z^2 + z}$

325. $\left(8x^3 - 2x^2 - 6x + 1\right) + \left(-3x^3 - 4x^2 - 7\right)$

326. $\left(9x^3 - 2x^2 - 6x + 1\right) + \left(5x^3 + 4x^2 - 3\right)$

327. $\left(-y^4 + 3y^3 + 2y - 11\right) + \left(-2y^3 + 6y + 5\right)$

328. $\left(4z^7 - 6z^5 - 3z^4 + 1\right) + \left(z^6 + 3z^5 + 2z^3 + 10\right)$

329. $\left(x^5 + 2x^3 - x^2\right) + \left(4x^5 + 3x^4 - 2x^3 + x^2 - x\right)$

330. $\left(m^4 - 3m^3 + 2m^2 + m - 6\right) + \left(3m^3 - 3m^2 - m + 4\right)$

Subtract.

331. $8x^2 + 2x$
$\underline{2x^2 + \ \ x}$

332. $10m^3 - 2m$
$\underline{\ 6m^3 + 3m}$

333. $3y^2 + 3y - 6$
$\underline{7y^2 - 2y + 5}$

334. $\ \ 9k^2 - 3k - 18$
$\underline{-11k^2 - 5k + \ 1}$

335. $6n^3 + 3n$
$\underline{5n^3 - \ \ n - 2}$

336. $\ \ 3x^2 - 2x - 2$
$\underline{-3x^2 \ \ + x - 8}$

337. $-7y^4 - 3y^3 - 2y^2 - y$
$\underline{\ 11y^4 + 2y^3 - 2y^2 \ \ \ \ -1}$

338. $z^5 - z^4 + 3z^3$
$\underline{\ \ \ 4z^4 \ \ \ \ \ \ + 3z^2 - 8z}$

339. $\left(9x^3 + 4x^2 - 10x - 7\right) - \left(5x^3 - 6x + 4\right)$

340. $\left(9x^3 - x^2 + 7x + 10\right) - \left(6x^3 - 4x + 7\right)$

341. $\left(5m^3 - 3m + 7\right) - \left(-5m + 8\right)$

342. $\left(14z^4 - z^2 + 3z\right) - \left(3z^3 - z^2 - 3x - 1\right)$

343. $\left(8a^5 - 3a^2 - a + 11\right) - \left(-a^5 + 2a^3 - 5a^2 + a - 4\right)$

344. $\left(p^4 - 9p^3 - 6p^2 + 8p - 1\right) - \left(-2p^4 - 3p^2 - 1\right)$

Objective 6 Graph equations defined by polynomials of degree 2.

Select several values for x; then find the corresponding y-values, and graph.

345. $y = x^2 - 2$

346. $y = x^2 + 2$

347. $y = 3x^2 - 4$

348. $y = 3 - x^2$

349. $y = -x^2 - 4$

350. $y = 3x^2 - 5$

Mixed Exercises

Perform the indicated operations. Write each resulting polynomial in descending powers of the variable. Then give the degree of this polynomial, and tell whether it is a *monomial*, a *binomial*, a *trinomial*, or *none of these*.

351. $\left(3x^3 + 2x^2 - 6x + 1\right) + \left(3x^3 - 4x^2 - 2\right)$

352. $\left(6y^2 + 2y - 3\right) - \left(2y^2 - 2y + 1\right)$

353. $\left(6y^4 - 3y^3 + 2y - 10\right) + \left(2y^3 + 6y + 5\right)$

354. $\left(x^5 + 2x^3 - x^2\right) + \left(4x^5 - 3x^4 - 2x^3 + 8x^2 - x\right)$

355. $\left(p^4 + 2p^3 - 6p^2 + 7p - 1\right) - \left(-2p^4 - 3p^2 + 1\right)$

356. $5 - \left(4 - 2y - 11y^2\right)$

357. $\left(3a^2 - 2a + 5\right) + \left(-2a^2 + 2a - 1\right) + \left(a^2 + 3\right)$

358. $\left(5x^3 - x + 3\right) - \left(2x^3 - x - 5\right) + \left(x^3 - 2x - 2\right)$

For the following polynomials, state the coefficient of the second term. Then evaluate the polynomial when $x = 4$ and $x = -3$.

359. $2x^2 + 3x - 1$

360. $3x^2 - 3x + 1$

361. $x^2 - x + 1$

362. $x^3 + x - 7$

363. $\frac{1}{2}x^2 + 3x - 1$

364. $-\frac{1}{3}x^2 + 4x - 2$

365. $-3x^3 - 2x^2 + 4x + 3$

366. $-x^2 - 2$

Add or subtract as indicated.

367. $\left(4x^2y+5xy+3y^2\right)+\left(-x^2y-2xy+5y^2\right)$

368. $\left(3c^2-5cd+6d^2\right)-\left(-2d^2+3cd-c^2\right)$

369. $\left(3rs+4r-5s\right)-\left(6s-2r-5sr\right)$

370. $\left(6ab+2bc-4ac\right)+\left(5ca-2cb-8ba\right)$

371. $\left(2x^2y+5xy-6xy^2\right)+\left(7xy+8xy^2\right)-\left(3x^2y+4xy\right)$

372. $\left(0.06ab+0.03a^2-0.05b^2\right)-\left(-0.08a^2+0.02b^2+0.06ab\right)$

Add.

373.
$$\begin{array}{r} 5x^3y-2x^2y^2+6xy^3 \\ \underline{-4x^3y+2x^2y^2-7xy^3} \end{array}$$

374.
$$\begin{array}{r} 12r^2t+3rt-8rt^2 \\ \underline{-4r^2t-5rt-6rt^2} \end{array}$$

Subtract.

375.
$$\begin{array}{r} 17a^3b-6a^2b^2+\ ab^3+5 \\ \underline{6a^3b\qquad\quad -7ab^3-2} \end{array}$$

376.
$$\begin{array}{r} -6rs+7rt-5st \\ \underline{2rs-9rt-\ st} \end{array}$$

Writing/Conceptual Exercises

377. Explain why the degree of the term 2^3 is not 3. What is its degree?

378. Can the sum of two polynomials in *x*, both of degree 4, be of degree 3? If so, give an example.

379. Can the sum of two polynomials in *x*, both of degree 3, be of degree 1? If so, give an example.

380. Is it possible to add two trinomials and obtain a sum which is a binomial? If so, give an example.

Section 5.5 Multiply Polynomials

Objective 1 Multiply a monomial and a polynomial.

Find the product.

381. $(4y^3)(5y^2)$

382. $(-9y^3)(-8y^3)$

383. $2z(5z^2+7)$

384. $-4p^3(8p^2-7p-7)$

385. $2k(k^5+4k^4-2k^3+6k^2-9)$

386. $-3y^2(4y^3+2y^2-8y+11)$

387. $2k(3-2k+5k^4)$

388. $-7m(3-5m^2+2m^3)$

389. $-4a(3-2a+7a^5)$

390. $-3r^4(2r^2-7r+5)$

391. $8mn(4m^2-4mn+7n^2)$

392. $-2r^2s(10r^2s^2-6rs+5rs^2)$

Objective 2 Multiply two polynomials.

Find the product.

393. $(x+2)(x+4)$

394. $(x-6)(x-2)$

395. $(2p+3)(p+4)$

396. $(9+3a)(4-2a)$

397. $(5n+1)(3n-7)$

398. $(2x-3)(3x-1)$

399. $(9r+7)(3r-5)$

400. $(x-2)(x^2+2x+4)$

401. $(y+5)(y^2-5y+25)$

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

403. $(2y-1)(3y^3-2y^2+y-7)$

404. $(4m^2+1)(2m^3-3m^2-4m)$

405. $(2z^2-3)(z^4-z^3+z^2-z+1)$

406. $(5x^2+3x+1)(2x^2-3x+5)$

Objective 3 Multiply binomials by the FOIL method.

Use the FOIL method to find the product.

407. $(x-3)(x+4)$

408. $(y+6)(y+2)$

409. $(r-8)(r+7)$

410. $(z-5)(z-8)$

411. $(2k-1)(k+3)$

412. $(4m-5)(m+8)$

413. $(8y+5)(2y+1)$

414. $(3x+5y)(2x-y)$

415. $(3m+n)(4m-2n)$

416. $(2p+5q)(3p-2q)$

417. $(2-5m)(4+3m)$

418. $(10k-11)(10k+11)$

419. $(1+3x)(3-2x)$

420. $(3-8a)(1-6a)$

421. $(5-4y)(1+2y)$

422. $(7p+1)(3p-1)$

423. $(5r-3s)(3r+5s)$

424. $(12m+5n)(-3m+2n)$

425. $(3x^2+2)(2x^2-5)$

426. $(5v^2+w^2)(v^2-3w^2)$

Mixed Exercises

Find the product.

427. $(5x^3)(3x^2)$

428. $4m(3m-7)$

429. $(q-7)(q-6)$

430. $(9p+4r)(6p-5r)$

431. $(x-6y)(x+6y)$

432. $-11p^2(-1+6p-7p^3+4p^5)$

433. $(6x^2+8x+5)(2x^2-1)$

434. $(3x^2-8x-6)(x-2)$

435. $(6x^3-15x^2+4x-3)(x^2+2x+1)$

436. $(2x^3+x^2-5x+1)(2x^2+x-2)$

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

438. $(3y-1)(4y^3+2y^2-y+5)$

439. $(2a^2-1)(4a^3+2a^2-a)$

440. $(3b^2-1)(b^4-2b^3+b^2-2b-1)$

441. $(3x^2-2x+3)(5x^3-x+5)$

442. $(3y^3-y^2+2)(-3y^3+2y+1)$

443. $(2m^3+3m-4)(-2m^3-4m+1)$

444. $(4x^2-x)(4x^2-5x+4)$

Section 5.6 Special Products.

Objective 1 Square binomials.

Find the square by using the pattern for the square of a binomial.

445. $(z+5)^2$

446. $(t-9)^2$

447. $(2x+1)^2$

448. $(5y-1)^2$

449. $(2m-7)^2$

450. $(3p+7)^2$

451. $(4-x)^2$

452. $(7+6y)^2$

453. $(4w-3q)^2$

454. $(2m-9p)^2$

455. $\left(5z-\frac{1}{2}\right)^2$

456. $\left(2x-\frac{1}{4}y\right)^2$

457. $\left(3x-\frac{1}{3}y\right)^2$

458. $\left(7a-\frac{1}{2}b\right)^2$

Objective 2 Find the product of the sum and difference of two terms.

Find the product by using the pattern for the sum and difference of two terms.

459. $(z-8)(z+8)$

460. $(k-12)(k+12)$

461. $(2b-7)(2b+7)$

462. $(8k-5p)(8k+5p)$

463. $(4p+3q)(4p-3q)$

464. $(5+3k)(5-3k)$

465. $(9-2y)(9+2y)$

466. $\left(x+\frac{1}{3}\right)\left(x-\frac{1}{3}\right)$

467. $\left(y+\frac{2}{3}\right)\left(y-\frac{2}{3}\right)$

468. $\left(3m-\frac{1}{3}\right)\left(3m+\frac{1}{3}\right)$

469. $\left(6a+\frac{2}{5}b\right)\left(6a-\frac{2}{5}b\right)$

470. $\left(\frac{3}{4}s+\frac{2}{5}t\right)\left(\frac{3}{4}s-\frac{2}{5}t\right)$

471. $\left(y^2+4\right)\left(y^2-4\right)$

472. $\left(5m^2-3n^3\right)\left(5m^2+3n^3\right)$

Objective 3 Find greater powers of binomials.

Find the product.

473. $(x-1)^3$

474. $(r+1)^3$

475. $(y+3)^3$

476. $(2x-1)^3$

477. $(2x+3)^3$

478. $(k-1)^4$

479. $(t-5)^4$

480. $(3x+2y)^4$

481. $(z-6)^4$

482. $(4s+3t)^4$

483. $(3x-2)^3$

484. $(b-1)^4$

Mixed Exercises

Find the product.

485. $(5y-2)^2$

486. $(6b-11)(6b+11)$

487. $(10b-3)^2$

488. $(7t+3t)(7t-3u)$

489. $(9k+2m)^2$

490. $(24-16w)(24+16w)$

491. $\left(3x+\frac{7}{3}\right)\left(3x-\frac{7}{3}\right)$

492. $\left(6y+\frac{1}{3}\right)^2$

493. $\left(5j+\frac{1}{2}k\right)^2$

494. $\left(\frac{4}{7}t+9u\right)\left(\frac{4}{7}t-9u\right)$

495. $\left(\frac{1}{3}b-\frac{1}{2}c\right)^2$

496. $\left(\frac{2}{3}x+\frac{4}{5}y\right)\left(\frac{2}{3}x-\frac{4}{5}y\right)$

497. $(3x-2y)^3$

498. $(3a-4b)^4$

499. $\left(\frac{1}{3}x+y\right)^3$

500. $\left(3x-\frac{1}{3}y\right)^3$

501. $(6x-2y)(6x+2y)$

502. $(x-2y)^4$

503. $\left(5a-\frac{1}{5}b\right)^2$

504. $(2x-y)^4$

505. $\left(\frac{1}{3}x-\frac{1}{2}y\right)^3$

506. $\left(3x-\frac{1}{7}y\right)\left(3x+\frac{1}{7}y\right)$

Writing/Conceptual Exercises

507. Explain how the expression x^2-y^2 and $(x-y)^2$ differ.

508. A student is asked to find the product $(x-4)^2$, and gives the answer x^2-16. Use a numerical example to explain why this is incorrect.

509. A student remembers that the square of a binomial is a trinomial. When asked to find $(x-4y)^2$, he gives the answer $x^2-4xy+16y^2$. Explain why this answer is incorrect.

510. Based on your experience in finding powers of binomials such as $(a+b)^2$, $(a+b)^3$, and $(a+b)^4$, how many terms would you expect to find in the simplified answer for $(a+b)^5$? Explain your answer. (Do not actually find the product.)

Section 5.7 Dividing Polynomials

Objective 1 Divide a polynomial by a monomial.

Divide the polynomial by $3m^2$.

511. $9m^3 + 3m^2$

512. $12m^4 - 9m^3 + 6m^2$

513. $18m^5 - 9m^3$

514. $27m^3 + 18m^2 - 3m$

515. $27m^3 + 18m^2 - 6m$

516. $4m^3 - m^2$

517. $-57m^3 + 30m^2 - 6m$

518. $3m^2 - 3$

519. $6m^2 - 3m + 2$

520. $21m^5 - 5m^4 - 2m + 3$

Perform the division.

521. $\dfrac{8p^4 + 24p^7}{4p^3}$

522. $\dfrac{12x^6 + 18x^5 + 30x^3}{6x^2}$

523. $\left(8y^6 - 6y^2\right) \div \left(4y\right)$

524. $\left(9z^5 - 27z^3 + 3z - 11\right) \div \left(3z\right)$

525. $\left(60x^4 - 20x^2\right) \div \left(2x\right)$

526. $\left(6m^5 - 4m^3 + 24m\right) \div \left(4m\right)$

527. $\left(m^2 + 7m - 14\right) \div \left(7m\right)$

528. $\dfrac{20p^4 - 25p^3 - 5p}{5p^2}$

529. $\dfrac{70q^4 - 30q^2 + 40q}{10q^2}$

530. $\dfrac{7y^9 + 9y^6 - 13y - 11}{y^3}$

531. $\dfrac{12z^5 + 8z^4 - 6z^3 + 5z}{-3z}$

532. $\dfrac{44x + 24x^4 + 3x^8}{4x}$

533. $\dfrac{6y^5 - 3y^4 + 9y^2 + 27}{-3y}$

534. $\dfrac{14y^2 - 14y + 70}{-7y^2}$

Objective 2 Divide a polynomial by a polynomial.

Perform the division.

535. $\dfrac{x^2-x-12}{x+3}$

536. $\dfrac{y^2+2y-24}{y+6}$

537. $\dfrac{2x^2+9x-35}{2x-5}$

538. $\dfrac{p^2+7p-30}{p-3}$

539. $\left(2x^2+5x+3\right)\div\left(2x+3\right)$

540. $\left(r^2-2r-20\right)\div\left(r-5\right)$

541. $\left(2b^2-13b+3\right)\div\left(2b+1\right)$

542. $\left(9w^2-6w+1\right)\div\left(3w-1\right)$

543. $\dfrac{5w^2-22w+4}{w-4}$

544. $\dfrac{6b^2+37b+7}{b+7}$

545. $\dfrac{25m^2-30m+9}{5m-3}$

546. $\dfrac{y^2-1}{y+1}$

547. $\dfrac{4x^2-9}{2x-3}$

548. $\dfrac{8y^3-18y^2-27y+10}{4y+5}$

549. $\dfrac{2z^3-5z^2+15z+6}{2z+1}$

550. $\dfrac{6m^3+5m^2-33m+8}{3m-2}$

551. $\left(24p^4-32p^3-9p^2+18p-8\right)\div\left(3p-4\right)$

552. $\left(12x^3-17x^2+30x-10\right)\div\left(3x^2-2x+5\right)$

553. $\dfrac{4x^4-20x^3+9x^2-5x+1}{4x^2+1}$

554. $\dfrac{4y^5-8y^4-3y^3+22y^2-15}{4y^2-3}$

555. $\dfrac{2y^4+3y^3-2y^2+3y-5}{y^2+1}$

556. $\dfrac{4x^4+2x^3-2x^2-2x-3}{x^2-1}$

557. $\dfrac{y^3-1}{y-1}$

558. $\dfrac{b^4-1}{b^2-1}$

559. $\dfrac{27x^5 - 3x^3 + 6x^2 - 2x}{3x - 1}$

560. $\dfrac{32x^5 + 243}{2x + 3}$

Writing/Conceptual Exercises

561. Suppose that a polynomial in the variable *y* has degree 10 and it is divided by a monomial in the variable *y* having degree 2. Describe the quotient in mathematical terms, giving type of expression and the degree.

562. In her algebra class, Mischa volunteered to work the following division problem on the blackboard:

$$\frac{12z^3 - 9z^2 + 3z}{3z}.$$

Mischa's answer was $4z^2 - 3z$. She said that the $3z$ terms in the numerator and denominator would "cancel out." Was she correct? Explain.

563. Matt, who is one of Mischa's classmates, said that her answer could not possibly be correct because it only had 2 terms. Was he right?

564. Stephanie, who is another one Mischa's classmates, told Mischa she could have found her mistake if she had checked her answer. Show the result if Stephanie checked Mischa's answer and if she checked the correct answer.

565. Justin's algebra instructor put the following division problem on a quiz:

$$\left(x^5 - 1\right) \div \left(x - 1\right).$$

Justin wrote the problem in the following way:

$$x - 1\overline{)x^5 - 1}.$$

What difficulty do you expect Justin will have when he tries to perform this division?

566. You are given the following division problem:

$$\left(-12x^3 + 10x^2 + x - 8\right) \div \left(3x - 2\right).$$

By looking at this problem, but without performing the division, determine which of the following would be the first term of the quotient.

(a) $-4x$ (b) $4x^2$ (c) $-4x^2$ (d) $-9x^2$

567. A student performs the division

$$\frac{3x^3 - 2x^2 + x - 5}{x - 4},$$

and obtains a remainder of $x - 33$. Without working the problem, explain why this remainder cannot be correct.

568. Two students give the following answers to a problem in which a polynomial is divided by the binomial $2x - 5$:

$$\text{Amanda:} \quad 8x + 5 + \frac{-7}{2x - 5}$$

$$\text{Dale:} \quad 8x + 5 - \frac{7}{2x - 5}.$$

Can both answers be correct? Explain.