Practice: Exponents

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Mini Reference. For $a \neq 0$, $m, n \in \mathbb{Q}$:

$$a^m a^n = a^{m+n}, \quad \frac{a^m}{a^n} = a^{m-n}, \quad (a^m)^n = a^{mn}, \quad a^{-m} = \frac{1}{a^m}, \quad a^0 = 1, \quad a^{\frac{p}{q}} = \sqrt[q]{a^p}.$$

Combining the Exponent Laws

1. Write in a simpler form and evaluate.
   a) $\dfrac{7^5 \cdot 7}{7^3}$ $7^3 = 343$
   b) $\left((-2)^3\right)^2$ $(-8)^2 = 64$
   c) $\left(\dfrac{3^4}{3^2}\right)^3$ $(3^2)^3 = 3^6 = 729$
   d) $\dfrac{(0.6)^7}{(0.6)^3(0.6)^2}$ $(0.6)^2 = 0.36$
   e) $-4^5 \cdot 4^{-3} - 4^2 = -16$
   f) $(-6)^4 \cdot (-6)^{-2}$ $(-6)^2 = 36$
   g) $-12^3 + (-12)^2$ $-1728 + 144 = -1584$
   h) $\dfrac{-9^9}{-9^7}$ $9^2 = 81$
2. Write each expression in simplest form without brackets.
   a) $(-x)^{10} + (-x)^4$ $x^{10} + x^4$
   b) $(-a)^7 + (-a)^3$ $-(a^7 + a^3)$
   c) $-p^6 + (-p)^2$ $-p^6 + p^2$
   d) $c^4 + (-c)^6$ $c^4 + c^6$
   e) $-r^5 + (-r)^5$ $-2r^5$
   f) $-t^4 + (-t)^3$ $-t^4 - t^3$
3. The simplified form of $\dfrac{1}{48}(3x^2)^3(-2xy^2)$ is
   A. $-\dfrac{9}{8}x^7y^2$
   B. $-\dfrac{3}{2}x^7y^2$
   C. $-\dfrac{9}{8}x^6y^2$
   D. $-\dfrac{1}{6}x^7y$
   A
4. $\dfrac{(4x^{-3}y^5)^2}{(2xy)^4}$ equals
   A. $\dfrac{y^6}{x^{10}}$
   B. $\dfrac{4y^6}{x^{14}}$
   C. $\dfrac{1}{4}x^{-14}y^{-6}$
   D. $\dfrac{4}{x^{14}}y^6$
   A
5. Simplify $(-2m^2n^{-3})^3(4m^{-1}n^2)^2\left(\dfrac{1}{8m^3n}\right)$ to the form $m^a n^b$. Enter $a + b$. $-16m^1n^{-6}$ *so* $1 + (-6) = -5$.
6. Simplify each expression.
   a) $a^{x+3}\,a^{2x-1}$ a^{3x+2}
   b) $\dfrac{m^{x+7}}{m^3}$ m^{x+4}
   c) $\dfrac{p^{3m+1}}{p^{m-4}}$ p^{2m+5}
   d) $\dfrac{x^{2y+5}\,x^{3y+1}}{x^{y+8}}$ x^{4y-2}

Integral Exponents

1. Write the following with *positive* exponents.
   a) x^{-4} $\frac{1}{x^4}$
   b) y^{-7} $\frac{1}{y^7}$
   c) 5^{-1} $\frac{1}{5}$
   d) $\frac{1}{a^{-3}}$ a^3
   e) $\frac{1}{6^{-1}}$ 6
2. Without a calculator, show $\frac{4}{8^{-2}} = 256$. $8^{-2} = 1/64$, *so* $4 \div \frac{1}{64} = 256$.
3. Simplify, express with positive exponents, and evaluate.
   a) $2^5 \cdot 2^{-3}$ $2^2 = 4$
   b) $10^0 \cdot 10^{-2}$ $10^{-2} = \frac{1}{100}$
   c) $\frac{1}{9^{-2}}$ $9^2 = 81$
   d) $\frac{7^{-3}}{7^{-1}}$ $7^{-2} = \frac{1}{49}$
   e) $(3^2)^{-2}$ $3^{-4} = \frac{1}{81}$
4. Express with positive exponents.
   a) n^2m^{-5} $\frac{n^2}{m^5}$
   b) $c^{-2}x^{-5}$ $\frac{1}{c^2x^5}$
   c) $16h^{-1}$ $\frac{16}{h}$
   d) $\frac{2}{3}\,b^{-8}$ $\frac{2}{3b^8}$
   e) $(y^{-4})^{-2}$ y^8
   f) $\frac{r^{-5}}{4}$ $\frac{1}{4r^5}$
   g) $\frac{1}{4x^{-9}}$ $\frac{x^9}{4}$
   h) $\frac{4}{x^{-9}}$ $4x^9$
   i) $\frac{a^2}{b^{-7}}$ a^2b^7
   j) $\frac{a^{-2}}{b^7}$ $\frac{1}{a^2b^7}$
5. Evaluate without a calculator.
   a) -2^{-3} $-\frac{1}{8}$
   b) $(-3)^{-2}$ $\frac{1}{9}$
   c) $-7^2 \cdot 8^{-2}$ $-\frac{49}{64}$
   d) $(-5)^0$ 1
   e) $[-(4.2)^0]^{-2}$ 1
6. Use a calculator (exact fraction/decimal).
   a) -4^{-3} $-\frac{1}{64}$
   b) $(-7)^{-1}$ $-\frac{1}{7}$
   c) $(0.5)^{-3}$ 8
   d) $(-0.02)^{-2}$ 2500
   e) $\left(\frac{5}{8}\right)^{-3}$ $\frac{512}{125}$
7. True or false.
   a) $6x^{-3} = \frac{6}{x^3}$ *T*
   b) $5a^{-4} = \frac{1}{5a^4}$ *F*
   c) $\frac{4}{b^{-6}} = 4b^6$ *T*
   d) $\frac{x^{-3}}{2} = \frac{2}{x^3}$ *F*
   e) $\frac{1}{5y^{-1}} = 5y$ *F*
   f) $\frac{1}{4p} = \frac{1}{4}p^{-1}$ *T*
   g) $(3x)^5 = \frac{1}{(3x)^{-5}}$ *T*
   h) $\left(\frac{1}{7}a\right)^{-2} = 49a^2$ *F*
8. Simplify with positive exponents.
   a) $x^8 \cdot x^{-5}$ x^3
   b) $m^5 + m^8$ *not like terms*
   c) $b^{-1} \cdot b^{-3}$ $\frac{1}{b^4}$
   d) $-w^0 + w^5$ $-1 + w^5$

9. Simplify with positive exponents.

a) $a^8 \times a^{-10}$ $\frac{1}{a^2}$

b) $10x^2 + 2x^{-1}$ $10x^2 + \frac{2}{x}$

c) $\frac{6y^{-6}}{2y^{-4}}$ $\frac{3}{y^2}$

d) $\frac{2a^{-5}}{4b^6}$ $\frac{1}{2a^5b^6}$

e) $-7x^{-2}$ $-\frac{7}{x^2}$

f) $-(7x)^{-2}$ $-\frac{1}{49x^2}$

g) $(-7x)^{-2}$ $\frac{1}{49x^2}$

h) $\frac{(-7x)^{-2}}{-7x^{-2}}$ $-\frac{1}{343}$

10. Simplify, answers with positive exponents.

a) $a^{-3}a^{-3}$ $\frac{1}{a^6}$

b) $(5b^8b^{-12})(-10b^3b^{-12})$ $-\frac{50}{b^{13}}$

c) $(-7x^3x^{-5})(x^2x^{-3})$ $-\frac{7}{x^3}$

d) $(-2a^3)^{-3} \cdot 3a^{12}$ $-\frac{3}{8}a^3$

e) $\frac{16a^6b^{-3}}{-4a^6b^3}$ $-\frac{4}{b^6}$

f) $(-3a^5b^{-3}c^0)^{-2}$ $\frac{b^6}{9a^{10}}$

11. Simplify. Final answers with positive exponents.

a) $\frac{32a^2b^{-4}}{4a^{-3}b^{-2}} \times \frac{-8a^{-2}}{-3b^{-3}}$ $\frac{64}{3}a^3b$

b) $\frac{10(p^3q^2r^0)^{-3}}{(8p^{-3}q^5r^3)^{-2}}$ $640\,\frac{q^4r^6}{p^{15}}$

c) $(-2x^5y^3z^8)^2 - (-2x^2y^{-8}z^{12})^3$ $4x^{10}y^6z^{16} + 8x^6\frac{z^{36}}{y^{24}}$

d) $(5a^3b^2)(-2a^{-2}b)^{-3} + (-5a^8b^{-9})^{-2}$ $-\frac{5}{8}a^9b^{-1} + \frac{1}{25}\frac{b^{18}}{a^{16}}$

12. Evaluate without a calculator.

a) $\left(\frac{2}{3}\right)^{-3}$ $\frac{27}{8}$

b) $\left(\frac{1}{5}\right)^{-2}$ 25

c) $\left(\frac{8}{5}\right)^{-1}$ $\frac{5}{8}$

d) $\left(\frac{3}{2}\right)^{-4}$ $\frac{16}{81}$

13. Simplify. Final answers with positive exponents.

a) $\left(\frac{c}{d}\right)^{-3}$ $\frac{d^3}{c^3}$

b) $\left(\frac{x}{4}\right)^{-3}$ $\frac{64}{x^3}$

c) $\left(\frac{p^2}{r^4}\right)^{-3}$ $\frac{r^{12}}{p^6}$

d) $\left(\frac{a^{-2}}{b^{-5}}\right)^{-3}$ $\frac{a^6}{b^{15}}$

e) $\left(\frac{-12x^{-3}}{6y^{-8}}\right)^{-1}$ $-\frac{x^3}{2y^8}$

f) $\left(\frac{12x^3y^{-1}}{-8x^{-1}y^5}\right)^{-2}$ $\frac{4y^{12}}{9x^8}$

14. Simplify. Final answers with positive exponents.

a) $\left(\frac{-x^3}{y}\right)^{-2} + \left(\frac{y^3}{x^5}\right)^2$ $\frac{y^2}{x^6} + \frac{y^6}{x^{10}}$

b) $49\left(\frac{7w^3x^{-5}z^4}{w^{-3}z}\right)^{-2} \times \frac{14(x^4z^8)^0}{x^{-8}z}$ $\frac{14x^{18}}{w^{12}z^7}$

15. The value of $\frac{2^{-3}+4^0}{2^{-1}}$ is

A. 2 **B.** $\frac{9}{4}$ **C.** 6 **D.** 8 ***B***

16. Let $p = 5\times10^{-6}$ and $q = 4\times10^{7}$. If $r = 5\times10^{3}$ and $\frac{pq}{r} = c \times 10^n$, then n equals

A. -2 **B.** -1 **C.** 1 **D.** 2 ***A***

17. Which statements are true?

i) $3a^{-3} = \frac{1}{3a^3}$, ii) $8x^4 \cdot 4x^7 = \frac{1}{2x^3}$, iii) $\frac{1}{2a} = 2a^{-1}$.

A. i only **B.** ii only **C.** iii only **D.** none ***D***

Scientific Notation

1. Complete the table.

Standard Notation	Expanded Form	Scientific Notation
246 000	2.46×10^5	2.46×10^5
18.7	1.87×10^1	1.87×10^1
56 000	5.6×10^4	5.6×10^4
	9.2×10^6	9.2×10^6
	7.5×10^2	7.5×10^2
		6.8×10^3
		3.9×10^1

2. Express each number in scientific notation.
   a) 4 750 4.75×10^3
   b) 12 040 000 1.204×10^7
   c) 0.0063 6.3×10^{-3}
   d) 98.2 9.82×10^1
   e) 0.000 000 74 7.4×10^{-7}

3. Express the number of kilometres in scientific notation.
   a) 384 400 km 3.844×10^5
   b) 2 500 000 km 2.5×10^6

4. Express each number in standard notation.
   a) 1.2×10^{11} 120 000 000 000
   b) 6.73×10^4 67 300
   c) 9.99×10^6 9 990 000
   d) 4.5×10^{-2} 0.045

5. Simplify and write in scientific notation.
   a) $(3.2 \times 10^4) \times 1000$ 3.2×10^7
   b) $(8.91 \times 10^7) \times 10$ 8.91×10^8
   c) $\dfrac{7.2 \times 10^8}{1000}$ 7.2×10^5
   d) $\dfrac{25\,000}{5 \times 10^2}$ 5.0×10^1

2. Complete the table.

Standard Notation	Expanded Form	Scientific Notation
0.000 0042	$4.2 \div 10^6$	4.2×10^{-6}
0.000 1	$1 \div 10^4$	1.0×10^{-4}
	$\frac{3.5}{10^4}$	3.5×10^{-4}
	$\frac{9.9}{10}$	9.9×10^{-1}
		6.9×10^{-2}
		8.5×10^{-4}

3. For each number, indicate how many places (and in which direction) the decimal must move to make the leading number between 1 and 10.
   a) 35 *Left* 1
   b) 480 000 *Left* 5
   c) 0.0042 *Right* 3
   d) 0.63 *Right* 1
   e) 91 230 000 *Left* 7

4. Express each number in scientific notation.
   a) 0.000 018 1.8×10^{-5}
   b) 0.007 7.0×10^{-3}
   c) 0.000 000 94 9.4×10^{-7}
   d) 102 600 1.026×10^5
   e) 0.6 6.0×10^{-1}
   f) 890 000 000 8.9×10^8
   g) 0.000 005 2 5.2×10^{-6}
   h) 0.034 3.4×10^{-2}
   i) 61 500 000 6.15×10^7

5. Express each number in *standard* notation.
   a) 2.7×10^{-3} 0.0027
   b) 5.01×10^{-8} 0.0000000501
   c) 1.28×10^{-4} 0.000128
   d) 7.45×10^{6} $7\,450\,000$
   e) 9.3×10^{1} 93

6. Express in scientific notation.
   a) 34.2×10^{5} 3.42×10^{6}
   b) 0.72×10^{3} 7.2×10^{2}
   c) 0.056×10^{-7} 5.6×10^{-9}
   d) 456×10^{-9} 4.56×10^{-7}
   e) 0.0045×10^{12} 4.5×10^{9}

7. Calculator—answer in scientific notation.
   a) $(3.2 \times 10^{8})(4.0 \times 10^{-5})$ 1.28×10^{4}
   b) $(1.5 \times 10^{5}) + (2.5 \times 10^{2})$ 1.5025×10^{5}
   c) $(0.06 \times 10^{-3})(0.2 \times 10^{-8})$ 1.2×10^{-13}
   d) $(2.3 \times 10^{1}) + (0.45 \times 10^{8})$ 4.5000023×10^{7}

8. Calculator—answer in *standard* notation.
   a) $(4.8 \times 10^{2})(2.4 \times 10^{-7})$ 0.0001152
   b) $(9.1 \times 10^{2}) + (0.75 \times 10^{-2})$ 910.0075
   c) $(0.04 \times 10^{-3})(3.0 \times 10^{-3})$ 0.00000012
   d) $(7.2) + (0.95 \times 10^{7})$ $9\,500\,007.2$

9. A number is $6\,950\,000$. In $a \times 10^{n}$ the value of n is **A.** 3 **B.** 4 **C.** 6 **D.** 7 ***C***

10. A film earned about $2\,450$ million dollars. In scientific notation this amount is **A.** 2.45×10^{10} **B.** 2.45×10^{9} **C.** 2.45×10^{6} **D.** 2.45×10^{3} ***B***

11. Speed of light $= 3 \times 10^{8}$ m/s; distance Earth–Sun $= 1.5 \times 10^{11}$ m. If time is $a \times 10^{n}$ seconds, find $a + n =$ _____.
    $\frac{1.5 \times 10^{11}}{3 \times 10^{8}} = 0.5 \times 10^{3} = 5.0 \times 10^{2} \Rightarrow a + n = 7.$

Rational Exponents — Part One

1. Evaluate without a calculator.
   a) $27^{\frac{1}{3}}$ 3
   b) $81^{\frac{1}{2}}$ 9
   c) $8^{\frac{2}{3}}$ 4
   d) $125^{\frac{1}{3}}$ 5
   e) $36^{\frac{1}{2}}$ 6
   f) $64^{\frac{1}{4}}$ $2\sqrt{2}$
   g) $49^{\frac{3}{2}}$ $7^3 = 343$
   h) $(9^2 + 16^2)^{\frac{1}{2}}$ $\sqrt{337}$
   i) $(0.25)^{0.5}$ 0.5
2. Determine the exact value without a calculator.
   a) $16^{-\frac{1}{2}}$ $\frac{1}{4}$
   b) $27^{-\frac{2}{3}}$ $\frac{1}{9}$
   c) $81^{-\frac{3}{4}}$ $\frac{1}{27}$
   d) $1000^{-\frac{1}{3}}$ $\frac{1}{10}$
   e) $64^{-\frac{5}{6}}$ $\frac{1}{32}$
3. Determine the exact value.
   a) $\left(\frac{1}{36}\right)^{\frac{1}{2}}$ $\frac{1}{6}$
   b) $\left(\frac{1}{9}\right)^{-\frac{1}{2}}$ 3
   c) $\left(\frac{1}{8}\right)^{\frac{4}{3}}$ $\frac{1}{16}$
   d) $\left(\frac{25}{9}\right)^{-\frac{3}{2}}$ $\frac{27}{125}$
   e) $\left(\frac{49}{16}\right)^{-\frac{3}{4}}$ $\frac{8\sqrt{7}}{49}$
4. Determine the exact value.
   a) $(-64)^{\frac{1}{3}}$ -4
   b) $(-8)^{\frac{2}{3}}$ 4
   c) $(-125)^{-\frac{1}{3}}$ $-\frac{1}{5}$
   d) $-(-27)^{\frac{2}{3}}$ -9
   e) $(-0.01)^{\frac{1}{2}}$ *No real value*
5. Use a calculator to two decimals.
   a) $5^{\frac{4}{3}}$ 8.55
   b) $7^{\frac{3}{4}}$ 4.30
   c) $(-6)^{\frac{2}{3}}$ 3.30
   d) $8^{-0.25}$ 0.59
   e) $(-0.5)^{\frac{2}{3}}$ 0.63
6. Write an equivalent expression using radicals.
   a) $a^{\frac{1}{4}}$ $\sqrt[4]{a}$
   b) $b^{\frac{1}{2}}$ $\sqrt{b}$
   c) $c^{\frac{2}{3}}$ $\sqrt[3]{c^2}$
   d) $d^{\frac{1}{5}}$ $\sqrt[5]{d}$
   e) $e^{\frac{1}{10}}$ $\sqrt[10]{e}$
   f) $f^{\frac{3}{2}}$ $\sqrt{f^3}$
   g) $g^{\frac{4}{3}}$ $\sqrt[3]{g^4}$
   h) $h^{\frac{5}{7}}$ $\sqrt[7]{h^5}$
7. A cube has volume 343 cm^3.
   a) Edge length (cm): $343^{1/3} = 7$
   b) Surface area (cm^2): $6 \cdot (343^{1/3})^2 = 6 \cdot 49 = 294$
8. A cube has volume V cm^3.
   a) Edge length: $V^{\frac{1}{3}}$
   b) Face area: $V^{\frac{2}{3}}$
9. Rewrite in radical form (evaluate when possible).
   a) $5^{\frac{1}{2}}$ $\sqrt{5}$
   b) $8^{\frac{1}{3}}$ 2
   c) $(-3)^{\frac{1}{3}}$ $-\sqrt[3]{3}$
   d) $\left(\frac{1}{4}\right)^{-\frac{1}{2}}$ 2
   e) $6^{-\frac{1}{2}}$ $\frac{1}{\sqrt{6}}$
   f) $100^{\frac{2}{3}}$ $\sqrt[3]{100^2}$
10. Order from greatest to least:
    $(-64)^{-\frac{2}{3}}$, $\left(\frac{1}{16}\right)^{\frac{1}{3}}$, $(-64)^{\frac{2}{3}}$, $\left(\frac{1}{16}\right)^{-\frac{1}{3}}$. 3, 4, 2, 1

Rational Exponents — Part Two

1. Write each power as an entire radical.
   a) $a^{\frac{4}{3}}$ $\sqrt[3]{a^4}$
   b) $b^{\frac{3}{2}}$ $\sqrt{b^3}$
   c) $c^{\frac{1}{4}}$ $\sqrt[4]{c}$
   d) $x^{-\frac{2}{3}}$ $\frac{1}{\sqrt[3]{x^2}}$
   e) $y^{-\frac{1}{3}}$ $\frac{1}{\sqrt[3]{y}}$
   f) $(2m)^{\frac{2}{3}}$ $\sqrt[3]{(2m)^2}$
   g) $(3n)^{\frac{2}{3}}$ $\sqrt[3]{(3n)^2}$
   h) $(-a)^{-\frac{5}{4}}$ $\frac{1}{\sqrt[4]{(-a)^5}}$
   i) $(-b)^{\frac{5}{4}}$ $\sqrt[4]{(-b)^5}$
   j) $(4x)^{-\frac{1}{2}}$ $\frac{1}{\sqrt{4x}}$
2. Simplify and then write an entire radical when appropriate.
   a) $2x^{\frac{3}{8}} \cdot 5x^{-\frac{3}{8}}$ 10
   b) $y^{\frac{6}{5}} + y^{\frac{4}{5}}$ $y^{4/5}(y^{2/5}+1)$
   c) $\left(a^{\frac{2}{3}}\right)^{\frac{3}{4}}$ $a^{1/2} = \sqrt{a}$
   d) $(c^2 d)^{\frac{3}{2}}$ $c^3 d^{3/2}$
   e) $x^{\frac{1}{2}} \cdot x^{-1}$ $x^{-1/2} = \frac{1}{\sqrt{x}}$
   f) $y^{\frac{2}{7}} + y^{\frac{5}{7}}$ $y^{2/7}(1+y^{3/7})$
   g) $\left(\frac{x}{y^4}\right)^{\frac{1}{2}}$ $\frac{\sqrt{x}}{y^2}$
   h) $\left(\frac{x^2}{y}\right)^{-\frac{3}{2}}$ $\frac{y^{3/2}}{x^3}$
3. Simplify.
   a) $64\left(a^{\frac{2}{3}}\right)^{\frac{1}{3}}$ $64a^{2/9}$
   b) $\left((16a)^{\frac{1}{3}}\right)^{\frac{1}{2}}$ $(16a)^{1/6}$
   c) $\left(81a^{\frac{1}{3}}\right)^{\frac{1}{2}}$ $9a^{1/6}$
   d) $y^{\frac{3}{2}} \cdot y^{\frac{1}{2}}$ y^2
   e) $a^3 b^{\frac{1}{2}}$ $a^3\sqrt{b}$
   f) $\frac{10x^{-\frac{3}{5}}}{5x^{\frac{3}{5}}}$ $2x^{-6/5}$
   g) $\frac{(a^4)^{\frac{1}{3}} + a}{9}$ $\frac{a^{4/3}+a}{9}$
4. Write each radical as a power a^n.
   a) $\sqrt[5]{a^3}$ $a^{3/5}$
   b) $\sqrt[5]{a^4}$ $a^{4/5}$
   c) $\sqrt{a^5}$ $a^{5/2}$
   d) $\frac{1}{\sqrt[4]{a}}$ $a^{-1/4}$
   e) $\frac{1}{\sqrt[4]{a^5}}$ $a^{-5/4}$
5. Write as a power and evaluate.
   a) $\sqrt[3]{\sqrt{64}}$ 2
   b) $\frac{1}{\sqrt[4]{625}}$ $\frac{1}{5}$
   c) $\sqrt{\sqrt{2401}}$ 7
6. Put in the form ax^n, $a \in \mathbb{Z}$, $n \in \mathbb{Q}$.
   a) $\sqrt[3]{27x^7}$ $3x^{7/3}$
   b) $\sqrt[4]{81x^3}$ $3x^{3/4}$
   c) $\sqrt[3]{-64x}$ $-4x^{1/3}$
   d) $\sqrt[4]{x^3}\sqrt{x}$ $x^{5/4}$
   e) $3\sqrt[3]{x} \cdot 3\sqrt[3]{x}$ $9x^{2/3}$
   f) $\left(\frac{25\sqrt[3]{x^5}}{5x^{1/3}}\right)^2$ $25x^{8/3}$
7. Equivalent expressions using positive exponents.
   a) $\sqrt{\sqrt{x^5}}$ $x^{5/4}$
   b) $\sqrt[3]{\sqrt{a^8}}$ $a^{4/3}$
   c) $\sqrt[3]{\sqrt{729y^{12}}}$ $3y^2$
   d) $\sqrt[3]{\sqrt{x^{2/3}}}$ $x^{1/9}$
   e) $(\sqrt[4]{2y-3})^{-3}$ $(2y-3)^{-3/4}$
   f) $\left(\sqrt[4]{x^4y^3}\right)^{3/2}$ $x^{3/2}y^{9/8}$
   g) $-\sqrt[3]{x^2}$ $-x^{2/3}$
   h) $\sqrt[3]{(-x)^2}$ $(-x)^{2/3}$

8. **Matching.** Match the numbers to letters. Assume $p, q > 0$.

(1) $\left(\frac{p}{q}\right)^{\frac{4}{3}}$

(2) $\left(\frac{p}{q}\right)^{\frac{3}{4}}$

(3) $\left(\frac{q}{p}\right)^{-\frac{4}{3}}$

(4) $\left(\frac{p}{q}\right)^{-\frac{3}{4}}$

(5) $\left(\frac{q}{p}\right)^{\frac{3}{4}}$

(A) $\sqrt[4]{\frac{q^3}{p^3}}$ (B) $\sqrt[4]{\frac{p^3}{q^3}}$ (C) $\sqrt[3]{\frac{p^4}{q^4}}$ (D) $\sqrt[3]{\frac{q^4}{p^4}}$

(1) C, (2) B, (3) C, (4) A, (5) A (repeats allowed)

9. **Multiple Choice.** Which is equivalent to $(-x^3)^{-\frac{5}{3}}$?

A. x^5 **B.** $-x^{1/3}$ **C.** $\frac{1}{x^5}$ **D.** $-\frac{1}{x^5}$ ***D***

10. **Multiple Choice.** Which is *not* equivalent to the others?

A. $a^{-\frac{4}{3}}$ **B.** $(\frac{1}{a^4})^{\frac{1}{3}}$ **C.** $\frac{1}{\sqrt[3]{a^4}}$ **D.** $\frac{1}{a^{4/3}}$

(none; all three are equivalent)

Practice Test — Exponents

1. The base and exponent in $(-3)^4$ are respectively
   A. -3 and 4 **B.** 3 and 4 **C.** -3 and -4 **D.** 4 and -3 *A*
2. The coefficient in $\dfrac{-5x^4}{2}$ is **A.** -5 **B.** $-\dfrac{5}{2}$ **C.** $\dfrac{-5x}{2}$ **D.** -2 *B*
3. $-a^0$ is equivalent to **A.** 0 **B.** 1 **C.** -1 **D.** $-a$ *C*
4. Consider: I) $4p^2q = 4ppq$; II) $(xy)^3 = x^3y^3$.
   A. I only **B.** II only **C.** I and II **D.** neither
   C
5. Which can be simplified to a^6? **A.** $a^2 \cdot a^4$ **B.** $(a^3)^2$ **C.** $\dfrac{a^8}{a^2}$ **D.** all of these *D*
6. $7a^3 \cdot 2a^4$ simplifies to **A.** $14a^{12}$ **B.** $9a^7$ **C.** $14a^7$ **D.** a^{12} *C*
7. $\dfrac{6a^{15}}{3a^7}$ can be written as **A.** $2a^8$ **B.** $\dfrac{1}{2}a^8$ **C.** $2a^{22}$ **D.** $\dfrac{1}{2}a^{22}$ *A*
8. $(-2p^3q)(3pq^2)(-4p^2q^3) = a\,p^x q^y$. The value of a is 24.
9. x^{-3} is equivalent to
   A. $\dfrac{1}{x^3}$ **B.** $\dfrac{1}{x^{-3}}$ **C.** $-3x$ **D.** $-\dfrac{1}{x^3}$ *A*
10. $\dfrac{12x^3}{2x^{-4}}$ simplifies to
    A. $6x^7$ **B.** $6x^{-7}$ **C.** $\dfrac{6}{x^7}$ **D.** $\dfrac{6}{x}$ *A*
11. $4x^{-2}$ is equivalent to
    A. $\dfrac{4}{x^2}$ **B.** $\dfrac{1}{4x^2}$ **C.** $4x^2$ **D.** $-\dfrac{4}{x^2}$ *A*
12. If $(2.5 \times 10^{-3})(4 \times 10^n) = 1.0 \times 10^2$, then $n =$
    A. 4 **B.** 5 **C.** 7 **D.** 9 ***A***
13. Copier paper is 1.0×10^{-4} m thick. About how many sheets make 0.25 m?
    A. 2.5×10^3 **B.** 2.5×10^4 **C.** 2.5×10^5 **D.** 2.5×10^6 *A*
14. Express $x^{3/5}$ in radical form.
    A. $\sqrt[5]{x^3}$ **B.** $\sqrt[3]{x^5}$ **C.** $\sqrt{x^{3/5}}$ **D.** $\dfrac{1}{\sqrt[5]{x^3}}$ *A*
15. If $a > 0$, which must be negative?
    A. $a^{-\frac{4}{3}}$ **B.** $(-a)^{-\frac{4}{3}}$ **C.** $(-a)^{-\frac{5}{4}}$ **D.** $-a^{\frac{5}{4}}$
    D
16. Use $(2^a)^4 = 2^{24}$, $(3^2)^b = 3^{10}$, $\dfrac{5^c}{5^2} = 5^4$, $7^d \cdot 7^3 = 7^{11}$.
    Find a, b, c, d. 6, 5, 6, 8
17. Write $\dfrac{(-3p^2q)^3(2pq^2)^{-2}}{6} = p^m q^n$ and find $m + n$. 3

Written Response (5 marks)

Use the following information for all parts: Average height $= 1.65$ m; hairs/person $= 1.25 \times 10^5$; world population $= 6.80 \times 10^9$; Earth circumference $= 4.00 \times 10^7$ m; $m_{\text{Earth}} = 5.98 \times 10^{24}$ kg; $m_{\text{Sun}} = 1.99 \times 10^{30}$ kg; $m_{\text{Mercury}} = 3.30 \times 10^{23}$ kg; $m_e = 9.11 \times 10^{-31}$ kg.

1. To the nearest million, how many people laid head-to-toe would encircle the Earth once? (Standard form.) $\dfrac{4.00 \times 10^7 \ m}{1.65 \ m/person} \approx 2.424 \times 10^7 \ people \Rightarrow \boxed{24{,}000{,}000}$
2. Estimate the total number of human hairs on Earth. (Scientific notation; mantissa to the nearest hundredth.) $(1.25 \times 10^5)(6.80 \times 10^9) = 8.50 \times 10^{14} \Rightarrow \boxed{8.50 \times 10^{14}}$
3. Approximately how many electrons have the same mass as Mercury? (Scientific notation; nearest hundredth.) $\dfrac{3.30 \times 10^{23}}{9.11 \times 10^{-31}} = \dfrac{3.30}{9.11} \times 10^{54} \approx 0.362 \times 10^{54} = \boxed{3.62 \times 10^{53}}$
4. How many times heavier is the Sun than the combined mass of Earth and Mercury? (Standard decimal, nearest thousand.) $\dfrac{1.99 \times 10^{30}}{5.98 \times 10^{24} + 3.30 \times 10^{23}} \approx 3.15 \times 10^5 \Rightarrow \boxed{315{,}000}$