

- 1 a** Add indices:
 $x^3 \times x^4 = x^{3+4} = x^7$
- b** Add indices:
 $a^5 \times a^{-3} = a^{5+(-3)} = a^2$
- c** Add indices:
 $x^2 \times x^{-1} \times x^2 = x^{2+(-1)+2} = x^3$
- d** Subtract indices:
 $\frac{y^3}{y^7} = y^{3-7} = y^{-4}$
- e** Subtract indices:
 $\frac{x^8}{x^{-4}} = x^{8-(-4)} = x^{12}$
- f** Subtract indices:
 $\frac{p^{-5}}{p^2} = p^{-5-2} = p^{-7}$
- g** Subtract indices:
 $a^{\frac{1}{2}} \div a^{\frac{2}{3}} = a^{\frac{3}{6} - \frac{4}{6}} = a^{-\frac{1}{6}}$
- h** Multiply indices:
 $(a^{-2})^4 = a^{-2 \times 4} = a^{-8}$
- i** Multiply indices:
 $(y^{-2})^{-7} = y^{-2 \times (-7)} = y^{14}$
- j** Multiply indices:
 $(x^5)^3 = x^{5 \times 3} = x^{15}$
- k** Multiply indices:
 $(a^{-20})^{\frac{3}{5}} = a^{-20 \times \frac{3}{5}} = a^{-12}$
- l** Multiply indices:
 $\left(x^{-\frac{1}{2}}\right)^{-4} = x^{-\frac{1}{2} \times -4} = x^2$
- m** Multiply indices:
 $(n^{10})^{\frac{1}{5}} = n^{10 \times \frac{1}{5}} = n^2$
- n** Multiply the coefficients and add the indices:
 $2x^{\frac{1}{2}} \times 4x^3 = (2 \times 4)x^{\frac{1}{2}+3} = 8x^{\frac{7}{2}}$
- o** Multiply the first two indices and add the third:
 $(a^2)^{\frac{5}{2}} \times a^{-4} = a^{2 \times \frac{5}{2}} \times a^{-4}$
 $= a^{5+(-4)}$
 $= a^1 = a$
- p** $\frac{1}{x^{-4}} = x^{1 \div -4} = x^4$
- q** $\left(2n^{-\frac{2}{5}}\right)^5 \div (4^3 n^4) = 2^5 n^{-\frac{2}{5} \times 5} \div ((2^2)^3 n^4)$
 $= 2^5 n^{-2} \div (2^6 n^4)$
 $= 2^{5-6} n^{-2-4}$

$$= 2^{-1}n^{-6} = \frac{1}{2n^6}$$

r Multiply the coefficients and add the indices.

$$x^3 \times 2x^{\frac{1}{2}} \times -4x^{-\frac{3}{2}} = (1 \times 2 \times -4)x^{3+\frac{1}{2}+(-\frac{3}{2})}$$

$$= -8x^2$$

$$s \quad (ab^3)^2 \times a^{-2}b^{-4} \times \frac{1}{a^2b^{-3}} = a^2b^6 \times a^{-2}b^{-4} \times a^{-2}b^3$$

$$= a^{2-2+(-2)}b^{6+(-4)+3}$$

$$= a^{-2}b^5$$

t $(2^2p^{-3} \times 4^3p^5 \div ((6p^{-3}))^0) = 1$
Anything to the power zero is 1.

2 a $25^{\frac{1}{2}} = \sqrt{25} = 5$

b $64^{\frac{1}{3}} = \sqrt[3]{64} = 4$

c $\left(\frac{16}{9}\right)^{\frac{1}{2}} = \frac{16^{\frac{1}{2}}}{9^{\frac{1}{2}}}$

$$= \frac{\sqrt{16}}{\sqrt{9}} = \frac{4}{3}$$

d $16^{-\frac{1}{2}} = \frac{1}{16^{\frac{1}{2}}}$

$$= \frac{1}{\sqrt{16}} = \frac{1}{4}$$

e $\left(\frac{49}{36}\right)^{-\frac{1}{2}} = \frac{1}{\left(\frac{49}{36}\right)^{\frac{1}{2}}}$

$$= \frac{1}{\frac{\sqrt{49}}{\sqrt{36}}}$$

$$= \frac{\sqrt{36}}{\sqrt{49}} = \frac{6}{7}$$

f $27^{\frac{1}{3}} = \sqrt[3]{27} = 3$

g $144^{\frac{1}{2}} = \sqrt{144} = 12$

h $64^{\frac{2}{3}} = \left(64^{\frac{1}{3}}\right)^2 = 4^2 = 16$

i $9^{\frac{3}{2}} = \left(9^{\frac{1}{2}}\right)^3$

$$= 3^3 = 27$$

j $\left(\frac{81}{16}\right)^{\frac{1}{4}} = \frac{81^{\frac{1}{4}}}{16^{\frac{1}{4}}}$

$$= \frac{3}{2}$$

$$\mathbf{k} \quad \left(\frac{23}{5}\right)^0 = 1$$

$$\mathbf{l} \quad 128^{\frac{3}{7}} = \left(128^{\frac{1}{7}}\right)^3 \\ = 2^3 = 8$$

$$\mathbf{3 a} \quad 4.35^2 = 18.9225 \approx 18.92$$

$$\mathbf{b} \quad 2.4^5 = 79.62624 \approx 79.63$$

$$\mathbf{c} \quad \sqrt{34.6921} = 5.89$$

$$\mathbf{d} \quad 0.02^{-3} = 125\,000$$

$$\mathbf{e} \quad \sqrt[3]{0.729} = 0.9$$

$$\mathbf{f} \quad \sqrt[4]{2.3045} = 1.23209\dots \approx 1.23$$

$$\mathbf{g} \quad (345.64)^{-\frac{1}{3}} = 0.14249\dots \approx 0.14$$

$$\mathbf{h} \quad (4.558)^{\frac{2}{5}} = 1.83607\dots \approx 1.84$$

$$\mathbf{i} \quad \frac{1}{(0.064)^{-\frac{1}{3}}} = (0.064)^{\frac{1}{3}} = 0.4$$

$$\mathbf{4 a} \quad \frac{a^2b^3}{a^{-2}b^{-4}} = a^{2-(-2)}b^{3-(-4)} \\ = a^4b^7$$

$$\mathbf{b} \quad \frac{2a^2(2b)^3}{(2a)^{-2}b^{-4}} = \frac{2a^2 \times 2^3b^3}{2^{-2}a^{-2}b^{-4}} \\ = \frac{2^4a^2b^3}{2^{-2}a^{-2}b^{-4}} \\ = 2^{4-(-2)}a^{2-(-2)}b^{3-(-4)} \\ = 2^6a^4b^7 = 64a^4b^7$$

$$\mathbf{c} \quad \frac{a^{-2}b^{-3}}{a^{-2}b^{-4}} = a^{-2-(-2)}b^{-3-(-4)} \\ = a^0b^1 = b$$

$$\mathbf{d} \quad \frac{a^2b^3}{a^{-2}b^{-4}} \times \frac{ab}{a^{-1}b^{-1}} = \frac{a^{2+1}b^{3+1}}{a^{-2+(-1)}b^{-4+(-1)}} \\ = \frac{a^3b^4}{a^{-3}b^{-5}} \\ = a^{3-(-3)}b^{4-(-5)} = a^6b^9$$

$$\mathbf{e} \quad \frac{(2a)^2 \times 8b^3}{16a^{-2}b^{-4}} = \frac{4a^2 \times 8b^3}{16a^{-2}b^{-4}} \\ = \frac{32a^2b^3}{16a^{-2}b^{-4}} \\ = \frac{32}{16}a^{2-(-2)}b^{3-(-4)} \\ = 2a^4b^7$$

$$\begin{aligned}
 \text{f} \quad \frac{2a^2b^3}{8a^{-2}b^{-4}} \div \frac{16ab}{(2a)^{-1}b^{-1}} &= \frac{2a^2b^3}{8a^{-2}b^{-4}} \times \frac{(2a)^{-1}b^{-1}}{16ab} \\
 &= \frac{2a^2b^3}{8a^{-2}b^{-4}} \times \frac{2^{-1}a^{-1}b^{-1}}{16ab} \\
 &= \frac{2^{1+1}a^{2+1}b^{3+1}}{8 \times 16 \times a^{-2+1}b^{-4+1}} \\
 &= \frac{2^0a^1b^2}{128a^{-1}b^{-3}} \\
 &= \frac{1}{128}a^{1-(-1)}b^{2-(-3)} = \frac{a^2b^5}{128}
 \end{aligned}$$

$$\begin{aligned}
 \text{5} \quad \frac{2^n \times 8^n}{2^{2n} \times 16} &= \frac{2^n \times (2^3)^n}{2^{2n} \times 2^4} \\
 &= \frac{2^n \times 2^{3n}}{2^{2n} \times 2^4} \\
 &= \frac{2^{n+3n-2n}}{2^4} \\
 &= \frac{2^4}{2^4} \\
 &= 2^{2n} \times 2^{-4} \\
 &= 2^{2n-4}
 \end{aligned}$$

$$\begin{aligned}
 \text{6} \quad 2^{-x} \times 3^{-x} \times 6^{2x} \times 3^{2x} \times 2^{2x} &= (2 \times 3)^{-x} \times 6^{2x} \times (2 \times 3)^{2x} \\
 &= 6^{-x} \times 6^{2x} \times 6^{2x} \\
 &= 6^{-x+2x+2x} \\
 &= 6^{3x}
 \end{aligned}$$

7 In each case, add the fractional indices.

$$\begin{aligned}
 \text{a} \quad 2^{\frac{1}{3}} \times 2^{\frac{1}{6}} \times 2^{-\frac{2}{3}} &= 2^{\frac{2}{6} + \frac{1}{6} - \frac{4}{6}} \\
 &= 2^{-\frac{1}{6}} = \left(\frac{1}{2}\right)^{\frac{1}{6}}
 \end{aligned}$$

$$\begin{aligned}
 \text{b} \quad a^{\frac{1}{4}} \times a^{\frac{2}{5}} \times a^{-\frac{1}{10}} &= a^{\frac{5}{20} + \frac{8}{20} - \frac{2}{20}} \\
 &= a^{\frac{11}{20}}
 \end{aligned}$$

$$\begin{aligned}
 \text{c} \quad 2^{\frac{2}{3}} \times 2^{\frac{5}{6}} \times 2^{-\frac{2}{3}} &= 2^{\frac{4}{6} + \frac{5}{6} - \frac{4}{6}} \\
 &= 2^{\frac{5}{6}}
 \end{aligned}$$

$$\begin{aligned}
 \text{d} \quad \left(2^{\frac{1}{3}}\right)^2 \times \left(2^{\frac{1}{2}}\right)^5 &= 2^{\frac{2}{3}} \times 2^{\frac{5}{2}} \\
 &= 2^{\frac{4}{6} + \frac{15}{6}} = 2^{\frac{19}{6}}
 \end{aligned}$$

$$\begin{aligned}
 \text{e} \quad \left(2^{\frac{1}{3}}\right)^2 \times 2^{\frac{1}{3}} \times 2^{-\frac{2}{5}} &= 2^{\frac{2}{3}} \times 2^{\frac{1}{3}} \times 2^{-\frac{2}{5}} \\
 &= 2^{\frac{2}{3} + \frac{1}{3} - \frac{2}{5}} = 2^{\frac{3}{5}}
 \end{aligned}$$

$$\begin{aligned}
 \text{8 a} \quad \sqrt[3]{a^3b^2} \div \sqrt[3]{a^2b^{-1}} &= (a^3b^2)^{\frac{1}{3}} \div (a^2b^{-1})^{\frac{1}{3}} \\
 &= a^1b^{\frac{2}{3}} \div a^{\frac{2}{3}}b^{-\frac{1}{3}} \\
 &= a^{1-\frac{2}{3}}b^{\frac{2}{3}-(-\frac{1}{3})} = a^{\frac{1}{3}}b
 \end{aligned}$$

$$\begin{aligned} \text{b} \quad \sqrt{a^3b^2} \times \sqrt{a^2b^{-1}} &= (a^3b^2)^{\frac{1}{2}} \times (a^2b^{-1})^{\frac{1}{2}} \\ &= a^{\frac{3}{2}}b^1 \times a^1b^{-\frac{1}{2}} \\ &= a^{\frac{3}{2}+1}b^{1+\frac{1}{2}} = a^{\frac{5}{2}}b^{\frac{1}{2}} \end{aligned}$$

$$\begin{aligned} \text{c} \quad \sqrt[5]{a^3b^2} \times \sqrt[5]{a^2b^{-1}} &= (a^3b^2)^{\frac{1}{5}} \times (a^2b^{-1})^{\frac{1}{5}} \\ &= a^{\frac{3}{5}}b^{\frac{2}{5}} \times a^{\frac{2}{5}}b^{-\frac{1}{5}} \\ &= a^{\frac{3}{5}+\frac{2}{5}}b^{\frac{2}{5}+\frac{1}{5}} = ab^{\frac{1}{5}} \end{aligned}$$

$$\begin{aligned} \text{d} \quad \sqrt{a^{-4}b^2} \times \sqrt{a^3b^{-1}} &= (a^{-4}b^2)^{\frac{1}{2}} \times (a^3b^{-1})^{\frac{1}{2}} \\ &= a^{-2}b^1 \times a^{\frac{3}{2}}b^{-\frac{1}{2}} \\ &= a^{-2+\frac{3}{2}}b^{1+\frac{1}{2}} \\ &= a^{-\frac{1}{2}}b^{\frac{1}{2}} \\ &= \frac{b^{\frac{1}{2}}}{a^{\frac{1}{2}}} = \left(\frac{b}{a}\right)^{\frac{1}{2}} \end{aligned}$$

$$\begin{aligned} \text{e} \quad \sqrt{a^3b^2c^{-3}} \times \sqrt{a^2b^{-1}c^{-5}} &= (a^3b^2c^{-3})^{\frac{1}{2}} \times (a^2b^{-1}c^{-5})^{\frac{1}{2}} \\ &= a^{\frac{3}{2}}b^1c^{-\frac{3}{2}} \times a^1b^{-\frac{1}{2}}c^{-\frac{5}{2}} \\ &= a^{\frac{3}{2}+1}b^{1+\frac{1}{2}}c^{-\frac{3}{2}-\frac{5}{2}} \\ &= a^{\frac{5}{2}}b^{\frac{1}{2}}c^{-4} \end{aligned}$$

$$\begin{aligned} \text{f} \quad \sqrt[5]{a^3b^2} \div \sqrt[5]{a^2b^{-1}} &= (a^3b^2)^{\frac{1}{5}} \div (a^2b^{-1})^{\frac{1}{5}} \\ &= a^{\frac{3}{5}}b^{\frac{2}{5}} \div a^{\frac{2}{5}}b^{-\frac{1}{5}} \\ &= a^{\frac{3}{5}-\frac{2}{5}}b^{\frac{2}{5}-\frac{1}{5}} = a^{\frac{1}{5}}b^{\frac{3}{5}} \end{aligned}$$

$$\begin{aligned} \text{g} \quad \frac{\sqrt{a^3b^2}}{a^2b^{-1}c^{-5}} \times \frac{\sqrt{a^{-4}b^2}}{a^3b^{-1}} \times \sqrt{a^3b^{-1}} &= \frac{(a^3b^2)^{\frac{1}{2}}}{a^2b^{-1}c^{-5}} \times \frac{(a^{-4}b^2)^{\frac{1}{2}}}{a^3b^{-1}} \times (a^3b^{-1})^{\frac{1}{2}} \\ &= \frac{a^{\frac{3}{2}}b^1}{a^2b^{-1}c^{-5}} \times \frac{a^{-2}b^1}{a^3b^{-1}} \times a^{\frac{3}{2}}b^{-\frac{1}{2}} \\ &= a^{\frac{3}{2}-2}b^{1-1}c^{0-5} \times a^{-2-3}b^{1-1} \times a^{\frac{3}{2}}b^{-\frac{1}{2}} \\ &= a^{-\frac{1}{2}}b^2c^5 \times a^{-5}b^2 \times a^{\frac{3}{2}}b^{-\frac{1}{2}} \\ &= a^{-\frac{1}{2}-5+\frac{3}{2}}b^{2+2+\frac{1}{2}}c^5 \\ &= a^{-4}b^{\frac{7}{2}}c^5 \end{aligned}$$