

1.1 WORKING with SURDS

1. Express each of the following in its simplest form:

- (a) $\sqrt{8}$ (b) $\sqrt{12}$ (c) $\sqrt{50}$ (d) $\sqrt{20}$ (e) $\sqrt{24}$ (f) $\sqrt{108}$
 (g) $\sqrt{60}$ (h) $\sqrt{72}$ (i) $\sqrt{300}$ (j) $\sqrt{27}$ (k) $\sqrt{96}$ (l) $\sqrt{48}$
 (m) $\sqrt{45}$ (n) $\sqrt{98}$ (o) $\sqrt{90}$ (p) $\sqrt{18}$ (q) $\sqrt{28}$ (r) $\sqrt{80}$
 (s) $\sqrt{32}$ (t) $\sqrt{160}$ (u) $\sqrt{150}$ (v) $\sqrt{44}$ (w) $\sqrt{63}$ (x) $\sqrt{175}$

2. Simplify:

- (a) $5\sqrt{8}$ (b) $3\sqrt{32}$ (c) $5\sqrt{40}$ (d) $2\sqrt{12}$ (e) $4\sqrt{18}$ (f) $3\sqrt{24}$
 (g) $3\sqrt{27}$ (h) $10\sqrt{48}$ (i) $2\sqrt{108}$ (j) $3\sqrt{45}$ (k) $2\sqrt{63}$ (l) $4\sqrt{20}$

3. Express each of the following in its simplest form:

- (a) $5\sqrt{2} + 3\sqrt{2}$ (b) $3\sqrt{7} - \sqrt{7}$ (c) $4\sqrt{3} + 2\sqrt{3} - 3\sqrt{3}$
 (d) $5\sqrt{6} - 2\sqrt{6} + \sqrt{6}$ (e) $4\sqrt{3} + 5\sqrt{3}$ (f) $8\sqrt{6} - 2\sqrt{6}$
 (g) $\sqrt{2} + 2\sqrt{2}$ (h) $3\sqrt{7} - 9\sqrt{7}$ (i) $5\sqrt{10} - 5\sqrt{10}$
 (j) $\sqrt{5} + 5\sqrt{5} - 3\sqrt{5}$ (k) $2\sqrt{3} + \sqrt{3} - 5\sqrt{3}$ (l) $5\sqrt{11} + 7\sqrt{11} - \sqrt{11}$

4. Express each of the following in its simplest form:

- (a) $\sqrt{12} + \sqrt{27}$ (b) $\sqrt{32} - \sqrt{8}$ (c) $\sqrt{72} - \sqrt{50}$
 (d) $\sqrt{2} + \sqrt{98}$ (e) $\sqrt{80} + \sqrt{20}$ (f) $\sqrt{24} + \sqrt{54}$
 (g) $\sqrt{180} - \sqrt{45}$ (h) $\sqrt{1000} - \sqrt{90}$ (i) $\sqrt{50} - \sqrt{8}$
 (j) $\sqrt{3} - \sqrt{12}$ (k) $\sqrt{75} + \sqrt{108} - \sqrt{3}$ (l) $\sqrt{5} + \sqrt{20} + \sqrt{80}$
 (m) $\sqrt{108} + \sqrt{12}$ (n) $\sqrt{32} - \sqrt{8}$ (o) $\sqrt{72} - \sqrt{50}$
 (p) $\sqrt{2} + \sqrt{98}$ (q) $\sqrt{80} + \sqrt{20}$ (r) $\sqrt{24} + \sqrt{54}$
 (s) $\sqrt{8} + 5\sqrt{2}$ (t) $3\sqrt{12} + \sqrt{27}$ (u) $3\sqrt{2} + 2\sqrt{8} - \sqrt{18}$

5. Simplify:

- (a) $\sqrt{5} \times \sqrt{5}$ (b) $\sqrt{2} \times \sqrt{2}$ (c) $\sqrt{11} \times \sqrt{11}$
 (d) $\sqrt{a} \times \sqrt{a}$ (e) $\sqrt{6} \times \sqrt{6}$ (f) $\sqrt{c} \times \sqrt{c}$
 (g) $\sqrt{k} \times \sqrt{k}$ (h) $\sqrt{3} \times \sqrt{6}$ (i) $\sqrt{8} \times \sqrt{2}$
 (j) $\sqrt{6} \times \sqrt{2}$ (k) $\sqrt{3} \times \sqrt{5}$ (l) $\sqrt{x} \times \sqrt{y}$
 (m) $\sqrt{2} \times \sqrt{8}$ (n) $\sqrt{12} \times \sqrt{3}$ (o) $\sqrt{5} \times \sqrt{20}$
 (p) $\sqrt{2} \times \sqrt{32}$ (q) $\sqrt{a} \times \sqrt{b}$ (r) $\sqrt{10} \times \sqrt{x}$
 (s) $\sqrt{p} \times \sqrt{q}$ (t) $\sqrt{k} \times \sqrt{6}$ (u) $\sqrt{2} \times \sqrt{10}$
 (v) $\sqrt{24} \times \sqrt{3}$ (w) $\sqrt{5} \times \sqrt{10}$ (x) $\sqrt{6} \times \sqrt{12}$
 (y) $\sqrt{20} \times \sqrt{3}$ (z) $\sqrt{4} \times \sqrt{8}$

6. (a) $3\sqrt{2} \times \sqrt{2}$ (b) $2\sqrt{5} \times 3\sqrt{5}$ (c) $3\sqrt{2} \times 2\sqrt{7}$ (d) $4\sqrt{3} \times 2\sqrt{3}$
 (e) $\sqrt{5} \times 3\sqrt{2}$ (f) $2\sqrt{6} \times 3\sqrt{3}$ (g) $8\sqrt{2} \times \sqrt{12}$ (h) $5\sqrt{3} \times 3\sqrt{5}$

7. Simplify:

- (a) $\frac{\sqrt{8}}{\sqrt{2}}$ (b) $\frac{\sqrt{27}}{\sqrt{12}}$ (c) $\frac{\sqrt{2}}{\sqrt{32}}$ (d) $\frac{\sqrt{3}}{\sqrt{27}}$
 (e) $\frac{\sqrt{20}}{\sqrt{5}}$ (f) $\frac{\sqrt{12}}{\sqrt{48}}$ (g) $\frac{\sqrt{54}}{\sqrt{24}}$ (h) $\frac{\sqrt{175}}{\sqrt{63}}$
 (i) $\frac{\sqrt{18}}{\sqrt{72}}$ (j) $\frac{\sqrt{6}}{\sqrt{54}}$ (k) $\frac{\sqrt{288}}{\sqrt{8}}$ (l) $\frac{\sqrt{1000}}{\sqrt{90}}$
 (m) $\frac{\sqrt{48}}{\sqrt{6}}$ (n) $\frac{\sqrt{3}}{\sqrt{24}}$ (o) $\frac{\sqrt{98}}{\sqrt{7}}$ (p) $\frac{\sqrt{50}}{\sqrt{250}}$

8. Expand and simplify:

- (a) $\sqrt{2}(1 - \sqrt{2})$ (b) $\sqrt{3}(\sqrt{3} + 1)$ (c) $\sqrt{5}(\sqrt{5} - 1)$
 (d) $\sqrt{2}(5 + \sqrt{2})$ (e) $\sqrt{2}(3 + \sqrt{6})$ (f) $2\sqrt{3}(\sqrt{8} + 1)$
 (g) $\sqrt{3}(\sqrt{6} - 2\sqrt{8})$ (h) $\sqrt{5}(\sqrt{5} + 2)$ (i) $4\sqrt{6}(2\sqrt{6} - \sqrt{8})$
 (j) $\sqrt{8}(\sqrt{2} + 4)$ (k) $2\sqrt{12}(\sqrt{3} + \sqrt{6})$ (l) $\sqrt{5}(\sqrt{200} + \sqrt{50})$
 (m) $\sqrt{3}(\sqrt{2} + 1)$ (n) $\sqrt{2}(\sqrt{8} + \sqrt{2})$ (o) $\sqrt{3}(\sqrt{2} + \sqrt{6})$
 (p) $\sqrt{5}(3 - \sqrt{5})$

9. Expand and simplify where possible:

- (a) $(\sqrt{2} + 3)(\sqrt{2} - 1)$ (b) $(\sqrt{5} + 1)(2\sqrt{5} - 4)$ (c) $(2\sqrt{2} + 3)(\sqrt{2} + 4)$
 (d) $(\sqrt{3} + 1)(\sqrt{3} - 1)$ (e) $(2 + \sqrt{5})(2 - \sqrt{5})$ (f) $(\sqrt{3} + \sqrt{2})(\sqrt{3} - \sqrt{2})$
 (g) $(\sqrt{2} - 4)(3\sqrt{2} - 1)$ (h) $(\sqrt{8} + 2)(\sqrt{8} + 1)$ (i) $(2\sqrt{3} + \sqrt{2})(\sqrt{3} + 3\sqrt{2})$
 (j) $(\sqrt{2} + 3)^2$ (k) $(\sqrt{2} + \sqrt{3})^2$ (l) $(2\sqrt{3} - 1)^2$
 (m) $(2\sqrt{7} - \sqrt{2})^2$ (n) $(5 - 2\sqrt{3})^2$ (o) $(\sqrt{3} + \sqrt{5})(\sqrt{3} - \sqrt{5})$
 (p) $(\sqrt{7} + 1)^2$ (q) $(\sqrt{6} + \sqrt{2})^2$ (r) $(\sqrt{2} + \sqrt{3})(\sqrt{2} - \sqrt{3})$

10. Express each of the following with a *rational denominator* and simplify where possible:

- (a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{\sqrt{3}}$ (c) $\frac{1}{\sqrt{5}}$ (d) $\frac{6}{\sqrt{3}}$
 (e) $\frac{10}{\sqrt{5}}$ (f) $\frac{2}{\sqrt{3}}$ (g) $\frac{3}{\sqrt{5}}$ (h) $\frac{20}{\sqrt{2}}$
 (i) $\frac{2}{\sqrt{2}}$ (j) $\frac{12}{\sqrt{3}}$ (k) $\frac{3}{\sqrt{6}}$ (l) $\frac{4}{\sqrt{5}}$
 (m) $\frac{10}{\sqrt{2}}$ (n) $\frac{35}{\sqrt{7}}$

11. Express each of the following with a *rational denominator* and simplify where possible:

- (a) $\frac{1}{2\sqrt{5}}$ (b) $\frac{4}{5\sqrt{2}}$ (c) $\frac{3}{3\sqrt{2}}$ (d) $\frac{12}{5\sqrt{6}}$
 (e) $\frac{8}{3\sqrt{2}}$ (f) $\frac{20}{7\sqrt{5}}$ (g) $\frac{50}{3\sqrt{10}}$ (h) $\frac{10}{3\sqrt{2}}$

12. Express each of the following in its simplest form with a rational denominator.

- (a) $\frac{\sqrt{3}}{\sqrt{2}}$ (b) $\frac{\sqrt{2}}{\sqrt{5}}$ (c) $\frac{\sqrt{8}}{\sqrt{2}}$ (d) $\frac{\sqrt{18}}{\sqrt{3}}$
 (e) $\frac{\sqrt{5}}{\sqrt{20}}$ (f) $\frac{\sqrt{2}}{\sqrt{12}}$ (g) $\frac{\sqrt{15}}{\sqrt{5}}$ (h) $\frac{\sqrt{8}}{\sqrt{6}}$
 (i) $\frac{\sqrt{5}}{\sqrt{2}}$ (j) $\frac{\sqrt{11}}{\sqrt{2}}$ (k) $\frac{\sqrt{7}}{\sqrt{3}}$ (l) $\frac{\sqrt{13}}{\sqrt{5}}$
 (m) $\frac{\sqrt{8}}{3\sqrt{2}}$ (n) $\frac{2\sqrt{3}}{3\sqrt{2}}$ (o) $\frac{5\sqrt{3}}{3\sqrt{5}}$ (p) $\frac{4\sqrt{5}}{5\sqrt{3}}$
 (q) $\frac{\sqrt{6}}{\sqrt{18}}$ (r) $\frac{\sqrt{50}}{\sqrt{10}}$ (s) $\frac{\sqrt{3}}{\sqrt{12}}$ (t) $\frac{\sqrt{5}}{\sqrt{2}}$

13. Express each of the following with a *rational denominator* and simplify where possible:

- (a) $\frac{1}{\sqrt{50}}$ (b) $\frac{18}{\sqrt{27}}$ (c) $\frac{5}{\sqrt{50}}$ (d) $\frac{3}{\sqrt{20}}$
 (e) $\frac{6}{\sqrt{18}}$ (f) $\frac{2}{\sqrt{8}}$ (g) $\frac{10}{\sqrt{12}}$ (h) $\frac{3}{\sqrt{50}}$
 (i) $\frac{4}{\sqrt{32}}$ (j) $\frac{2\sqrt{5}}{\sqrt{54}}$ (k) $\frac{3\sqrt{2}}{\sqrt{24}}$ (l) $\frac{2\sqrt{5}}{\sqrt{45}}$