3 Simplify these expressions using the index laws.

a $n^4 \times n^5 \times n^2$ **b** $p^8 \div p^3 \times p^5$ **c** $y^{13} \div y^4 \div y^2$

5 Simplify:

a $3a^4 \times 5a^3 \times 2a$ **b** $30g^{10} \div 6g^3 \times 4g^5$ **c** $100x^{13} \div 2x \div 5x^4$

d $(3u^5)^3 \times 2u^4$ **e** $56d^{19} \div (2d^4)^3$ **f** $(4k^6)^5 \div (2k^2)^5$

g $\dfrac{9v^8 \times 8v^6}{12v^{11}}$ **h** $\dfrac{8m^{11} \times 10m^2}{5m \times 4m^3}$ **i** $\dfrac{(12b^5)^2}{4b^2 \times (3b^3)^2}$

6 Simplify:

a $\dfrac{(m^6)^3 \times m^4}{m^7}$ **b** $\dfrac{(t^8)^5 \times (t^2)^3}{t^{10}}$ **c** $\dfrac{c^{30}}{(c^2)^4 \times c^6}$

d $\dfrac{s^{15} \times (s^4)^4}{(s^4)^3 \times s^7}$ **e** $(k^9)^5 \div \left(\dfrac{k^4}{k}\right)^7$ **f** $\left(\dfrac{h^{11}}{h^3}\right)^3 \times \dfrac{h^5}{h^3}$

a $\dfrac{(3u^4)^2 \times 6u^{10}}{u^4 \times (3u^2)^3 \times u^2}$ **b** $\dfrac{10(pq)^2 \times 20p^{20}q^{14}}{(2p^6q^3)^2 \times 5p^5q}$

8 Simplify each of the following expressions and evaluate where possible.

a $2^a \times 2^b$ **b** $k^m \times k^n$ **c** $5^x \times 5$ **d** $3^n \times 3^n$

e $2^{5t} \times 2^t$ **f** $p^q \times p^q \times p^q$ **g** $5^{m+1} \times 5^{m+3}$ **h** $a^{2b+5} \times a^{5-2b}$

m $\dfrac{6^{e+3}}{6^3}$ **n** $\dfrac{5^{x+2}}{5^x}$ **o** $\dfrac{m^{p+q}}{m^{p-q}}$ **p** $\dfrac{x^{7y+6}}{x^{4+7y}}$

q $(2^a)^b$ **r** $(n^5)^k$ **s** $(e^f)^f$ **t** $(p^{2q})^6$

u $(5^3)^{7u}$ **v** $(6^{2a})^{3b}$ **w** $(2^x)^{y+z}$ **x** $(a^{m-n})^k$

9 Half of 2^{2n} would be:

A 2^n **B** 1^{2n} **C** 1^n **D** 2^{2n-1}

10 Find one quarter of 2^n in index form.

4 Evaluate:

a $6^0 + 4$ **b** $5 - 12^0$ **c** 4×7^0
d $5^0 + 3^0$ **e** $8a^0 - 2$ **f** $9p^0 \times 5$
g $20 \div 4t^0$ **h** $3 - 10x^0$ **i** $4k^0 + 7m^0$

j $p^0 + q^0 + r^0$ **k** $x^0 - y^0 - z^0$ **l** $3 + 9u^0 - 4^0$

m $6a^0 - b^0 + 3c^0$ **n** $14m^0 + (14m)^0 - 8n^0$ **o** $5^0 + (5a)^0 + 5a^0$

4 Write each expression with a positive index.

a m^{-1} **b** p^{-1} **c** h^{-2} **d** n^{-3} **e** e^{-6} **f** y^{-4}

5 Write each of these with a negative index.

a $\dfrac{1}{a}$ **b** $\dfrac{1}{x}$ **c** $\dfrac{1}{c^2}$ **d** $\dfrac{1}{u^3}$ **e** $\dfrac{1}{p^5}$ **f** $\dfrac{1}{y^8}$

11 Write each of these in surd form.

a $a^{\frac{3}{2}}$

b $m^{\frac{2}{3}}$

c $p^{\frac{4}{3}}$

d $n^{\frac{3}{5}}$

e $k^{\frac{5}{6}}$

f $y^{\frac{7}{2}}$

g $x^{-\frac{1}{2}}$

h $c^{-\frac{1}{3}}$

i $e^{-\frac{3}{2}}$

j $s^{-\frac{2}{3}}$

k $v^{-\frac{4}{5}}$

l $b^{-\frac{7}{6}}$

12 Write each of these in index form.

a $x\sqrt{x}$

b $x^2\sqrt{x}$

c $x \times \sqrt[3]{x}$

d $x^2 \times \sqrt[3]{x}$

e $x \times \sqrt[5]{x}$

f $x^2 \times \sqrt[4]{x}$

g $x^3\sqrt{x}$

h $x^4 \times \sqrt[7]{x}$

i $\dfrac{1}{\sqrt{x}}$

j $\dfrac{1}{\sqrt[3]{x}}$

k $\dfrac{1}{\sqrt[5]{x}}$

l $\dfrac{1}{\sqrt[7]{x}}$

m $\dfrac{1}{\sqrt[x]{x}}$

n $\dfrac{1}{x \times \sqrt[3]{x}}$

o $\dfrac{1}{x^2 \times \sqrt{x}}$

p $\dfrac{1}{x^2 \times \sqrt[3]{x}}$

13 Write each of these in the form $a^m \times \sqrt[n]{a}$, where m and n are positive integers.

a $a^{\frac{3}{2}}$

b $a^{\frac{5}{2}}$

c $a^{\frac{4}{3}}$

d $a^{\frac{5}{3}}$

14 a Which is greater, $2^{\frac{1}{2}}$ or $3^{\frac{1}{3}}$? [HINT: Raise each number to the power of 6.]

Solve the following exponential equations

$2^x = 32$	$2^x = 512$	$3^x = 81$
$7^x = 2401$	$5^x = 625$	$6^x = 216$
$3^x = \frac{1}{9}$	$2^x = \frac{1}{16}$	$8^x = \frac{1}{64}$

$49^x = 7$	$128^x = 2$	$81^x = \frac{1}{27}$
$9^x = 27$	$16^x = 8$	$5^x = 5\sqrt{5}$
$4^x = \sqrt{2}$	$9^x = \frac{1}{\sqrt{3}}$	$2^{x+1} = 16$
$3^{x-1} = 243$	$3^{2x-1} = 9$	$\left(\frac{1}{4}\right)^x = 64$

a) $\quad 8^{x-1} = 2^{x+2}$	b) $144^{2x+1} = 12^{5x-1}$
c) $5^{3x+1} = 25^{x+1}$	d) $4^{-x+1} = 2^{2x}$
e) $64^a = 8^{a+2}$	f) $2^{m+1} = 16^{m+7}$
g) $36^{2x} = 216^{x-1}$	h) $3^{a-7} = 27^{2a}$