Substitution and simultaneous equations

Worked solutions

KS3 Maths topic practice

This topic online

1 $F = 5v + 20$

a. Work out the value of F when $v = 6$.

b. Work out the value of v when $F = 95$.

(4 marks)

a) $F = 5 \times 6 + 20 = 30 + 20 = 50$

b) Substitute $F = 95$: $95 = 5v + 20$

b) Subtract 20

$5v = 75$, so $v = 15$

Check

$5 \times 15 + 20 = 95$

2 The area of a trapezium is given by the formula

$A = \frac{1}{2}(a + b)h$

a. Work out A when $a = 5$, $b = 9$ and $h = 4$

b. Work out h when $A = 42$, $a = 5$ and $b = 9$

(3 marks)

a)

$A = \frac{1}{2}(5 + 9) \times 4$

$A = \frac{1}{2} \times 14 \times 4$

$A = 7 \times 4$

$A = 28$

$\boxed{28}$

b)

$42 = \frac{1}{2}(5 + 9)h$

$42 = 7h$

$\div 7 \quad 6 = h \quad \div 7$

$\boxed{h = 6}$

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3 $v = u + at$

a. Work out the value of v when $u = 7$, $a = 9.8$ and $t = 5$.

b. Work out the value of t when $v = 87$, $u = 12$ and $a = 5$.

(4 marks)

a) $v = 7 + 9.8 \times 5 = 7 + 49 = 56$

b) Substitute

$87 = 12 + 5t$

b) Subtract 12

$5t = 75$, so $t = 15$

Check

$12 + 5 \times 15 = 87$

4 Make x the subject of the formula

$y = 2x + 9$

(2 marks)

Making x the subject means leaving x alone on one side. Apply the same inverse operation to both sides to keep the equality true

$y - 9 = 2x$ (−)

$x = \frac{y - 9}{2}$ (÷2)

$x = \frac{y - 9}{2}$

5 Make k the subject of the formula

$m = \frac{k}{5} - 2$

(2 marks)

$m + 2 = \frac{k}{5}$ (+2)

$k = 5(m + 2) = 5m + 10$ (×5)

$k = 5(m + 2)$

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6

a. Make r the subject of $C = 2\pi r$

b. Make b the subject of $P = 2(a + b)$

c. Make x the subject of $y = \frac{x + 4}{3}$

(3 marks)

a)

$C = 2\pi r$

$\div 2\pi$ $\quad \frac{C}{2\pi} = r$ $\quad \div 2\pi$

$$r = \frac{C}{2\pi}$$

b)

$P = 2(a + b)$

$\div 2$ $\quad \frac{P}{2} = a + b$ $\quad \div 2$

$- a$ $\quad \frac{P}{2} - a = b$ $\quad -$

$$b = \frac{P}{2} - a$$

c)

$y = \frac{x + 4}{3}$

$\times 3$ $\quad 3y = x + 4$ $\quad \times 3$

$- 4$ $\quad 3y - 4 = x$ $\quad -$

$$x = 3y - 4$$

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7 Solve the simultaneous equations

$x + y = 11$

$x - y = 3$

(3 marks)

We need one pair (x, y) that makes both equations true. Adding the equations makes $+y$ and $-y$ cancel, leaving an equation containing only x

Add the two equations

$$2x = 14, \text{ so } x = 7$$

Substitute into $x + y = 11$: $7 + y = 11$, so $y = 4$

Check in the second equation

$7 - 4 = 3$ ✓

$\boxed{x = 7, y = 4}$

8 Solve the simultaneous equations

$2x + 3y = 12$

$2x + y = 8$

(3 marks)

Subtract the second equation from the first

$$2y = 4, \text{ so } y = 2$$

Substitute into $2x + y = 8$: $2x + 2 = 8$, so $2x = 6$ and $x = 3$

Check in the first equation

$6 + 6 = 12$ ✓

$\boxed{x = 3, y = 2}$

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9 At the school tuck shop:

2 cookies and 1 drink cost £2.30

1 cookie and 1 drink cost £1.60

Work out the cost of one cookie and the cost of one drink. (3 marks)

Work in pence

$2c + d = 230$

$c + d = 160$

Subtract the equations

$c = 70$

$70 + d = 160$

$d = 90$

Check: $140 + 90 = 230$

Cookie 70p, drink 90p

10 Solve the simultaneous equations

$3x + 2y = 16$

$x + y = 6$ (3 marks)

$3x + 2y = 16$

$x + y = 6$

x2 the second equation

$2x + 2y = 12$

Subtract from the first

$x = 4$

$4 + y = 6$

$y = 2$

Check: $12 + 4 = 16$

$x = 4, y = 2$

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11 Assume a ≠ b.

Make x the subject of

$ax = bx + c$

(3 marks)

Collect the x terms on one side

$ax - bx = c$

Factorise

$x(a - b) = c$

Divide by $(a - b)$

$$x = \frac{c}{a - b}$$

Assume $a \neq b$. Dividing by zero is not allowed

$$\boxed{x = \frac{c}{a-b}}$$

EXTENSION QUESTIONS

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12 a. Make t the subject of $3t + a = bt - 5$

b. Make x the subject of $y = \dfrac{2x + 1}{x - 3}$

(5 marks)

a)

$$3t + a = bt - 5$$

$$3t - bt + a =$$

$$3t - bt =$$

Factorise out t

$$t(3 - b) =$$

$\div(3 - b)$ $\quad t = -a/3 - b\}$ $\quad \div(3 - b)$

Multiply top and bottom by -1

$$\boxed{t = \frac{a + 5}{b - 3}}$$

b)

$$y = \frac{2x + 1}{x - 3}$$

$x(x - 3)$ $\quad y(x - 3) = 2x + 1$ $\quad x(x - 3)$

$$xy - 3y = 2x + 1$$

$$xy - 2x - 3y = 1$$

$+3y$ $\quad xy - 2x = 3y + 1$ $\quad +3y$

Factorise out x

$$x(y - 2) = 3y + 1$$

$\div(y - 2)$ $\quad x = \dfrac{3y + 1}{y - 2}$ $\quad \div(y - 2)$

$$\boxed{x = \frac{3y + 1}{y - 2}}$$

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13 Solve the simultaneous equations

$3x + 2y = 24$

$2x + 5y = 27$

(4 marks)

Multiply the first equation by 5 and the second by 2

$15x + 10y = 120$ and $4x + 10y = 54$

Subtract

$11x = 66$, so $x = 6$

Substitute into $3x + 2y = 24$: $18 + 2y = 24$, so $y = 3$

Check in the second equation

$12 + 15 = 27$ ✓

$\boxed{x = 6, y = 3}$

EXTENSION QUESTIONS

14 A theme park sells adult tickets and child tickets.

3 adult tickets and 2 child tickets cost £40

2 adult tickets and 5 child tickets cost £45

Mr Okafor buys 2 adult tickets and 3 child tickets. He pays with a £50 note.

Work out how much change he should get.

(5 marks)

$3a + 2c = 40$

$2a + 5c = 45$

×2 the first, ×3 the second

$6a + 4c = 80$

$6a + 15c = 135$

Subtract

$11c = 55$

÷11 $c = 5$ ÷11

$3a + 10 = 40$

$3a = 30$

÷3 $a = 10$ ÷3

Cost = $2 \times 10 + 3 \times 5 = £35$

Change = $50 - 35 = £15$

$\boxed{£15}$

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