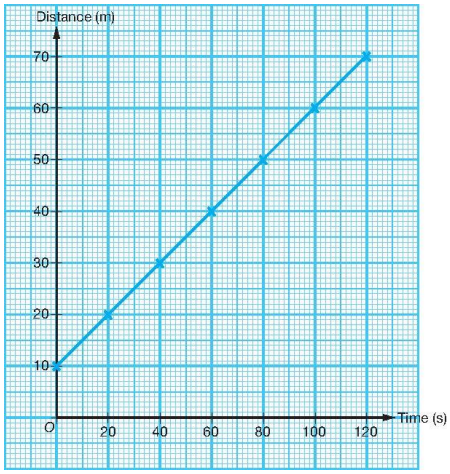
Form 4: Chapter 7
Graphs of Motion
Fully-worked Solutions

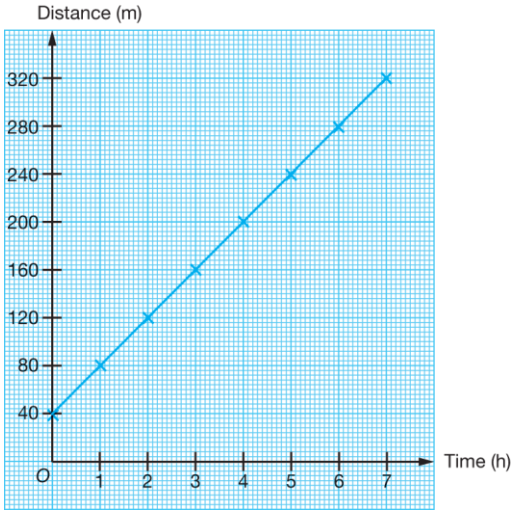
UPSKILL 7.1

1



2

s (m)	0	80	120	160	200	240	280	320
t (h)	0	1	2	3	4	5	6	7



3

Graph	*Gradient of graph*	*Interpretation of graph*
AB	$\frac{10\text{ m}}{5\text{ s}} = 2\text{ m s}^{-1}$	Uniform speed of 2 m s^{-1} from *H* to *K*
BC	0 m s^{-1}	Stationary at *K* for 7 seconds 10 m from *H*
CD	$-\frac{10\text{ m}}{4\text{ s}} = -2.5\text{ m s}^{-1}$	Return from *K* to *H* with a uniform velocity of 2.5 m s^{-1}

4 (a) Speed = $\frac{140-40}{1} = 100$ km h^{-1}

(b) Speed = 0 km h^{-1}

(c) Gradient = $= \frac{140}{2} = -70$

Hence, speed = 70 km h^{-1}

5 (a) Average speed of the truck

$= \frac{300}{16} = 18.75$ m s^{-1}

(b) Gradient $-\frac{300}{10} = -30$

Hence, the speed of the taxi = 30 m s^{-1}

(c) Distance from *Q* = 300 – 60 = 240 m

6 (a) Difference of distance = 24 – 12 = 12 m

(b) The speed of the bicycle

$= \frac{16-4}{8-0} = \frac{16-4}{8} = 1.5$ m s^{-1}

(c) The time taken to meet = $2\frac{2}{3}$ s

7 (a) The time when both vehicles meet = 0840

(b) Speed of bus = $\frac{60}{\frac{50}{60}} = 72$ km h^{-1}

(c) Gradient = $-\frac{120}{\frac{60}{60}} = -120$

Hence, the speed of taxi = 120 km h^{-1}

8 (a) Speed = $\frac{15}{6} = 2\frac{1}{2}$ m s^{-1}

(b) The period of time at rest = 14 – 6 = 8 s

(c) $\frac{x}{24}=\frac{5}{4}$

$x=30$

9 (a) Gradient $=-\frac{100}{10}=-10$

Speed = 10 m s^{-1}

(b) The period of time at rest is 10 s

(c) Average of speed $=\frac{200}{T}=\frac{20}{3}$

$T=\frac{3}{20}\times 200$

$T=30$

10 (a) Gradient $=-\frac{180}{6}=-30$

Speed of car = 30 m s^{-1}

(b) Speed of van $=\frac{80}{3}=26\frac{2}{3}$ m s^{-1}

(c) Distance travelled by the car

$=180-80$

= 100 m

11 (a) Distance of run

$=80-30$

= 50 m

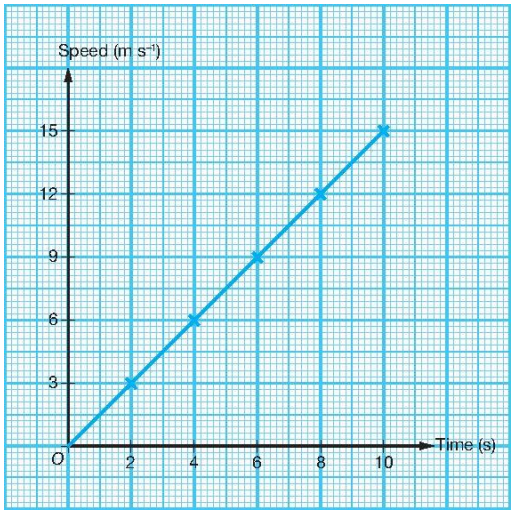
(b) Speed $=\frac{30}{2}=15$ m s^{-1}

(c) Average speed $=\frac{100}{t}=\frac{25}{3}$

$t=12$

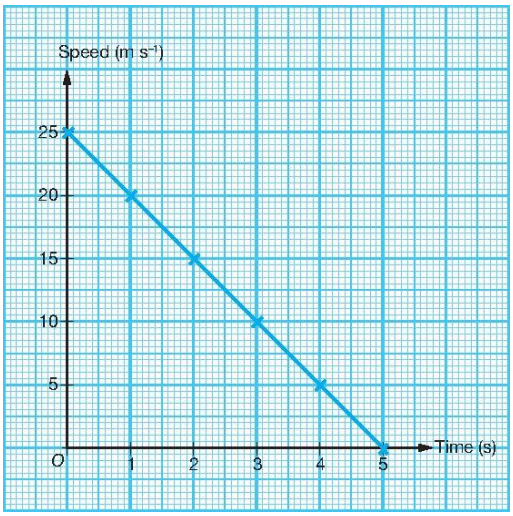
UPSKILL 7.2

1



2

v (m s^{-1})	25	20	15	10	5	0
t (s)	0	1	2	3	4	5



3 (a) Distance = 110 × 2 = 220 km

(b) Distance $=\frac{1}{2}\times 6\times 20=60$ m

(c) Distance $=\frac{1}{2}\times(6+16)(8)=88$ m

4 (a) Total distance

$=6\times 10+\frac{1}{2}(10+24)(5)+\frac{1}{2}(7)(24)$

= 229 m

(b) Total distance

$=\frac{1}{2}(10+30)(5)+\frac{1}{2}(30+18)(2)+3(18)$

= 100 + 48 + 54

= 202 m

5 (a)

Graf	*Gradient of graph*	*Interpretation of graph*
HK	-15 km h^{-2}	The deceleration is 15 km h^{-2}
KL	0 km h^{-2}	The acceleration is 0 km h^{-2} / The uniform speed is 30 km h^{-1}.
LM	$46\frac{2}{3}$ km h^{-2}	The acceleration is $46\frac{2}{3}$ km h^{-2}.

(b) The car decelerates uniformly from a speed of 60 km h^{-1} with a deceleration of 15 km h^{-2} until the speed is 30 km h^{-1} in 2 hours. Then, the car travels with a uniform speed of 30 km h^{-1} for 30 km in 1 hour. Then, the car accelerates uniformly with an acceleration of $46\frac{2}{3}$ km h^{-2} for 97.5 km until it reaches a speed of 100 km h^{-1} in 1.5 hours.

6 (a) Distance = 265

$$\frac{1}{2}(10+40)(7)+\frac{1}{2}(40+u)(3)=265$$

$$175+\frac{3(40+u)}{2}=265$$

$$\frac{3(40+u)}{2}=90$$

$$40+u=\frac{180}{3}$$

$$40+u=\frac{180}{3}$$

$$u=20$$

(b) Average speed = $\frac{175}{7}$ = 25 m s^{-1}

(c) Rate of change of speed

$$= -\frac{40-20}{3}$$

$$= -6\frac{2}{3} \text{ m s}^{-2}$$

7 (a) The time travelling at uniform speed = 12

$$t-4=12$$
$$t=16$$

(b) Total distance = 330 m

$$\frac{1}{2}(v+15)(8)+4(15)+\frac{1}{2}(4)(15)=330$$
$$4v+60+60+30=330$$
$$4v=180$$
$$v=45$$

(c) Rate of change of speed

$$=\frac{30}{4}$$
$$=7.5\text{ m s}^{-2}$$

8 (a) Uniform speed = 10 m s^{-1}

(b) (i) Rate of change of speed = $\frac{5}{7}$

$$\frac{10}{t}=\frac{5}{7}$$
$$5t=70$$
$$t=14$$

(ii) Total distance

$$=\frac{1}{2}(14)(10)+10(2)+\frac{1}{2}(10+16)(8)$$
$$=194\text{ m}$$

Average speed = $\frac{194}{24}=8\frac{1}{12}$ m s^{-1}

9 (a) Distance travelled at a uniform speed = 144 m

$$18(12-t)=144$$
$$12-t=8$$
$$t=4$$

(b) Rate of change of speed

$$=-\frac{18}{3}$$
$$=-6\text{ m s}^{-2}$$

(c) Total distance

$$=\frac{1}{2}\times(30+18)\times4+144+\frac{1}{2}(3)(18)$$
$$=267\text{ m}$$

Average speed = $\frac{267}{15}=17\frac{4}{5}$ m s^{-1}

10 (a) Distance travelled at a uniform speed

$$10\times8=80\text{ m}$$

(b) Rate of change of speed

$$=\frac{8}{4}=2\text{ m s}^{-2}$$

(c) Total distance = 156

$$\frac{1}{2}(v+8)(8)+10(8)=156$$
$$4(v+8)+80=156$$
$$4v+32+80=156$$
$$4v=44$$
$$v=11$$

11 (a) Speed = 20 m s^{-1}

(b) Rate of change of speed

$$=\frac{20}{6}=3\frac{1}{3}\text{ m s}^{-2}$$

(c) Total distance travelled by motorcycle P

$$=\frac{1}{2}\times T\times20$$
$$=10T$$

Total distance travelled by motorcycle Q

$$=\frac{1}{2}(6)(20)+20(T-6)$$
$$=60+20T-120$$
$$=20T-60$$

$$20T-60-10T=30$$
$$10T=90$$
$$T=9$$

12 (a) Uniform speed = 25 m s^{-1}

(b) Rate of change of speed = $\frac{25-10}{5}=3\text{ m s}^{-2}$

(c) Total distance = 212.5 m

$$\frac{1}{2}(10+25)(5)+25(t-5)=212.5$$
$$\frac{175}{2}+25t-125=212.5$$
$$175+50t-250=425$$
$$50t=500$$
$$t=10$$

13 (a) Distance travelled at a uniform speed
$= 2 \times 12 = 24\text{ m}$

(b) Rate of change of speed
$= \frac{12}{4} = 3\ \text{m s}^{-2}$

(c) Distance travelled in the first 4 seconds
$= \frac{1}{2}(4)(12) = 24\text{ m}$

Distance travelled from the 6th second to the t^{th} second $= \frac{1}{2}(12 + 20)(t - 6)$
$= 16(t - 6)$
$= 16t - 96$

Hence, $24 = \frac{1}{3}(16t - 96)$
$72 = 16t - 96$
$16t = 168$
$t = 10.5$

14 (a) Distance travelled by the car
$= \frac{1}{2}(6)(30) + \frac{1}{2}(30 + 10)(4) = 170\ \text{m}$

Distance travelled by the motorcycle
$= \frac{1}{2}(10)(10) = 50\ \text{m}$

Difference of distance
$= 170 - 50 = 120\text{ m}$

(b) Rate of change of speed
$= \frac{30}{6} = 5\ \text{m s}^{-2}$

(c) Gradient along the straight line *OP*
$\frac{v}{12} = \frac{10}{10}$
$v = 12$

Summative Practice 7

Multiple Choice Questions

1 Speed $= \frac{120 - 70}{0.5} = 100\ \text{km h}^{-1}$

Answer: D

2 Average speed $= \frac{60 + 120}{30} = 6\ \text{m s}^{-1}$

Answer: C

3 Distance = 260 m

$\frac{1}{2}(9 + 16)(t) + (18 - t)(16) = 260$

$\frac{25}{2}t + 288 - 16t = 260$

$25t + 576 - 32t = 520$
$-7t = -56$
$t = 8$

Answer: C

4 Total distance
$= \frac{1}{2}(6)(8) + \frac{1}{2}(8 + 24)(4) + 5(24)$
$= 208\text{ m}$
Answer: C

5 Rate of change of speed
$= -\frac{11 - 3}{5} = -\frac{8}{5}\ \text{m s}^{-2}$
Answer: C

Structured Questions

1 (a) (i) Distance between Abidin's house and the cake shop = 5 km
(ii) Distance between the cake shop and the public library
$= 12 - 5 = 7\text{ km}$

(b) (i) Speed $= \frac{5}{\frac{15}{60}} = 20\ \text{km h}^{-1}$

(ii) Speed $= \frac{12 - 5}{\frac{45 - 15}{60}} = 14\ \text{km h}^{-1}$

(c) Average speed $= \frac{12}{\frac{45}{60}} = 16\ \text{km h}^{-1}$

2 (a) Speed $= \frac{25}{5} = 5\ \text{m s}^{-1}$

(b) Gradient $= -\frac{25}{13 - 5} = -3\frac{1}{8}$

Speed $= 3\frac{1}{8}\ \text{m s}^{-1}$

(c) Distance = 25 m

(d) Average speed $= \frac{50}{13} = 3\frac{11}{13}\ \text{m s}^{-1}$

3 (a) $h = 3 - 1.75 = 1.25$ hours = 75 minutes
(b) $k = 5.5 - 4 = 1.5$ hours = 90 minutes
(c) Distance $= 90 - 50 = 40\ \text{km}$
(d) (i) Speed $= \frac{50}{1.75} = 28\frac{4}{7}\ \text{km h}^{-1}$

(ii) Speed $= \frac{90 - 50}{1} = 40\ \text{km h}^{-1}$

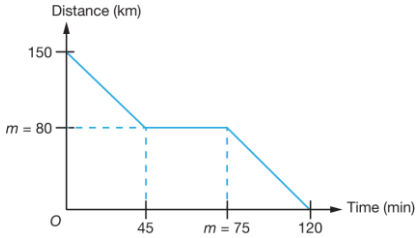
(iii) Gradient $= -\frac{90}{2} = -45$

Speed = 45 km h^{-1}

(e) Average speed $= \frac{180}{7.5} = 24\ \text{km h}^{-1}$

4 (a) (i) $m = 80,\ n = 75$

(ii)



(b) Average speed $= \dfrac{150}{\frac{120}{60}} = 75 \text{ km h}^{-1}$

5 (a) Selva won the race
(b) 36 – 18 = 18 seconds
(c) 200 – 140 = 60 m
(d) Aishah's average speed
$= \dfrac{200}{40} = 5 \text{ m s}^{-1}$

6 (a) Rate of change of speed = 60 km h^{-1}

$$\frac{110-u}{0.5} = 60$$
$$110-u = 30$$
$$u = 80$$

(b) Distance travelled at uniform speed = 66 km

$$110(k-0.5) = 66$$
$$110k - 55 = 66$$
$$k = 1.1$$

(c) Total distance
$$= \frac{1}{2}(80+110)(0.5) + 66 + \frac{1}{2}(0.4)(110)$$
= 47.5 + 66 + 22
= 135.5 km

Average speed $= \dfrac{135.5}{1.5} = 90\dfrac{1}{3} \text{ km h}^{-1}$

7 (a) Rate of change of speed = 1.5 m s^{-2}

$$\frac{v-6}{4} = 1.5$$
$$v-6 = 6$$
$$v = 12$$

(b) Total distance = 122 m

$$\frac{1}{2}(6+v)(4) + 8v = 122$$
$$12 + 2v + 8v = 122$$
$$10v = 110$$
$$v = 11$$

8 (a) Rate of change of speed = 1.2 m s^{-2}

$$\frac{v-8}{10} = 1.2$$
$$v-8 = 12$$
$$v = 20$$

(b) Total distance = 184

$$\frac{1}{2}(8+v)(10) + \frac{1}{2}(6)(v) = 184$$
$$40 + 5v + 3v = 184$$
$$8v = 144$$
$$v = 18$$

9 (a) Distance = 120 m

$$\frac{1}{2}(25+15)(x) = 120$$
$$20x = 120$$
$$x = 6$$

(b) Rate of change of speed = 3 m s^{-2}

$$\frac{v-15}{10-x} = 3$$
$$\frac{v-15}{10-6} = 3$$
$$v-15 = 12$$
$$v = 27$$

10 (a) $\dfrac{1}{2}(8+v)(4) = \dfrac{1}{5} \times 14v$

$$5(8+v)(4) = 2(14v)$$
$$160 + 20v = 28v$$
$$8v = 160$$
$$v = 20$$

(b) Total distance
$$= \frac{1}{2}(8+20)(4) + 14(20)$$
$$= 56 + 280$$
$$= 336 \text{ m}$$

Average speed $= \dfrac{336}{18} = 18\dfrac{2}{3} \text{ m s}^{-1}$

11 (a) Rate of change of speed = -3 m s^{-2}

$$-\frac{30-u}{4} = -3$$
$$30-u = 12$$
$$u = 18$$

(b) Distance travelled at uniform speed
= 18(2)
= 36 m

(c) Total distance
$$= \frac{1}{2}(30+18)(4) + 36 + \frac{1}{2}(18)(6)$$
$$= 186 \text{ m}$$

Average speed $= \dfrac{186}{12} = 15.5 \text{ m s}^{-1}$

SPM SPOT

1 Speed = 6 m s^{-1}

Gradient = 6

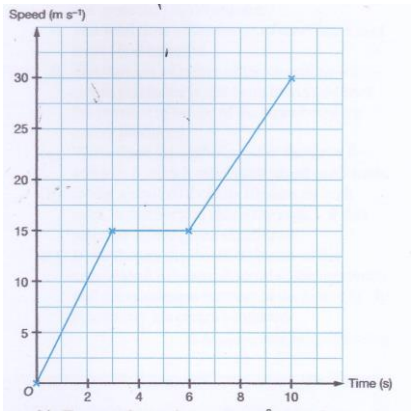
$$\frac{k-5}{30}=6$$

$$k-5=180$$

$$k=185$$

Answer: D

2 (a)



(b) Rate of change of speed in the first 3 s = $\frac{15}{3}$ = 5 m s^{-2}

The particle accelerates 5 m s^{-2} in the first 3 seconds. Then, the particle travels at a uniform speed of 15 m s^{-1} for 3 seconds. Then, the particle accelerates 3.75 m s^{-2} for the last 4 seconds.

(c) (i) Rate of change of speed in the last 4 seconds

$$=\frac{30-15}{10-6}$$

= 3.75 m s^{-2}

(ii) Average speed

$$=\frac{\text{Total distance}}{\text{Total time}}$$

$$=\frac{\frac{1}{2}(3)(15)+3(15)+\frac{1}{2}(15+30)(4)}{10}$$

$$=\frac{\frac{315}{2}}{10}$$

= 15.75 m s^{-1}

