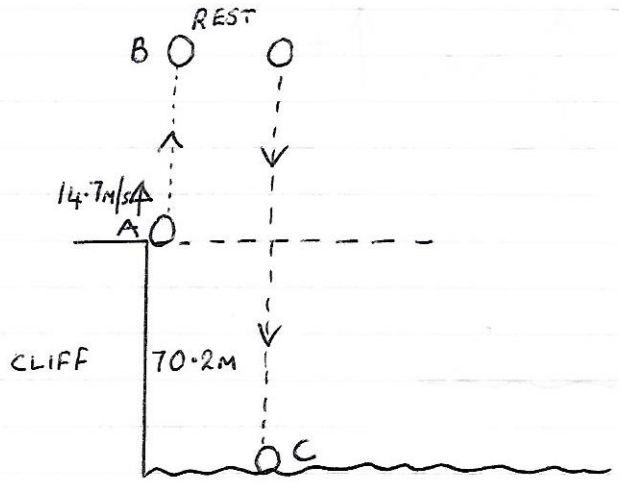
Vertical Motion Under Gravity 2 : Answers

1)



a) $u = +14{\cdot}7$
$t = 2$
$a = -9{\cdot}8$
$V = V$

$V = u + at$
$V = 14{\cdot}7 - 9{\cdot}8(2)$
$V = 14{\cdot}7 - 19{\cdot}6$
$V = -4{\cdot}9$ m/s

ie Speed downwards of 4·9 m/s

b) AC

$u = +14{\cdot}7$
$a = -9{\cdot}8$
$s = -70{\cdot}2$
$V = V$

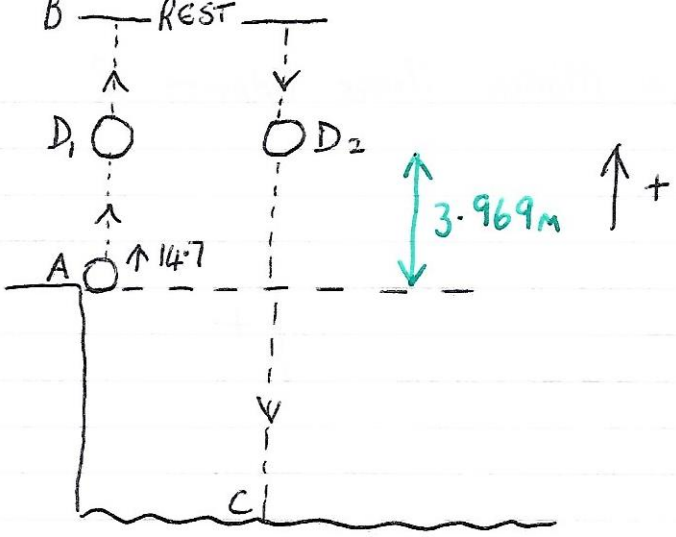
$V^2 = u^2 + 2as$
$V^2 = 14{\cdot}7^2 + 2(-9{\cdot}8)(-70{\cdot}2)$
$V^2 = 216{\cdot}09 + 1375{\cdot}92$
$V^2 = 1592{\cdot}01$
$V = \pm 39{\cdot}9$ m/s

Obvious on way down ∴ −ve sign applies.

∴ speed down of 39·9 m/s

c) Find time interval between the 2 times when it is 3·969m above the cliff. (One on way up, one on way down)

Proceed as follows



AD

$u = +14.7$
$s = +3.969$
$a = -9.8$
$t = t$

$s = ut + \frac{1}{2}at^2$

$3.969 = 14.7t - 4.9t^2$

$4.9t^2 - 14.7t + 3.969 = 0$

$\div 4.9 \quad t^2 - 3t + 0.81 = 0$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{3 \pm \sqrt{9 - 4(1)(0.81)}}{2}$$

$$t = \frac{3 \pm \sqrt{5.76}}{2} = \frac{3 \pm 2.4}{2}$$

$$= +\frac{5.4}{2} \quad \text{or} \quad +\frac{0.6}{2}$$

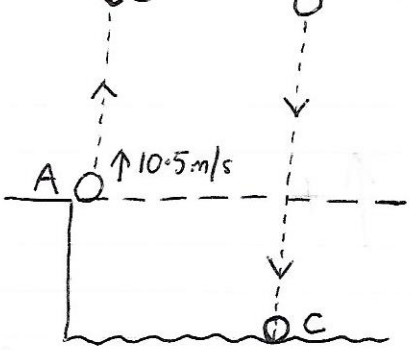
$= 2.7$ secs or 0.3 secs

$\therefore$

After 0·3 secs it is at D on way up
After 2·7 secs it is at D on way down

$\therefore$ Time interval $= 2.7 - 0.3$
$= 2.4$ secs.

2)



AB

a) $u = +10{\cdot}5$
$a = -9{\cdot}8$
$v = 0$ (at rest)
$s = s$

$$v^2 = u^2 + 2as$$
$$0^2 = 10{\cdot}5^2 - 19{\cdot}6s$$
$$19{\cdot}6s = 10{\cdot}5^2$$
$$s = \frac{10{\cdot}5^2}{19{\cdot}6}$$
$$s = 5{\cdot}625\text{ m}$$

$\therefore$ 5·625m above A is greatest height

b) AC

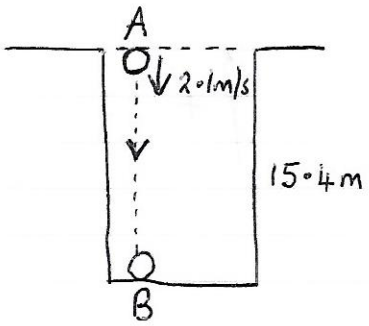
$u = +10{\cdot}5$
$a = -9{\cdot}8$
$t = 5$
$s = s$

$$s = ut + \frac{1}{2}at^2$$
$$s = 10{\cdot}5(5) - 4{\cdot}9(25)$$
$$s = 52{\cdot}5 - 122{\cdot}5$$
$$s = -70$$

$\therefore$ 70 m below A.

ie Height of cliff is 70m

3)



↑ +

a) AB

$u = -2.1$
$s = -15.4$
$a = -9.8$
$v = v$

$v^2 = u^2 + 2as$
$v^2 = (-2.1)^2 + 2(-9.8)(-15.4)$
$v^2 = 4.41 + 301.84$
$v^2 = 306.25$
$v = \pm 17.5 \text{ m/s}$

On way down so -17.5 m/s applicable.

∴ speed at bottom = 17·5 m/s

b) $v = u + at$

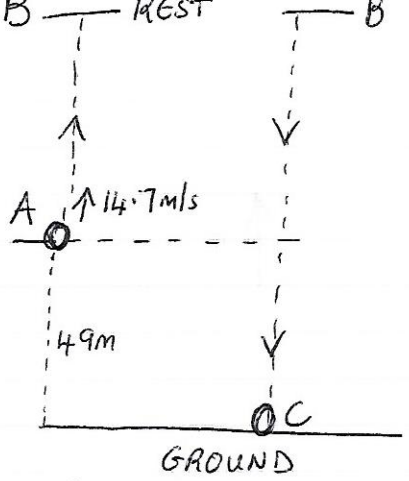
$-17.5 = -2.1 - 9.8t$

$9.8t = -2.1 + 17.5$
$9.8t = 15.4$

$t = \frac{15.4}{9.8}$

$t = 1.57$ secs to reach the bottom

4)



a) AC

$u = +14{\cdot}7$
$a = -9{\cdot}8$
$s = -49$
$t = t$
$v = v$

Easy to find v first which is part b)

$$v^2 = u^2 + 2as$$
$$v^2 = 14{\cdot}7^2 + 2(-9{\cdot}8)(-49)$$
$$v^2 = 216{\cdot}09 + 960{\cdot}4$$
$$v^2 = 1176{\cdot}49$$
$$v = \pm 34{\cdot}3 \text{ m/s}$$

Therefore hits ground when $v = -34{\cdot}3$ m/s

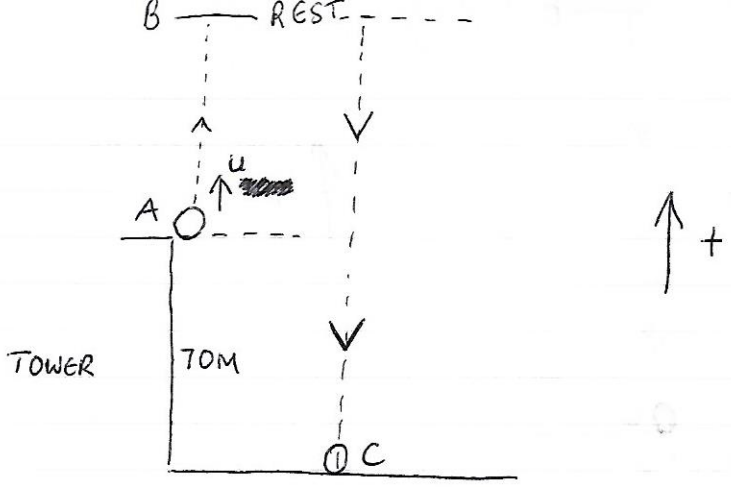
(b) ie speed of 34·3 m/s

Now (a) $v = u + at$

$$-34{\cdot}3 = 14{\cdot}7 - 9{\cdot}8t$$
$$9{\cdot}8t = 14{\cdot}7 + 34{\cdot}3$$
$$9{\cdot}8t = 49$$
$$t = \frac{49}{9{\cdot}8}$$
$$t = 5 \text{ secs}$$

∴ Takes 5 secs to reach ground.

5)



a) AB

$u = u$
$a = -9.8$
$v = 0$
$t = 2.5$

$v = u + at$
$0 = u - 9.8(2.5)$

$9.8(2.5) = u$

$+24.5 \text{ m/s} = u$

ie 24.5m/s upwards QED

b)
$u = +24.5$
$t = 4$
$a = -9.8$
$s = s$

$s = ut + \frac{1}{2}at^2$

$s = 24.5(4) - 4.9(4^2)$

$s = 98 - 78.4$
$s = +19.6 \text{ M}$

∴ stone is 19.6m above A

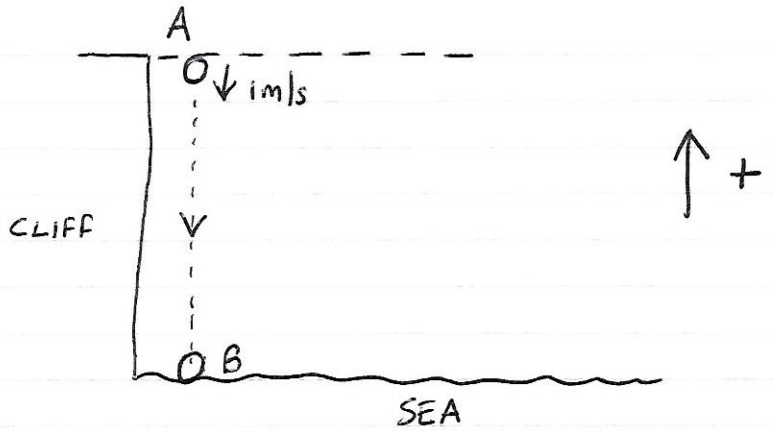
c) AC

$u = +24.5$
$a = -9.8$
$v = v$
$s = -70$ ← ground is 70m below A

$v^2 = u^2 + 2as$
$v^2 = 24.5^2 - 19.6(-70)$

$v^2 = 600.25 + 1372$
$v^2 = 1972.25$
$v = \pm 44.41 \text{ m/s}$ ie 44.41 m/s when hits ground

6)



a) AB

$u = -1$
$a = -9.8$
$t = 2.5$
$V = V$

$V = u + at$
$V = -1 - 9.8(2.5)$
$V = -1 - 24.5$
$V = -25.5 \text{ m/s}$

ie 25.5 m/s is speed as it hits sea

b) AB

$u = -1$
$V = -25.5$
$a = -9.8$
$t = 2.5$
$S = S$

$S = \frac{(u+V)t}{2}$

$S = \frac{(-1-25.5)2.5}{2}$

$S = -\frac{26.6}{2} \times 2.5$

$S = -33.25 \text{ m}$

∴ Height of cliff = 33.25 m