Equations Of Motion 4

Problems on the Equations of Motion

M1 An object accelerates at $4ms^{-2}$ from an initial speed of $8ms^{-1}$. How far does it travel in 10s?

M 2. A car accelerates at $6ms^{-2}$, its initial speed is $15ms^{-1}$ and it covers a distance of 200m. Calculate its final velocity.

M 3 A ball is thrown to a height of 40m above its starting point, with what velocity was it thrown?

M 4 A car travelling at $30ms^{-1}$ slows down at $1.8ms^{-2}$ over a distance of 250m. How long does it take to stop?

M 5 If a stone is thrown vertically down a well at $5ms^{-1}$, when will it reach the water surface 60m below?

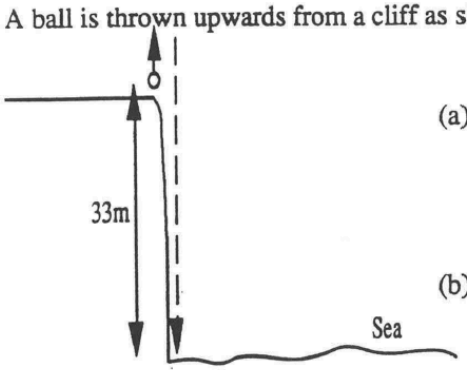
M 6 A rifle barrel is 0.6m long and the muzzle velocity of bullets leaving the gun is $350ms^{-1}$. Calculate the average acceleration of the bullets and estimate the time of transit in the barrel.

M 7 In an experiment to find "g" a steelball falls from rest through 40cm. The time taken was 0.29s. What is the value for "g".

M 8 A trolley accelerates down a sloping ramp. Two photo-cells spaced 0.5m apart measure the velocities to be 20cm s^{-1} and 50cm s^{-1}.
Calculate the acceleration of the trolley and the time taken to cover the 0.5m.

M 9 A helicopter is rising vertically at $10ms^{-1}$ when a wheel falls off.
The wheel hits the ground 8s later. Calculate at what height the helicopter was flying when the wheel came off.

M10 A ball is thrown upwards from a cliff as shown below. INITIAL SPEED 0 m/s



(a) After 2s find the height of the ball above sea level, its speed and direction.

(b) Find the total distance travelled.

M11 A car is able to accelerate from rest to 60 miles per hour in 9 s. Assuming that 60 m.p.h. equals $27\ ms^{-1}$, (i) what is the car's mean acceleration?
(ii) How far does the car travel in the 9 s from rest (assuming uniform acceleration)?
(iii) How far will the car travel during the next 9 s if a steady 60 m.p.h. is maintained?

M12 A car travels at a constant speed of 20 m/s for 30 s and then breakes so as to come to a sto after a further 10 s. The retardation (negative acceleration) is constant during this last 10 s period.
Find (a) the total distance travelled by the car during the whole forty seconds
(b) the retardation during the braking.

M13 A stone is dropped from a high window and takes exactly 2 s to reach the ground. air resistance is negligible and the acceleration due to gravity may be taken to be $10\ ms^{-2}$
(a) How fast is the stone moving 1 s after being released?
(b) How fast is the stone moving 2 s after being released?
(c) What is the mean speed of the stone during the whole 2 s ?
(d) How far did the stone fall?

M14 A ball bearing is dropped in a laboratory and timed by an automatic device which registers a time of exactly half a second when the ball goes through a vertical distance of 1.20 m. What value does this give for g ?

M15 A cricketer throyghs a ball vertically upwards into the air and then catches it as it falls. If the ball rises ten metres above his hands, for how long is it in the air? (take $g = 10\ m/s^2$).

M16 A juggler throws a ball into the air and catches it 1.6 s later. How high above his hands did it rise?

EQUATIONS of MOTION

M1 $a = 4\,ms^{-2}$ $u = 8\,ms^{-1}$ $s = ?$ $t = 10s$

$s = ut + \frac{1}{2}at^2 = 8\times10 + \frac{1}{2}\times4\times100 = 80 + 200 = \underline{280m}$

M2. $a = 6\,ms^{-2}$ $u = 15\,ms^{-1}$ $s = 200m$ $v = ?$

$v^2 = u^2 + 2as = 15^2 + 2\times6\times200 = 225 + 2400 = 2625$

$\underline{v = 51.2\,ms^{-1}}$

M3 $u = ?$ $v = 0$ (at highest point) $a = -10\,ms^{-2}$ $s = 40m$

$v^2 = u^2 + 2as$

$0 = u^2 - 2\times10\times40$

$800 = u^2$ $\underline{u = 28.3\,ms^{-1}}$

M4 $u = 30\,ms^{-1}$ $a = -1.8\,ms^{-2}$ $s = 250m$ $t = ?$

$\underline{s = ut + \frac{1}{2}at^2}$ ~ Not advisable since you end up with a quadratic

Find v first, then use $v = u + at$

$v^2 = u^2 + 2as = 900 - 2\times1.8\times250 = 0$ $v = 0$

$t = \frac{v-u}{a} = \frac{0-30}{-1.8} = \underline{16.7s}$

M5 $u = 5\,ms^{-1}$ $t = ?$ $s = 60m$ $a = 10\,ms^{-2}$

Again find v first. ($s = ut + \frac{1}{2}at \Rightarrow 60 = 5t + 5t^2$)

$v^2 = u^2 + 2as = 25 + 2\times10\times60 =$ $v = 35\,ms^{-1}$

$t = \frac{v-u}{a} = \frac{35-5}{10} = \underline{3s}$

M6 $s = 0.\ m$ $u = 0$ $v = 350\,ms^{-1}$ $a = ?$ $t = ?$

$v^2 = u^2 + 2as$

$350^2 = 0 + 1.2a$

$a = \frac{122500}{1.2}\,ms^{-2}$

$t = \frac{v-u}{a} = \frac{350-0}{102083} = \underline{3.4\times10^{-3}s}$

M7 $u = 0$ $s = 0.4m$ $t = 0.29s$ $g = ?$

$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times g \times 0.29^2 = 0.4$

$g = 9.5\ ms^{-2}$ (Nkg^{-1})

M8. $s = 0.5m$ $u = 20\ cms^{-1} = 0.2\ ms^{-1}$ $v = 50\ cms^{-1} = 0.5\ ms^{-1}$ $a = ?$

$v^2 = u^2 + 2as$

$0.25 = 0.04 + 2 \times a \times 0.5$ $a = -0.21\ ms^{-2}$

M9 $u = 10\ ms^{-1}$ $t = 8s$ $a = -10\ ms^{-2}$

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

$= 10 \times 8 - \frac{1}{2} \times 10 \times 64$

$= -240m$ = displacement of wheel

i.e. ground is 240m below point of release.

height of helicopter = 240m

M10 (a) $u = 4ms^{-1}$ $a = -10ms^{-2}$ $s = ?$ $t = 2s$ Take ↑ As Positive.

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

$= 4 \times 2 - \frac{1}{2} \times 10 \times 4 = 8 - 20 = -12m$ (displacement)

Height = 33 − 12 = 21m

$v = u + at = 4 - (10 \times 2) = -16\ ms^{-1}$

$v = 16\ ms^{-1}$ downwards

(b) 

$v^2 = u^2 + 2as$

$0 = 16 - 2 \times 10 \times s \Rightarrow s = 0.8m$

Total $s = 2 \times 0.8 + 33 = 34.6m$

M11.

S	u	v	a	t
	0	27	a	9

i. $a = \frac{v-u}{t} = \frac{27-0}{9} = 3ms^{-2}$.

ii. $s = \left(\frac{u+v}{2}\right)t = \frac{0+27}{2} \times 9 = 121.5m$

iii. $s = V \times t = 27 \times 9 = 243m$

M12. s u v a t (Part 2)
20 0 10

a) Part 1 $s = vt$
$= 20 \times 30$
$= 600\,m$

Part 2 $s = \left(\frac{u+v}{2}\right)t$
$= \frac{20+0}{2}\ 10$
$= 100\,m$

Total = Part 1 + Part 2
= 600 + 100
= 700m

b) s u v a t
100 20 0 a 10.

$v = u + at$

$a = \frac{v-u}{t} = \frac{0-20}{10} = -2\,ms^{-2}$ (negative sign is important!)

M13 s u v a t.
0 V −10

a) $v = u + at$
$= 0 + -10 \times 1$
$= -10\,ms^{-1}$

b) $v = u + at$
$= 0 - 10 \times 2$
$= -20\,ms^{-1}$

c) Av speed ⇒ $\frac{\text{Total dist}}{\text{Time}}$

$= \frac{20}{2}$

$= 10\,m/s$

Total dist $s = ut + \frac{1}{2}at^2$
$= 0 \times 2 + \frac{1}{2} \times -10 \times 2^2$
$= -20m$

d) 20m (see (c))

M14.

S	u	v	a	t
−1.2	0		a	0.5

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

$-1.2 = 0 + \frac{1}{2} a\, 0.5^2$

$-1.2 = 0.125a$

$a = -9.6\ m/s^2$

M15 N.B. $g = 10\ m/s^2$

S	u	v	a	t
−10	?	0	10	t

$V^2 = u^2 + 2as$

$0 = u^2 + 2 \times 10 \times -10$

$0 = u^2 + (-200)$

$u^2 = 200$

$u = \pm 14.1$ choose Positive as down therefore $-14\ m/s = u$

$V = u + at$

$0 = -14 + 10t$

$-10t = -14$

$t = \frac{-14}{-10} = 1.4s$

M16 s u v a t

s 0 -9.8 0.8

At max height when $v = 0$ and $t = 0.8s$

$u = v - at$

$= 0 - -9.8 \times 0.8$.

$u = 7.84 \text{ m/s}$

$s = ut + 1/2 at^2$

$= 7.84 \times 0.8 + 1/2 \times -9.8 \times 0.8^2$

$= 6.3 + -3.1$

$= \underline{3.2 \text{ m}}$