2-1

$d = vt$ AND

$v = (110\ km/hr)\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,hr}{3600\,s}\right) = \cancel{30}\ 31\ m/s$

$t = 2\,s$ SO

$d = (31\ m/s)(2\,s) \approx \boxed{62\ m}$

2-6

(a) TOTAL TIME = 3 hr 20 min (= 3.33 hr)

WE NEED TO TREAT THE PROBLEM IN TWO PARTS

(I) VELOCITY = V_1 = 95 km/hr FOR 130 km

(II) VELOCITY = V_2 = 65 km/hr ~~FOR~~ AFTERWARD

(I) WE CAN FIND THE TIME IT STARTED TO RAIN:

$x_{RAIN} = \cancel{x_0}^{\,x_0=0} + v_0 t + \frac{1}{2}\cancel{a}^{\,a=0} t^2$, $v_0 = v_1$

$x_{RAIN} = v_0 t_{RAIN}$

$\hookrightarrow t_{RAIN} = \frac{x_{RAIN}}{v_1} = \frac{130\,km}{95\,km/hr} \approx 1.37\,hr$

(II) NOW WE CAN FIND THE FINAL POSITION BECAUSE WE KNOW HOW LONG WE DROVE IN TOTAL

$x_{HOME} = x_{RAIN} + V_2 t + \frac{1}{2}\cancel{a}^{\,a=0} t^2$

$x_{RAIN} = 130\ km$

$V_2 = 65\ km/hr$

$t = 3.33\,h - 1.37\,hr = 1.96\,hr$

$x_{HOME} = 130\,km + (65\,km/hr)(1.96\,hr) = \boxed{257\ km}$

NEXT PAGE

2-6 CONTINUED

(b) AVERAGE SPEED $= \dfrac{257\text{ km}}{3.33\text{ hr}} = \boxed{77.2\text{ km/hr}}$

2-12

SINCE THE TRAINS HAVE THE SAME SPEED THEY WILL TRAVEL THE SAME DISTANCE AND MEET IN THE MIDDLE.

THEY WILL EACH TRAVEL $\frac{8.5}{2} = 4.25\text{ km}$

~~THE~~ IT WILL TAKE THEM

$$t = \frac{d}{v} = \left(\frac{4.25\text{ km}}{95\ \frac{\text{km}}{\text{hr}}}\right) = \boxed{0.0447\text{ hr}}$$

$$(0.0447\text{ hr})\left(\frac{3600\text{ s}}{1\text{ hr}}\right) = \boxed{161\text{ s} = 2\text{ min } 41\text{ s}}$$

2-21

SINCE AVERAGE ACCELERATION IS GIVEN BY $\bar{a} = \frac{\Delta V}{\Delta t} = \frac{V_f - V_i}{t_f - t_i}$, WE KNOW THAT $\Delta t = \frac{\Delta V}{\bar{a}}$

WE ALSO NEED TO CONVERT THE VELOCITIES TO m/s

$$V_f = (110\ \text{km/hr})\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right) = 30.5\ \text{m/s}$$

$$V_i = (80\ \text{km/hr})\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\left(\frac{1\ \text{hr}}{3600\ \text{s}}\right) = 22.2\ \text{m/s}$$

SO NOW,

$$\Delta t = \frac{30.5\ \text{m/s} - 22.2\ \text{m/s}}{1.8\ \text{m/s}^2} = \boxed{4.7\ \text{s}}$$

2-29

(a) At AND Bt^2 MUST EACH HAVE THE SAME UNITS AS x (m)

SO UNITS$\{A\}$ = m/s, UNITS$\{B\}$ = m/s²

(b) $a = \frac{d^2x}{dt^2} \longrightarrow a = \frac{d}{dt}\left(\frac{d}{dt}(At + Bt^2)\right)$

$$= \frac{d}{dt}(A + 2Bt)$$

$$\boxed{a = 2B}$$

(c) $v(t=5) = \left.\frac{dx}{dt}\right|_{t=5s} = A + 2Bt\Big|_{t=5s} = \boxed{A + 10B = v(t=5)}$

$a(t=5) = \left.\frac{d^2x}{dt^2}\right|_{t=5s} = 2B \longrightarrow \boxed{2B = a(t=5s)}$

(d) $v(t) = \frac{dx}{dt} = \boxed{A - 3Bt^{-4} = v(t)}$

2-36

IN THE FIRST 0.2 s THE CAR TRAVELS

$$\Delta x = V_0 t = (18\,m/s)(0.2\,s) = 3.6\,m$$

SO NOW THE DRIVER HAS

$(20\,m) - (3.6\,m) = 16.4\,m$ TO STOP.

~~WE~~ SINCE ACCELERATION IS CONSTANT

WE CAN USE

$$V_f^2 = 2a(x - x_0) + V_0^2 \longrightarrow x = \frac{(V_f^2 - V_0^2)}{2a} + x_0$$

WHERE $\begin{cases} a = -3.65\,m/s^2 \\ V_0 = 18\,m/s \\ V_f = 0\,m/s \\ x_0 = 0\,m \end{cases}$ SO....

$$X = \frac{-(18\,m/s)^2}{2(3.65\,m/s^2)} = 44\,m$$

NOW WE NEED TO ADD THE

3.6 m HE WENT BEFORE

APPLYING THE BRAKES TO GET

HIS TOTAL DISTANCE TRAVELLED

$$44 + 3.6 = \boxed{47.6\,m}$$

HE DID NOT STOP IN TIME

2-51

(a) AT THE MAXIMUM HEIGHT $V=0$

SO WE CAN USE

$$(V_f^2 - V_0^2) = 2a(x - x_0)$$

WITH

$$\begin{cases} V_0 = 20\,m/s \\ V_f = 0\,m/s \\ x_0 = 0\,m \end{cases} \quad a = g = -9.8\,m/s^2$$

SO,

$$x = \frac{(V_f^2 - V_0^2)}{2a} + x_0 = \frac{-(20\,m/s)^2}{-2g} = \boxed{20\,m = X}$$

(b) AGAIN, $V=0$ SO

$$V_f = V_0 + at \rightarrow t = \frac{V_f - V_0}{a} = \frac{-20\,m/s}{-10\,m/s}$$

$$\boxed{t = 2\,s}$$

→ $\boxed{2-58}$

(a) CHOOSE UP TO BE POSITIVE

THEN SINCE IT RUNS OUT OF FUEL AT 950m WE CAN USE

$$V^2 = 2a(x-x_0) + V_0^2 \quad \text{WITH} \quad \begin{cases} a = -g = +3.2\,m/s^2 \\ V_0 = 0\,m/s \\ x_0 = 0\,m \\ x = 950\,m \end{cases}$$

$$V = \sqrt{2a(x-x_0) + V_0^2} = \left(2a(x-x_0)+V_0^2\right)^{1/2}$$

$$V = \left\{2(3.2\,m/s^2)(950\,m)\right\}^{1/2} = \boxed{80\,m/s = V}$$

(b) NOW THAT WE HAVE V AT THE TIME IT RUNS OUT OF FUEL WE CAN USE IT IN:

$$V = V_0 + at$$

$$80\,m/s = (3.2\,m/s^2)t \longrightarrow \boxed{t = 25\,s}$$

(c) WE CAN FIND HOW FAR UP IT GOES AFTER IT RUNS OUT OF FUEL USING

$$V^2 = 2a(x-x_0) + V_0^2 \quad \text{WITH} \quad \begin{cases} a = -g = -9.8\,m/s^2 \\ x_0 = 950\,m \\ V_0 = 80\,m/s \\ V = 0\,m/s \end{cases}$$

$$x = \frac{V^2 - V_0^2}{2a} + x_0$$

$$= \frac{-(80\,m/s)^2}{-2(9.8\,m/s^2)} + 950\,m \approx \boxed{1270\,m}$$

(d) WE KNOW IT TOOK 25s FOR THE FUEL TO RUN OUT, NOW WE NEED TO FIND THE TIME FOR THIS SECOND PHASE

WE CAN USE $V = V_0 + at$ WITH $\begin{cases} V_0 = 80\,m/s \\ a = -9.8\,m/s^2 \\ V = 0 \end{cases}$

$$t = \frac{-80\,m/s^2}{-9.8\,m/s^2} \approx 8\,s$$

SO TOTAL TIME IS $25\,s + 8\,s = \boxed{33\,s = t}$

2.58 CONT.

(e) USE $(v^2 - v_0^2) = 2a(x - x_0)$ w/ $\begin{cases} v_0 = 0\,m/s \\ x_0 = 1270\,m \\ a = -g \end{cases}$ $x = 0\,m$

$$v = \left(2a(x - x_0) + v_0^2\right)^{1/2}$$

$$v = \left(2(-10\,m/s^2)(-1270\,m)\right)^{1/2}$$

$v = 159\,m/s$ (DOWN)

$\hookrightarrow \boxed{v = -159\,m/s}$

(f) TOTAL TIME IS 33 s (FROM PART (d))
PLUS THE TIME TO FALL

USE $v = v_0 + at$ $v_0 = 0\,m/s$, $a = g$, $v = -159\,m/s$

$$t = \frac{v - v_0}{a} \qquad t = \frac{-159\,m/s}{-10\,m/s^2} = 15.9\,s$$

TOTAL TIME $= 33\,s + 15.9\,s = \boxed{49\,s = t}$

2-62 WE KNOW

$x_0 = 1.5\,m$
$x = 0\,m$
$a = -g$
$t = 2\,s$

USE

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v_0 = \frac{(x - x_0) - \frac{1}{2} a t^2}{t}$$ PLUG IN VALUES

$$v_0 = \frac{-1.5\,m - \frac{1}{2}(-10\,m/s^2)(2\,s)^2}{2\,s} = \frac{-1.5\,m + 20\,m}{2\,s} =$$

$$\boxed{v_0 = 9.25\,m/s}$$

2-73 OUR INITIAL VELOCITY IS

$$V_0 = \left(100 \tfrac{km}{h}\right)\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,h}{3600\,s}\right) = 27.8\,m/s$$

AND IF

$$|a| = 30g = 30(9.8\,m/s^2) = 294\,m/s^2$$

$$V_f = 0\,m/s$$

WE CAN PLUG THESE INTO

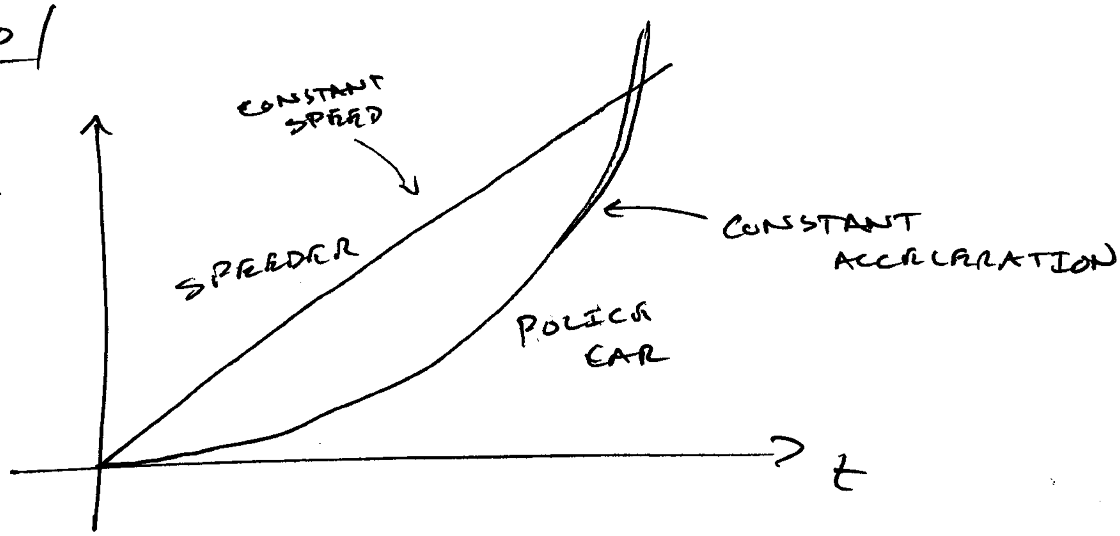
$$V_f^2 - V_0^2 = 2a(x - x_0)$$

WHERE $(x - x_0)$ IS THE SIZE OF THE CRUMPLE ZONE.

THEN $$(x - x_0) = \frac{0 - (27.8\,m/s)^2}{2(-294\,m/s^2)} = \boxed{1.3\,m}$$

2-90

(a)



(b) WE CAN FIND THE TIME BY USING THE SPEEDER'S VELOCITY

$$V_s = \left(130\,km/h\right)\left(\frac{1000\,m}{1\,km}\right)\left(\frac{1\,hr}{3600\,s}\right) = 36.1\,m/s$$

AND THE FACT THAT HE'S CAUGHT AFTER 750 m

$$V = d/t \rightarrow t = \frac{d}{V} = \frac{750\,m}{36.1\,m/s}$$

$$\boxed{t = 21\,s}$$

2-90 | (CONTINUED)

(c) NOW WE KNOW THE TIME OF OVERTAKING SO WE CAN FIGURE OUT THE POLICE CAR'S ACCELERATION WITH

$$x = x_0 + V_0 t + \frac{1}{2} a t^2 \quad \text{WITH} \begin{cases} x = 750\ m \\ x_0 = 0\ m \\ V_0 = 0\ m/s \\ t = 21\ s \end{cases}$$

$$750\ m = \frac{1}{2} a (21\ s)$$

$$\boxed{a = 3.5\ m/s^2}$$

(d) NOW THAT WE KNOW THE POLICE CAR'S ACCELERATION WE CAN PLUG IT INTO

$$V = V_0 + a t \quad \text{WITH} \begin{cases} V_0 = 0\ m/s \\ a = 3.5\ m/s^2 \\ t = 21\ s \end{cases}$$

$$V = (3.5\ m/s^2)(21\ s)$$

$$\boxed{V = 72\ m/s}$$