PHYSICS 160: HW #3

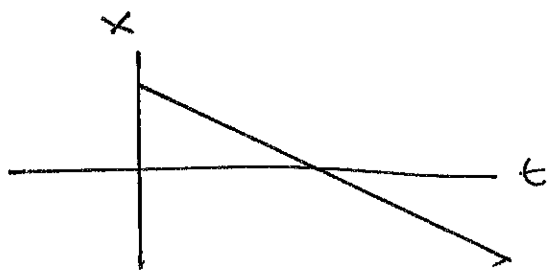
MASTERING PHYSICS: x vs. t, Sign of V AND a, motorcycle catches car, 2.77, 2.85, 2.93

RANDOMIZED, SO YOUR ANSWER will be different

Written: 2.88

Displacement Versus time

A

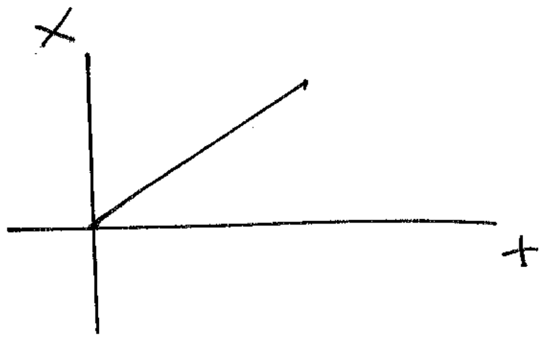


: No Acceleration since straight-line

Negative velocity since x Decreasing

Goes past stop sign since x Becomes Negative

B

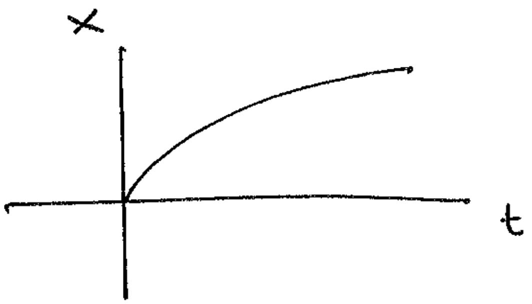


No Acceleration

positive velocity since x increasing

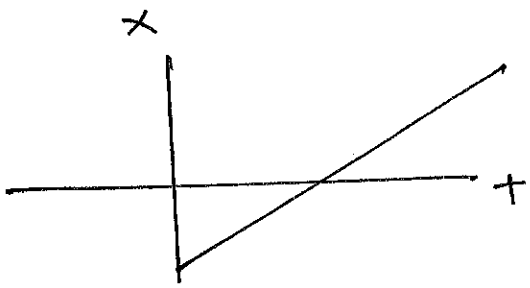
Starts at stop sign

C.



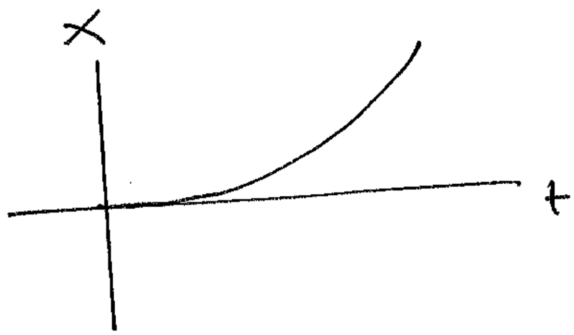
DECREASING Speed Since
Decreasing Slope
positive velocity Since
x increasing
⇒ Negative Acceleration
starts at stop sign

D



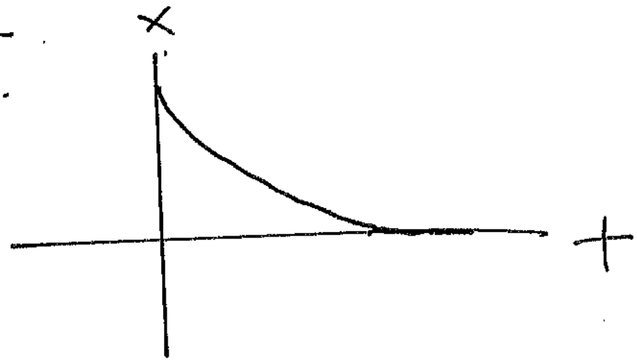
No Acceleration
positive velocity
Starts Before stop sign,
goes through Stop Sign

E.



INCREASING speed
Since increasing slope
positive velocity
⇒ positive Acceleration
Starts at stop sign

F.



Decreasing Speed
Since Decreasing
Slope.
Negative velocity
⇒ positive Acceleration
Starts in Front of
Stop Sign, Stops at
Stop sign.

Part A: Driver ignores ... Since East is
positive ⇒ $\boxed{\text{Graph D}}$

Part B: Continues West. West = Negative
⇒ $\boxed{\text{Graph A}}$

Part C: traveling West, slows and stops ⇒ $\boxed{\text{Graph F}}$

Part D: starts From rest at stop sign ... ⇒ $\boxed{\text{Graph E}}$

Direction of V and a:

Part A: Elevator moving downward $\Rightarrow V<0$

Comes to rest $\Rightarrow$ Decreasing speed $\Rightarrow$ a opposite to $V \Rightarrow a>0 \Rightarrow \boxed{(-,+)}$

Part B: Baseball thrown upwards

moving upwards $\Rightarrow V>0$

gravity decreasing speed $\Rightarrow$ a opposite to $V \Rightarrow a<0 \Rightarrow \boxed{(+,-)}$

Part C: at very top

at top $V=0$, gravity still downwards

$\Rightarrow a<0 \Rightarrow \boxed{(0,-)}$

A motorcycle Catches a Car:

Motor cycle Following Car with Constant speed

$\Rightarrow$ STRAIGHT LINE FOR CAR. $V_{Car} \neq 0$

So NOT HORIZONTAL LINE $\Rightarrow$ GRAPH D AND E INCORRECT

AT FIRST Motorcycle HAS Constant speed $\Rightarrow$ STRAIGHT LINE FROM 0 to t_1 $\Rightarrow$ GRAPH B

INCorrect

At t_1 Motorcycle Accelerates $\Rightarrow$ PARABOLA

with  SHAPE $\Rightarrow$ GRAPH C

INcorrect

$\therefore$ $\boxed{\text{MOST BE GRAPH A}}$

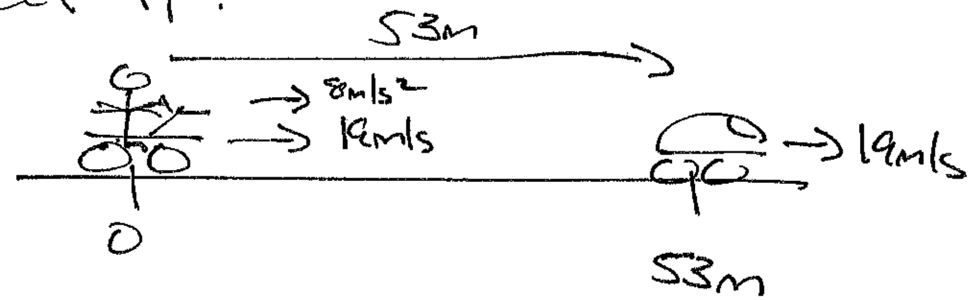
PART B: How long for motorcycle to catch car?

To catch car: $X_{motorcycle} = X_{car}$

Let t be elapsed time since t_1, i.e., let $t = t_2 - t_1$ that problem wants

Since both car and motorcycle have same speed initially at t_1, they are still 53m apart.

$\Rightarrow$ at t_1:



For motorcycle: $X_0 = 0$, $V_0 = 19\,m/s$, $a = 8\,m/s^2$

For car: $X_0 = 53\,m$, $V_0 = 19\,m/s$, $a = 0$

$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

$$\Rightarrow X_{motorcycle} = (19\,m/s)t + \frac{1}{2}(8\,m/s^2)t^2$$

$$X_{car} = 53\,m + (19\,m/s)t$$

$$X_{motorcycle} = X_{car} \Rightarrow (19\,m/s)t + \frac{1}{2}(8\,m/s^2)t^2 = 53\,m + (19\,m/s)t$$

$$\Rightarrow \frac{1}{2}(8\,m/s^2)t^2 = 53\,m \Rightarrow t = \sqrt{\frac{2(53\,m)}{8\,m/s^2}}$$

$$= \sqrt{13.25\,s^2} = 3.64\,s$$

Unit: $\frac{m}{m/s^2} = m \times \frac{s^2}{m} = s^2$

Part C: How FAR DOES motorcycle go FROM t_1?

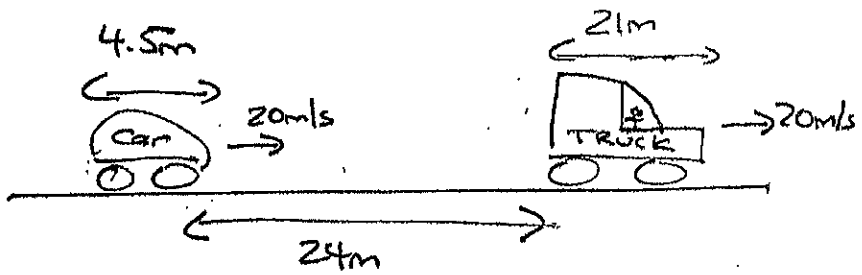
Again, FROM $t_1 \Rightarrow$ USE t (DON'T ASK ME why they gave the 3s!) $\Rightarrow X_{motorcycle} = ?$

$$X_{motorcycle} = (19\,m/s)(3.64\,s) + \frac{1}{2}(8\,m/s^2)(3.64\,s)^2 = 122.161\,m$$

$$= \underline{122\,m}$$

USED FULL ANSWER FROM CALCULATOR

2.77

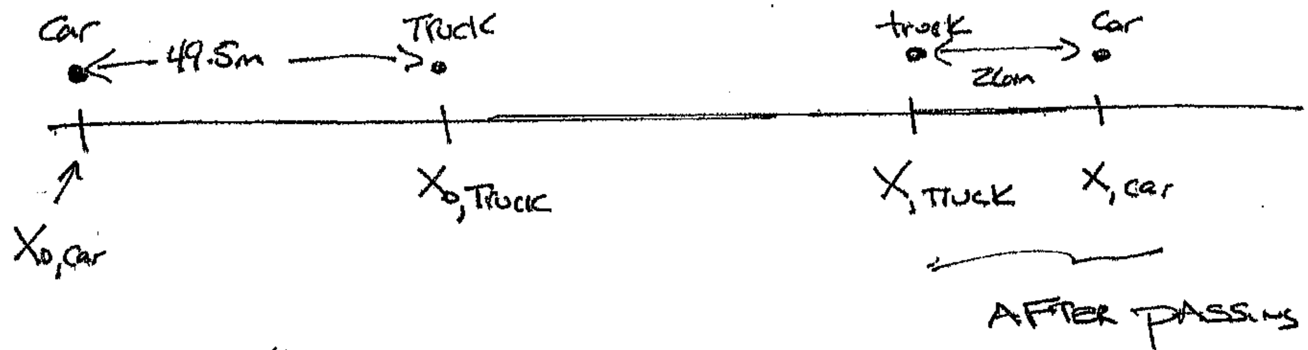


CAR ACCELERATES:

$a_c = .6\,m/s^2$

CAR PASSES WHEN ITS REAR IS 26m IN FRONT OF TRUCK.

THE REAR OF THE CAR AND THE FRONT OF THE truck ARE THE IMPORTANT LOCATIONS. SO IN "PARTICLE" MODEL



$49.5m = 4.5m + 24m + 21m$

Put origin at Car's INITIAL POSITION $\Rightarrow$

$$X_{o,car} = 0\ ,\ X_{o,truck} = 49.5m$$

CAR PASSES WHEN $X_{car} = X_{truck} + 26m$

For Car: $V_{0,c} = 20m/s$, $a_c = .6m/s^2$

For truck: $V_{0,T} = 20m/s$, $a_T = 0$

$$X = X_0 + V_0 t + \frac{1}{2}at^2 \Rightarrow X_{car} = 0 + (20m/s)t + \frac{1}{2}(.6m/s)t^2$$

$$X_{Truck} = 49.5m + (20m/s)t + 0$$

$$X_{car} = X_{truck} + 26m$$

$$\Rightarrow (\cancel{20m/s})t + (.3m/s^2)t^2 = 49.5m + (\cancel{20m/s})t + 26m$$

$$\Rightarrow (.3m/s^2)t^2 = 75.5m$$

$$\Rightarrow t = \sqrt{\frac{75.5m}{.3m/s^2}} = 15.864s = \underline{\underline{15.9s}}$$

unit: $m \times \frac{s^2}{m} = s^2$

b) WHAT distance DOES Car go?

$X_{car} = ?$

$$X_{car} = (20\,m/s)t + (.3\,m/s^2)t^2 = (20\,m/s)(15.864\,s) + (.3\,m/s^2)(15.864\,s)^2$$

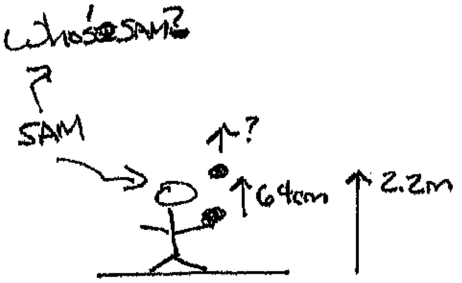
$$\Rightarrow X_{car} = 392.78\,m = \underline{\underline{393\,m}}$$

c) Car's final speed?

$$V_{car} = V_{0,car} + a_c t \Rightarrow V_{car} = 20\,m/s + (.6\,m/s^2)(15.864\,s)$$

$$\Rightarrow V_{car} = 29.5184\,m/s = \underline{\underline{29.5\,m/s}}$$

2.85



DURING LAUNCH: $V_0 = 0$, $a = 35 m/s^2$

$x - x_0 = 64cm \times \frac{1m}{100cm} = .64m$

a) what is speed ~~at~~ when SAM lets go?

$V = ? \Rightarrow V^2 = V_0^2 + 2a(x - x_0)$

$\Rightarrow V^2 = 0^2 + 2(35 m/s^2)(.64m) \Rightarrow V = \sqrt{44.8 m^2/s^2} = \underline{6.693 m/s}$

b) How High Above ground Does it go?

WHEN SAM LETS go THE SHOT BECOMES A ~~FREE~~ FREE-FALL OBJECT. IT'S INITIAL VELOCITY FOR THE FREE-FALL IS THE FINAL VELOCITY OF THE LAUNCH.

$\Rightarrow V_0 = 6.693 m/s, \; a = -9.8 m/s^2, \; X_0 = 2.2m$

↳ USE DISTANCE ABOVE GROUND

How High $\Rightarrow V = 0, \; X = ?$

$V^2 = V_0^2 + 2a(X - X_0)$ WORKS AGAIN!

$0 = (6.693 m/s)^2 + 2(-9.8 m/s^2)(X - 2.2m)$

$$\Rightarrow 0 = 44.8\,m^2/s^2 - 19.6\,m/s^2(X - 2.2\,m)$$

$$\Rightarrow X = 2.2\,m + \frac{44.8\,m^2/s^2}{19.6\,m/s^2} = 2.2\,m + 2.29\,m$$

UNIT: $\frac{m^2}{s^2} \times \frac{s^2}{m} = m$

$$\Rightarrow \underline{\underline{X = 4.49\,m}}$$

c) HOW MUCH TIME BEFORE BALL RETURNS TO his HEAD AT 1.83m

$V_0 = 6.693\,m/s$, $a = -9.8\,m/s^2$, $X_0 = 2.2\,m$, $X = 1.83\,m$, $t = ?$

$X = X_0 + V_0 t + \frac{1}{2}at^2$ will work

$$1.83\,m = 2.2\,m + 6.693\,m/s\,t + \tfrac{1}{2}(-9.8\,m/s^2)t^2$$

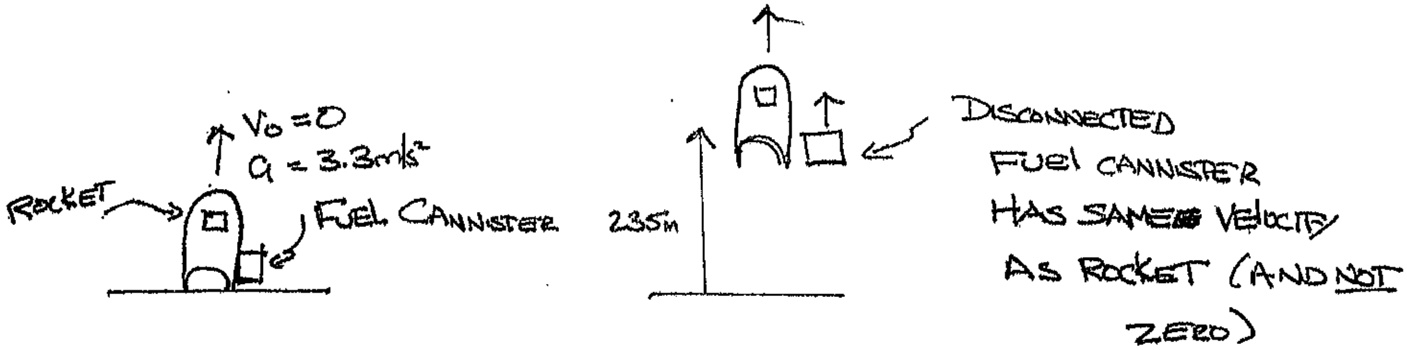
$$\Rightarrow -.37\,m = 6.693\,m/s\,t - 4.9\,m/s^2\,t^2$$

$$\Rightarrow +4.9\,m/s^2\,t^2 - 6.693\,m/s\,t - .37\,m = 0$$

$$\Rightarrow t = \frac{6.693\,m/s \pm \sqrt{(6.693\,m/s)^2 - 4(4.9\,m/s^2)(-.37\,m)}}{2(4.9\,m/s^2)} = \frac{6.693\,m/s \pm \sqrt{52.052\,m^2/s^2}}{9.8\,m/s}$$

$$\Rightarrow t = 1.42\,s \text{ OR } -.05\,s \quad \Rightarrow \underline{\underline{t = 1.42\,s}}$$

2.93



a) HOW HIGH IS ROCKET WHEN CANNISTER HITS GROUND?

FIRST FIND HOW FAST ROCKET IS GOING AT 235m:

ROCKET: $V_0 = 0$, $a = 3.3 m/s^2$, $X = 235m$, $X_0 = 0$, $V = ?$

$V^2 = V_0^2 + 2a(X - X_0)$ GIVES ANSWER IMMEDIATELY.

$V^2 = 0^2 + 2(3.3 m/s^2)(235m - 0) \Rightarrow V = \sqrt{1551 m^2/s^2} = 39.38 m/s$

$\Rightarrow$ FOR CANNISTER: $V_0 = 39.38 m/s$, $a = -9.8 m/s^2$, $X_0 = 235m$

↳ NO AIR RESISTANCE

CANNISTER HITS GROUND $\Rightarrow X = 0$

$X = X_0 + V_0 t + \frac{1}{2}at^2$ WILL LET US FIND t_{FALL} ← ELAPSED TIME SINCE CANNISTER DISCONNECTED

THEN WE CAN FIGURE OUT ROCKET'S HEIGHT.

$$\Rightarrow 0 = 235m + (39.38m/s)t_{fall} + \frac{1}{2}(-9.8m/s^2)t_{fall}^2$$

$$\Rightarrow 0 = 235m + (39.38m/s)t_{fall} - 4.9m/s^2\, t_{fall}^2$$

$$\Rightarrow +4.9m/s^2\, t_{fall}^2 - (39.38m/s)t_{fall} - 235m = 0$$

$$\Rightarrow t_{fall} = \frac{39.38m/s^2 \pm \sqrt{(39.38m/s)^2 - 4(4.9m/s^2)(-235m)}}{2(4.9m/s^2)}$$

$$= \frac{39.38m/s \pm \sqrt{6157m^2/s^2}}{9.8m/s^2} = 12.0s \text{ OR } \cancel{-3.99s}$$

$t_{fall} = 12s$. TO FIND ROCKET'S HEIGHT, WE "RESET" THE ROCKET'S INFORMATION. t_{fall} IS HOW LONG SINCE DISCONNECTION WHEN ROCKET WAS GOING 39.38m/s AND WAS 235m ABOVE GROUND $\Rightarrow$

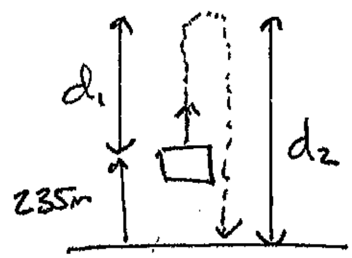
RESET ROCKET: $X_0 = 235m$, $V_0 = 39.38m/s$, $a = 3.3m/s^2$
$t = 12s$, $X = ?$

$$X = X_0 + V_0 t + \frac{1}{2}at^2 \Rightarrow X = 235m + (39.38m/s)(12s) + \frac{1}{2}(3.3m/s^2)(12s)^2$$

$$\Rightarrow X = 945.16m = 945m$$

b) WHAT TOTAL DISTANCE?

CANNISTER WAS TRAVELING UPWARDS INITIALLY



Total distance $d = d_1 + d_2$

(d_1, d_2 BOTH POSITIVE)

$d_2 = d_1 + 235m \Rightarrow d = d_1 + d_1 + 235m$

$\Rightarrow d = 2d_1 + 235m$

FIND d_1 FROM FACT $V=0$ at MAX HEIGHT

$\Rightarrow V_0 = 39.38 m/s,\ V = 0,\ a = -9.8 m/s^2;\ X - X_0 = d_1$

$\Rightarrow V^2 = V_0^2 + 2a(X - X_0) \Rightarrow 0 = (39.38 m/s)^2 + 2(-9.8 m/s^2) d_1$

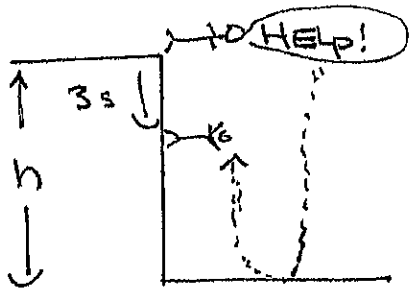
$\Rightarrow 0 = 1551 m^2/s^2 - 19.6 m/s^2\, d_1$

$\Rightarrow d_1 = \dfrac{1551 m^2/s^2}{19.6 m/s^2} = 79.13m$

UNIT: $\dfrac{m^2}{s^2} \times \dfrac{s^2}{m} = m$

$\Rightarrow d = 2(79.13m) + 235m = \underline{\underline{393m}}$

2.88



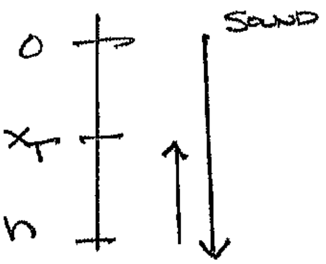
TEACHER : $V_0 = 0$, $a = \pm 9.8\,m/s^2$

SOUND : $V = V_0 = 340\,m/s^*$, $a = 0$

WHAT IS CLIFF'S HEIGHT?

* (SOUND'S SPEED IS Constant)

CALL HEIGHT h AND SET ZERO at top and MAKE DOWN POSITIVE.



IF TEACHER IS AT POSITION X_T AFTER 3S, THE SOUND HAS TRAVELED A DISTANCE $2h - X_T$, IN THAT 3S.

FOR SOUND, SINCE IT HAS A constant speed

$$d = V_0 t \Rightarrow (2h - X_T) = (340\,m/s)(3s) \Rightarrow (2h - X_T) = 1020\,m$$

FIND X_T FROM $X = X_0 + V_0 t + \frac{1}{2}at^2$

$$\Rightarrow X_T = 0 + \cancel{0(3s)}^{0} + \tfrac{1}{2}(9.8\,m/s^2)(3s)^2 = 44.1\,m$$

$$\Rightarrow 2h - 44.1\,m = 1020\,m \Rightarrow h = \frac{1064.1\,m}{2} = 532.05\,m$$

$$\approx \underline{532\,m}$$

b) How FAST IS TEACHER going?

$V = ?$, $V_0 = 0$, $a = 9.8 m/s^2$, $X = h = 532 m$, $X_0 = 0$

$\Rightarrow V^2 = V_0^2 + 2a(X - X_0) \Rightarrow V^2 = 0 + 2(9.8 m/s^2)(532 m)$

$\Rightarrow V = \sqrt{10427.2 m^2/s^2} = \underline{\underline{102 m/s}}$