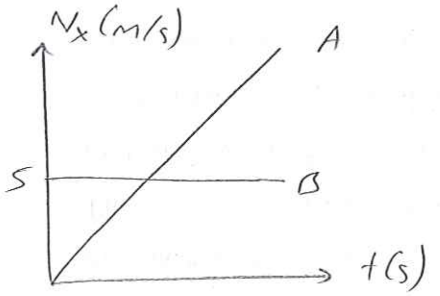
2.32

b) From figure E2.32

around $t = 1s$ $x_A = x_B \cong 5m$

around $t = 3s$ $x_A = x_B \cong 15m$

c)




d) around $t \cong 2s$, x vs t plots of both cars have the same slope

e) We found that $x_A = x_B$ for $t=1s$ and $t=3s$ in part (b)

For $t=1s$: $x_A > x_B$ before 1s and $x_B > x_A$ after 1s.

Hence B passes A.

For $t=3s$ $x_B > x_A$ before 3s and $x_A > x_B$ after 3s.

Hence A passes B.

2.43

a) Since the acceleration is constant we can use $v_y^2 = v_{oy}^2 + 2a_y(y-y_0)$

$v_{oy} = 0$ $y - y_0 = 525 m/s$ $a_y = 2.25 ms^{-2}$

+y

$v_y = \sqrt{2 \cdot (2.25)(525)} = 48.6 ms^{-1}$ : The velocity at the engine failure.

$v_{oy} = 48.6 ms^{-1}$ $a_y = -9.80 ms^{-2}$ $v_y = 0$ [at the heighest point]

$$y - y_0 = \frac{v_y^2 - v_{oy}^2}{2a_y} = \frac{0 - (48.6)^2}{2(-9.80)} = 121m$$ : After the engine failure to the heighest point

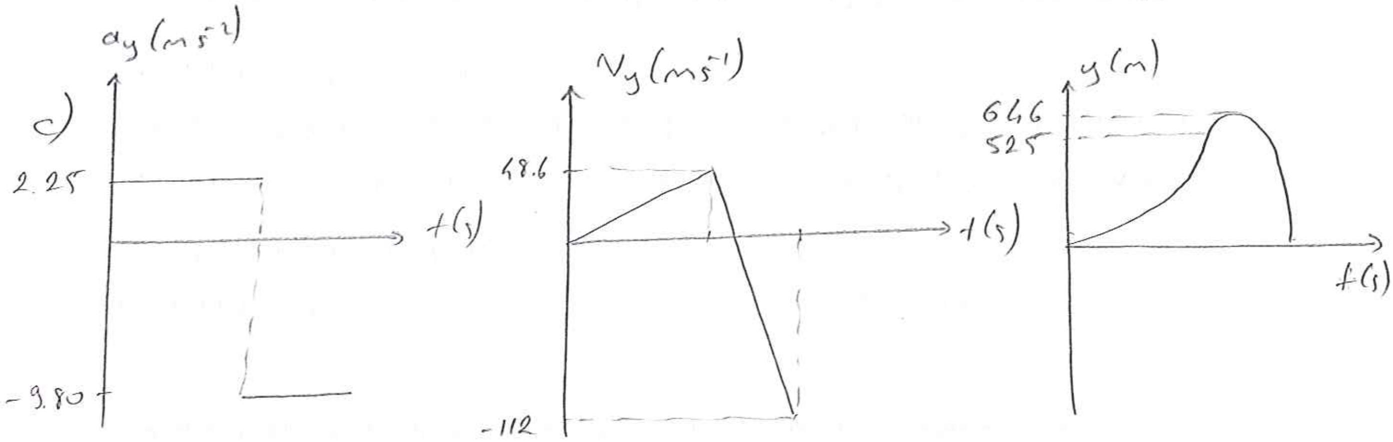
Total height $= 525 + 121 = 646m$

b) $y - y_0 = -525\,m \qquad a_y = -9.80\,ms^{-2} \qquad v_{0y} = 48.6\,ms^{-1}$

$v_y = -\sqrt{48.6^2 + 2(-9.80)(-525\,m)} = -112\,ms^{-1}$

$v_y - v_{0y} = t \cdot a_y \implies t = \dfrac{-112 - 48.6}{-9.80} = 16.4\,s$ : Time from the engine failure to crash

c)




2.44

a) $t = 0.250\,s \qquad y - y_0 = v_0 t + \frac{1}{2} a_y t^2$

$y - 40 = 5 \cdot 0.250 + \frac{1}{2}(-9.80)(0.250)^2 = 0.94\,m$

$\implies \boxed{y = 40.9\,m}$

$v_y = v_{0y} + a_y t$

$= 5 + (-9.80) \cdot 0.250 = \underline{2.55\,ms^{-1}}$

$t = 1.00\,s \qquad y - y_0 = v_0 t + \frac{1}{2} a_y t^2$

$y - 40 = 5 \cdot 1 + \frac{1}{2}(-9.80)(1)^2 = 0.10\,m$

$\implies \boxed{y = 40.1\,m}$

$v_y = 5 + (-9.80) \cdot 1 = \underline{-4.80\,ms^{-1}}$

b) $y - y_0 = -40.0\,m \qquad v_{0y} = 5.00\,ms^{-1} \qquad a_y = -9.80\,ms^{-2}$

$-40.0 = (5.00)t - (4.90)t^2$

solving for $t = (0.51 \pm 2.90)\,s$ $\quad t$ must be positive

Hence $\underline{t = 3.41\,s}$

c) $v_y = v_{0y} + a_y t \implies v_y = 5 + (-9.80) \cdot 3.41 = \boxed{-28.4\,ms^{-1}}$

2.76)

a) $v_x(t) = \alpha - \beta t^2$ $\qquad a_x = \dfrac{dv_x}{dt} = \underline{\underline{-2\beta t}}$

$$x = \int_0^t (\alpha - \beta t'^2)\, dt' = \left(\alpha t - \beta \frac{t^3}{3}\right) + C$$

$$x(0) = \alpha . 0 - \beta \frac{0^3}{3} = 0 \implies C = 0$$

$$\boxed{x(t) = \alpha t - \beta \frac{t^3}{3}}$$

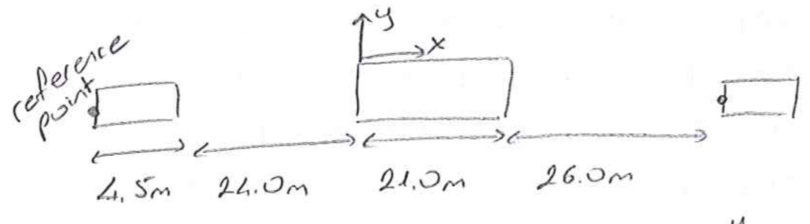
b) Maximum positive displacement occurs when $v_x$ changes sign.

$$v_x(t) = 0 \implies \alpha - \beta t^2 = 0$$

$$\alpha = \beta t^2 \implies t = \sqrt{\frac{\alpha}{\beta}}$$

$$x\left(\frac{\sqrt{\alpha}}{\sqrt{\beta}}\right) = \alpha \sqrt{\frac{\alpha}{\beta}} - \frac{\alpha\sqrt{\alpha}}{3\sqrt{\beta}} = \frac{2\alpha\sqrt{\alpha}}{3\sqrt{\beta}}$$

2.77) Acceleration is given as $a = 0.600\ ms^{-2}$, which is constant. We can use constant acceleration formulas directly.




a) We can choose any point on the car as our reference point. Here we choose back of the car.

We can also choose any coordinate system. Since the velocity of the truck and the initial velocity of the car are equal we choose a coordinate system fixed on the truck.

The back of the car is displaced from $x = -28.5m$ to $x = 47.0m$. $\quad x - x_0 = 75.5m \quad v_0 = 0 \quad a = 0.600\ ms^{-2}$

$$x - x_0 = \cancel{v_{0x}}^{0} t + \frac{1}{2} a_x t^2 \qquad t = \sqrt{\frac{2(x-x_0)}{a_x}} = 15.86\ s$$

b) $x = \underbrace{x'}_{\text{distance travelled by the car relative to the coordinate system fixed on the truck}} + \underbrace{vt}_{\text{distance travelled by the coordinate system}}$

$x = 75.5\,m + 20\,ms^{-1} \cdot 15.86\,s = \underline{\underline{393\,m}}$

c) $v_x = v_{0x} + a_x t = \underline{\underline{29.5\,ms^{-2}}}$

2.79

a) $a(t) = \alpha + \beta t$

$$v(t) = \int_0^t (\alpha + \beta t')\,dt' = v_0 + \alpha t + \frac{\beta t^2}{2}$$

$$x(t) = \int_0^t \left(v_0 + \alpha t' + \frac{\beta t'^2}{2}\right) dt' = v_0 t + \frac{\alpha t^2}{2} + \frac{\beta t^3}{6} + x_0$$

$$x(t) = x_0 \implies v_0 t + \frac{\alpha t^2}{2} + \frac{\beta t^3}{6} = 0$$

$\alpha = -2.00\,ms^{-2}$

$\beta = 3.00\,ms^{-3}$

$t = 4.00\,s$

$$4v_0 - \frac{2 \cdot 16}{2} + \frac{\overset{32}{3 \cdot 64}}{6} = 0$$

$$4v_0 - 16 + 32 = 0 \implies \underline{\underline{v_0 = -4.00\,ms^{-1}}}$$

b) $v_x(t) = v_0 + \alpha t + \dfrac{\beta t^2}{2}$

$$= -4 + (-2) \cdot 4 + \frac{3 \cdot 16}{2} = \underline{\underline{12.0\,ms^{-1}}}$$