2006 PHYSICS 10310 - Exam I

MC1

$$[F_{air}] = N = kg\ m/s^2$$
$$[A] = m^2$$
$$[v] = m/s$$

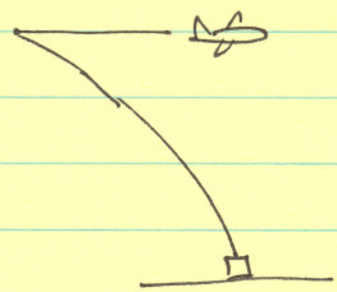
$$[C] = \frac{[F_{air}]}{[A][v^2]} = \frac{kg\ m/s^2}{m^2 \cdot m^2/s^2} = kg/m^3 .$$

(E)

MC2 Car has non-zero initial velocity and constant positive acceleration

(C)

MC3



Horizontal velocity of plane & crate remains the same, so crate fall vertically down wrt plane.

(B)

MC4 Apparent weight $w = m(g+a)$. In this case $a = -g$ so we get $w = 0$.

(D)

MC5 Only two forces present: (i) gravity and (ii) normal force.

(C)

II

a) Free fall acceleration: $v_y^2 - v_{0y}^2 = 2a(y - y_0)$

$$y - y_0 = \frac{-v_{0y}^2}{2(-g)} = \frac{(250\,m/s \cdot \sin 65^\circ)^2}{2 \cdot 9.81\,m/s^2} = \underline{\underline{2617\,m}}$$

b) „up" & „down" times are equal.

$$v_y - v_{0y} = a t_{up} \Rightarrow -v_{0y} = -g t_{up} \Rightarrow t_{up} = \frac{v_{0y}}{g}$$

$$t = t_{up} + t_{down} = \frac{2 v_{0y}}{g} = \frac{2 \cdot 250\,m/s \cdot \sin 65^\circ}{9.81\,m/s^2} = \underline{\underline{46.2\,s}}$$

c) Range:

$$R = \frac{v_0^2}{g} \sin 2\theta = \frac{(250\,m/s)^2}{9.81\,m/s^2} \cdot \sin 130^\circ = \underline{\underline{4881\,m}}$$

III

NII × 3:

$$T_1 - m_1 g = m_1 a \qquad \text{up positive}$$
$$T_3 - T_1 = m_2 a \qquad \text{right positive}$$
$$m_3 g - T_3 = m_3 a \qquad \text{down positive.}$$

a) $m_3(g - a) - m_1(g + a) = m_2 a \Rightarrow (m_1 + m_2 + m_3) a = (m_3 - m_1) g$

⇓

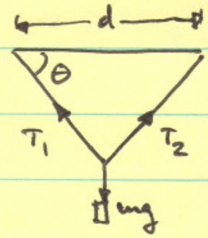
$$a = \frac{m_3 - m_1}{m_1 + m_2 + m_3} = \frac{2.5 - 1.5}{1.5 + 4.0 + 2.5} g = \frac{1}{8} g = \underline{\underline{1.23\,m/s^2}}$$

b) $T_1 = m_1(g + a) = 1.5\,kg\,(9.81\,m/s^2 + 1.23\,m/s^2) = \underline{\underline{16.6\,N}}$ $\qquad \frac{9}{8} m_1 g$!

$T_2 = m_2(g - a) = 2.5\,kg\,(9.81\,m/s^2 - 1.23\,m/s^2) = \underline{\underline{21.5\,N}}$ $\qquad \frac{7}{8} m_3 g$.

IV

a)



$\frac{\ell}{2}\cos\theta = \frac{d}{2}$

⇓

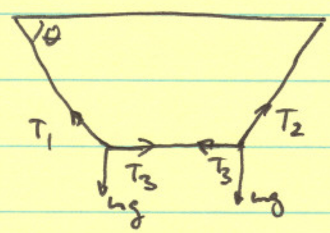
$\theta = \text{ArcCos}\,\frac{d}{\ell} = \text{ArcCos}\,\frac{1}{1.2} = \underline{\underline{33.6°}}$

b)

NII @ knot: $2T_1 \sin\theta = mg$ ($T_1 = T_2$ by symmetry)

$T_1 = \frac{mg}{2\sin\theta} = \frac{0.5\,kg \cdot 9.81\,m/s^2}{2 \cdot \sin 33.6°} = \underline{\underline{4.44\,N}}$

c)



Angle θ: $2 \cdot 0.4\,m \cos\theta + 0.4\,m = 1\,m$

$\theta = \text{ArcCos}\left(\frac{1-0.4}{2 \cdot 0.4}\right) = 41.4°$

NII @ left mass:

x: $T_1 \cos\theta_{\ell} = T_3$

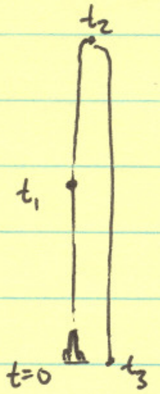
y: $T_1 \sin\theta = mg$

⇓

$T_1 = \frac{mg}{\sin\theta} = \frac{0.25\,kg \cdot 9.81\,m/s^2}{\sin 41.4°} =$ ~~16.5 N~~ $\underline{\underline{3.71\,N}}$

$T_3 = 3.71\,N \cdot \cos 41.4° = \underline{\underline{2.78\,N}}$

(V)



Part 1: $t=0 - t=t_1$ motor on.

$y_1 = \frac{1}{2} a t_1^2$ $\quad v_1 = a t_1$ $\quad a = 20\,m/s^2$

$t_1 = 20\,s.$

Part 2: moving towards highest point w/engine off. free fall acceleration!

$$\begin{cases} (y_2 - y_1) = v_1 (t_2 - t_1) - \frac{1}{2} g (t_2 - t_1)^2 \\ v_2 = v_1 - g(t_2 - t_1) \Rightarrow t_2 - t_1 = \frac{v_1}{g} = t_1 \frac{a}{g} \quad (v_2 = 0). \end{cases}$$

$\Downarrow$

$$y_2 - y_1 = a t_1 \, a t_1/g - \frac{1}{2} g (t_1 \, a/g)^2 = \frac{1}{2} a^2 t_1^2 / g$$

a) Total height:

$$y_2 = y_1 + (y_2 - y_1) = \frac{1}{2} a t_1^2 + \frac{1}{2} a^2 t_1^2 / g = \frac{1}{2} a t_1^2 (1 + a/g)$$

$$= \frac{1}{2} \cdot 20\,m/s^2 \cdot (20\,s)^2 \left(1 + \frac{20\,m/s^2}{9.81\,m/s^2}\right) = \underline{\underline{12.2\ km}}$$

b) $t_2 = t_1 (1 + a/g)$

Free fall from height y_2: $y_2 = \frac{1}{2} g (t_3 - t_2)^2 = \frac{1}{2} a t_1^2 (1 + a/g)$

$$t_3 - t_2 = t_1 \sqrt{\frac{a}{g}\left(1 + \frac{a}{g}\right)}$$

Total time: $t_3 = t_2 + (t_3 - t_2) = t_1 \left[(1 + a/g) + \sqrt{\frac{a}{g}\left(1 + \frac{a}{g}\right)} \right]$ $\quad \boxed{\frac{a}{g} = 2.04}$

$= \underline{\underline{111\ s}}$

(V) cont'd

c) $v_3 = g(t_3 - t_2) = g t_1 \sqrt{\frac{a}{g}\left(1 + \frac{a}{g}\right)}$ = [illegible]

$= t_1 \sqrt{a(a+g)} = \underline{\underline{488\ \text{m/s}}}$