PHYS1131 HIGHER PHYSICS 1A
SOLUTIONS - TUTORIAL 3

Q1.

(a) \[ F = (m_1 + m_2)a \]

\[ \therefore a = \frac{F}{(m_1 + m_2)} = \frac{3}{(1 + 2)} \text{ms}^{-2} = 1.0 \text{ms}^{-2} \]

Internal force: \[ F \text{int} = m_2a = ... = 1.0 \text{N} \]

Q2.

In all cases, the force on the man is \( N - mg = ma \).

(a) \[ N = mg = 980 \text{N} \]

(b) \[ N = mg = 980 \text{N} \]

(c) \[ N - mg = ma \Rightarrow N = m(a + g) = 100 \times 11.8 = 1180 \text{N} \]

(d) \[ mg - N = ma \Rightarrow N = m(g - a) = 680 \text{N} \]

(e) \[ mg - N = ma \Rightarrow N = 580 \text{N} \]

(f) \[ N - mg = ma \Rightarrow N = m(g + a) = 1480 \text{N} \]

Q3.

(a) \[ \text{Force } m_1: \hspace{5mm} g \sin \theta - T = m_1a \]

\[ \text{Force } m_2: \hspace{5mm} T - m_2g = m_2a \]

Eliminate \( T \): add:

\[ m_1g \sin \theta - m_2g = (m_1 + m_2)a \]

\[ a = \frac{(m_1g \sin \theta - m_2g)/(m_1 + m_2)}{-0.10g} \]

\[ m_1g \sin \theta - T = m_1a \]

\[ T = m_1g \sin \theta + m_1a = 18 \text{N} \]

Q4.

\[ \begin{align*}
T & \quad (1) \hspace{5mm} T \cos \theta = mg \\
\theta & \quad \text{(N2 in vertical)} \\
mg & \quad (2) \hspace{5mm} T \sin \theta = ma \\
\tan \theta & \quad \text{divide (1) by (2)} \\
& \quad \text{a} / \text{g} \\
a & \quad \text{g} \tan \theta
\end{align*} \]
Q5.

Maximum friction force = \( \mu_s N = \mu_s F = 36 \) N.
Weight = \( mg = 29 \) N.
The block will not move.
Actual friction force = 29 N.

\[
F = \sqrt{60^2 + 29.4^2} = 67N
\]

\[
\theta = \tan^{-1}(60/29.4) = 63.9^0
\]

\[
\theta = 64^0
\]

Q6.
(a) If the string doesn’t stretch, the acceleration of both masses has the same magnitude, \( a \), but opposite directions. Let’s suppose that the 5kg mass accelerates down with \( a \), and that the 2 kg mass accelerates up with \( a \). (If this supposition is wrong, then \( a \) will turn out to be negative.)

\[
\begin{align*}
N2 &\text{ on } 5 \text{ kg } (m_1) & m_1g - T = m_1a \\
N2 &\text{ on } 2 \text{ kg } & T - m_2g = m_2a \\
(m_1 + m_2)a &= (m_1 - m_2)g \\
\therefore a &= (m_1 - m_2)g \div (m_1 + m_2) = 20 \div 7g
\end{align*}
\]

\[
v = at = 1.26 \text{ m/s}
\]

\[
y = 1/2at^2 = 0.19m
\]

\[
v = -1.26 \text{ m/s}
\]

\[
y = 1.29 - 0.19 = 1.1m
\]

(b) 2 kg mass:

\[
y = 1/2at^2 = 0.19m
\]

5 kg mass:

\[
y = 1.29 - 0.19 = 1.1m
\]

(c) \( a = -g \)

(d) Mass A:

\[
v_0 = 1.26, y_0 = 0.19
\]

\[
y = y_0 + v_0t + 1/2at^2
\]

\[
0 = 0.19 + 1.26t - 4.9t^2
\]

\[
\therefore t = 0.36s
\]

Mass B:

\[
v_0 = -1.26, y_0 = 1.1
\]

\[
y = 1.1 - 1.26t - 4.9t^2
\]

\[
y = 0 \therefore t = 0.36s
\]
Past exam question

i) Newton 2 for $m_2$:  
\[ F = m_2g \]
Newton 2 for $m_1$ (vertical):  
\[ 0 = m_2a_{\text{vert}} = F \sin \theta - m_1g = m_2g \sin \theta - m_1g \]
\[ \sin \theta = \frac{m_1}{m_2} \]

ii) Newton 2 for $m_1$ (horizontal):  
\[ m_1a_{\text{centrip}} = m_1r\omega^2 = F \cos \theta = m_2g \cos \theta \]
substitute for $r$ and $\omega$:
\[ m_1(R \cos \theta) \left(\frac{2\pi}{T}\right)^2 = m_2g \cos \theta \]
\[ T = 2\pi \sqrt{\frac{m_1R}{m_2g}} \]

iii) The tension in both ends of the string is $F$, so, from symmetry, the line of $N$ bisects the angle between the segments of the string. So $N$ is at an angle to the vertical
\[ \alpha = \frac{(90^\circ - \theta)}{2} \]
\[ N = 2F \cos \alpha \]

iv) With finite friction, the tension in the string supporting $m_1$ may be greater than or less than $m_2g$ by the limit of the static friction. So a range of $\theta$, both greater than and less than the value found above, is possible.

v&vi) \[ 0 < \theta < \pi/2, \text{ so } 0 < m_1/m_2 < 1 \]

If $m_1 > m_2$, then the weight of $m_1$, which equals the tension in the string, is not great enough both to support $m_1$ vertically and to provide centripetal acceleration. So $m_2$ rises until it hits the bottom of the tube.