45. When Apollo astronauts landed on the moon, they left one astronaut behind in a circular orbit around the moon. For the half of the orbit spent over the far side of the moon, that individual was completely cut off from communication with the rest of humanity. How long did this lonely state last? Assume a sufficiently low orbit that you can use the moon’s surface gravitational acceleration (see Appendix E) for the spacecraft.

Supplement:

Ch 4 problem #45
Ch 5 problems
# 7, 15, 23, 29, 33, 41, 5

\[ r_{\text{moon}} = 1.76 \times 10^6 \text{ m} \]
\[ g_{\text{moon}} = 1.62 \text{ m/s}^2 \]

Now we know that centripetal acceleration has to equal gravitational acceleration @ the moon's surface

\[ \omega^2 r = g_{\text{moon}} \]
\[ \omega = \frac{2\pi}{T} \]

\[ \Rightarrow \left( \frac{2\pi}{T} \right)^2 r = g_{\text{moon}} \]
\[ T = \frac{2\pi}{\sqrt{r g_{\text{moon}}}} \]
Now for \( \frac{1}{2} \) of the orbital period, the ship will be out of radio contact.

\[
\frac{1}{2} T = \pi \sqrt{\frac{r}{g_{\text{moon}}} = 3.1416 \sqrt{\frac{1.76 \times 10^4}{1.62}}}
\]

\[
= 3.76 \times 10^3 \text{ sec or 54.3 min}
\]
7. Object A accelerates at 8.1 m/s² when a 3.3-N force is applied. Object B accelerates at 2.7 m/s² when the same force is applied. (a) How do the masses of the two objects compare? (b) If A and B were stuck together and accelerated by the 3.3-N force, what would be the acceleration of the composite object?

\[ F = ma \]

\[ \Rightarrow m_1a_1 = m_2a_2 \]

\[ \frac{m_2}{m_1} = \frac{a_1}{a_2} = \frac{8.1}{2.7} = 3 \]

\[ m_2 \text{ is three times more massive than } m_1 \]

\[ m_1 = \frac{3.3}{8.1} = 0.407 \text{ kg} \quad m_2 = \frac{3.3}{2.7} = 1.22 \text{ kg} \]

\[ b) \quad a = \frac{F}{m_1 + m_2} = \frac{3.3 \text{ N}}{1.63 \text{ kg}} = 2.03 \text{ m/s}^2 \]
Problem

15. A 1.25-kg object is moving in the \( x \) direction at 17.4 m/s. 3.41 s later, it is moving at 26.8 m/s at 34.0° to the \( x \)-axis. What are the magnitude and direction of the force applied during this time?

\[
\vec{F}_{\text{ave}} = \frac{\vec{m} \Delta \vec{v}}{\Delta t}
\]

\[
\vec{v}_{\text{init}} = \begin{pmatrix} 17.4 \\ 0 \end{pmatrix} \text{ m/s}
\]

\[
\vec{v}_{\text{final}} = 26.8 \left( \begin{pmatrix} \cos 34^\circ \\ \sin 34^\circ \end{pmatrix} \right) \text{ m/s} = \begin{pmatrix} 22.2 \\ 15.0 \end{pmatrix} \text{ m/s}
\]

\[
\Delta \vec{v} = \vec{v}_{\text{final}} - \vec{v}_{\text{init}} = \begin{pmatrix} 4.8 \\ 15.0 \end{pmatrix} \text{ m/s}
\]

\[
\vec{F}_{\text{ave}} = \frac{1.25 \left( \frac{4.8}{15.0} \right)}{3.41} = \begin{pmatrix} 1.77 \\ 5.49 \end{pmatrix} \text{ N}
\]

\[|\vec{F}_{\text{ave}}| = 5.77 \text{ N}\]

\[\theta = \tan^{-1} \left( \frac{5.49}{1.77} \right) \approx 72.2^\circ\]

Direction: \[
\begin{pmatrix} 1.77 \\ 5.49 \end{pmatrix}
\]
23. A neutron star is a fantastically dense object with the mass of a star crushed into a region about 10 km in diameter. If my mass is 75 kg, and if I would weigh $5.8 \times 10^{14}$ N on a certain neutron star, what is the acceleration of gravity on the neutron star?

\[ W = mg \quad \Rightarrow \quad g = \frac{W}{m} \]

For a neutron star:

\[ g = \frac{5.8 \times 10^{14} \text{ N}}{75 \text{ kg}} = 7.73 \times 10^{12} \frac{\text{m}}{\text{sec}^2} \]

This is nearly a trillion times the force of gravity on the Earth!
An airplane encounters sudden turbulence, and you feel momentarily lighter. If your apparent weight seems to be about 70% of your normal weight, what are the magnitude and direction of the plane's acceleration?

\[ -mg + ma = -1.7mg \]

\[ \Rightarrow a = 0.3g = 2.9 \text{ m/s}^2 \]

(This assumes that there is no horizontal component to the acceleration. You might want to discuss the impact that a horizontal component would have on solving this problem.)
33. An elevator moves upward at 5.2 m/s. What is
the minimum stopping time it can have if the
passengers are to remain on the floor?

\[ a = g \]

Simply put, the deceleration of the
elevator cannot be greater than
9.8 m/sec^2 if the individual is
to remain on the floor.

\[
v = v_0 + at \Rightarrow 5.2 \text{ m/s} + (-9.8 \text{ m/s}^2)t = 0
\]

\[
t = \frac{5.2 \text{ m/s}}{-9.8 \text{ m/s}^2} = 0.531 \text{ sec}
\]
11. A 2200-kg airplane is pulling two gliders, the first of mass 310 kg and the second of mass 260 kg, down the runway with an acceleration of 1.9 m/s² (Fig. 5-37). Neglecting the mass of the two ropes and any frictional forces, determine (a) the horizontal thrust of the plane's propeller; (b) the tension force in the first rope; (c) the tension force in the second rope; and (d) the net force on the first glider.

\[ F = (m_1 + m_2 + m_3)a \]
\[ = (2200 + 310 + 260) \text{kg} \times (1.9 \text{ m/s}^2) \]
\[ = 5,266 \text{ N} \]

\[ T_1 = F - m_1a = (m_2 + m_3)a \]
\[ = 1,080 \text{ N} \]
c) \( T_z = m_3 a = 494 \text{ N} \)

d) \( F_z = m_2 a = 589 \text{ N} \)
51. A 7.2-kg mass is hanging from the ceiling of an elevator by a spring of spring constant 150 N/m whose unstretched length is 50 cm. What is the overall length of the spring when the elevator (a) starts moving upward with acceleration 0.95 m/s²; (b) moves upward at a steady 14 m/s; (c) comes to a stop while moving upward at 14 m/s, taking 9.0 s to do so? (d) If the elevator measures 3.2 m from floor to ceiling, what is the maximum acceleration it could undergo without the 7.2-kg mass hitting the floor?

\[ F_s = m(g + a) \]

\[ \alpha = +0.95 \text{ m/sec}^2 \]

\[ F_s = m(9.8 + 0.95) \]

\[ = 77.4 \text{ N} \]

\[ F_s = kx \]

Length of spring = 0.80 + x = 80 + \frac{F_s}{k} \]

Take this one step further... \[ L_{spring} = 0.80m + \frac{m(g + a)}{k} \]
So for a):

\[ L_{\text{spring}} = 0.8 + \frac{7.2 (9.8 + 0.95)}{150} \]

\[ = 1.32 \text{ m} \]

b) \( a = 0 \)

\[ L_{\text{spring}} = 0.8 + \frac{7.2 (9.8)}{150} \]

\[ = 1.27 \text{ m} \]

c) \( a = \frac{\Delta v}{t} = \frac{-14 \text{ m/s}}{0.1 \text{s}} = -1.56 \text{ m/s}^2 \)

\[ L_{\text{spring}} = 0.8 + \frac{7.2 (9.8 - 1.56)}{150} \]

\[ = 1.20 \text{ m} \]
d) \[ L_{\text{spring}} = 3.2 = 0.8 + \frac{mg \Delta x}{k} \]

\[
\frac{2.4k}{m} - g = a
\]

\[ a_{\text{max}} = \frac{2.4 \times 150}{2.2} - 9.8 \]

\[ = 40.2 \text{ m/s}^2 \approx 4g \]