5.14

Var	Given value	Units	Description
r		m	radius of space station
d	960	m	diameter of space station
a_c		$\frac{m}{s^2}$	centripetal acceleration (artificial gravity)
g	9.80	$\frac{m}{s^2}$	acc. due to gravity on earth
f		s^{-1}	frequency of rotation
T		s	period of rotation
v		$\frac{m}{s}$	tangential speed

$$r = \frac{d}{2}$$

$$= \frac{960\,\text{m}}{2}$$

$$= 480\,\text{m}$$ ✓

$$a_c = 1.5g$$

$$= 1.5\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)$$

$$= 15.\,\frac{\text{m}}{\text{s}^2}$$ ✓

5.14 (continued)

$$f = \frac{1}{T}$$

$$v = \frac{2\pi r}{T} = 2\pi r f$$

$$a_{\mathrm{c}} = \frac{v^2}{r} = 4\pi^2 r f^2$$

$$f = \sqrt{\frac{a_{\mathrm{c}}}{4\pi^2 r}}$$

$$= \sqrt{\frac{15.\ \frac{\mathrm{m}}{\mathrm{s}^2}}{4\pi^2 (480\,\mathrm{m})}}$$

$$= 0.028\,\mathrm{s}^{-1}$$ ✓

$$T = \frac{1}{f}$$

$$= \frac{1}{0.028\,\mathrm{s}^{-1}}$$

$$= 36.\ \mathrm{s}$$ ✓

5.14 (continued)

Var	Given value	Units	Description
r_c		m	new distance from center for 0.75g

$$0.75\,g = 4\pi^2 r_c f^2$$

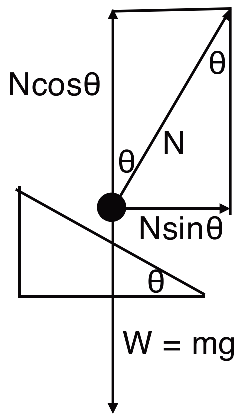
$$r_c = \frac{0.75\,g}{4\pi^2 f^2}$$

$$= \frac{0.75\left(9.80\,\frac{m}{s^2}\right)}{4\pi^2\left(0.028\,s^{-1}\right)^2}$$

$$= 2.4\times10^2\ m$$ ✓

5.16

Car is coming towards you, out of the page on a curve with banking angle θ.



Var	Given value	Units	Description
N		N	normal force on car
θ	68	°	banking angle
m		kg	mass of car
g	9.80	$\frac{m}{s^2}$	acc. due to gravity
F_c		N	centripetal force on car
v		$\frac{m}{s}$	speed of car
r	100	m	radius of curve

$$N\sin\theta = F_c$$

$$N\cos\theta = mg$$

Divide top equation by the bottom one.

5.16 (continued)

$$\frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$\tan\theta = \frac{F_c}{mg}$$

$$F_c = \frac{mv^2}{r}$$

$$\tan\theta = \frac{v^2}{rg}$$

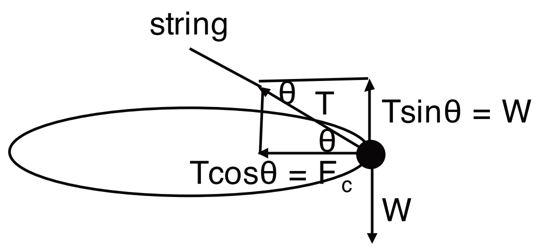
$$v = \sqrt{rg\tan\theta}$$

$$= \sqrt{(100\,\text{m})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)\tan(68°)}$$

$$= 49.3\,\frac{\text{m}}{\text{s}}$$ ✓

5.18

Tension in string must provide centripetal force to keep can in circle and support weight of can.



Var	Given value	Units	Description
T		N	tension in string
F_c		N	centripetal force
m	0.115	kg	mass of can and contents
v	10.0	$\frac{m}{s}$	tangential speed
r	1.00	m	radius of circular path
θ		°	angle of string with horizontal
g	9.80	$\frac{m}{s^2}$	acc. due to grav.
W		N	weight of can and contents

$$F_c = \frac{m v^2}{r}$$

$$= \frac{(0.115\,\text{kg})\left(10.0\,\frac{\text{m}}{\text{s}}\right)^2}{1.00\,\text{m}}$$

5.18 (continued)

$$= 11.5\,\mathrm{N}$$ ✓

$$W = mg$$

$$= (0.115\,\mathrm{kg})\left(9.80\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)$$

$$= 1.13\,\mathrm{N}$$ ✓

$$\tan\theta = \frac{W}{F_c}$$

$$\theta = \operatorname{atan}\frac{W}{F_c}$$

$$= \operatorname{atan}\frac{1.13\,\mathrm{N}}{11.5\,\mathrm{N}}$$

$$= 5.61°$$ ✓

$$W = T\sin\theta$$

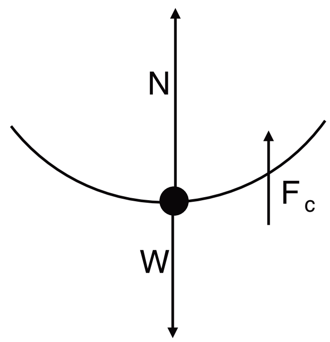
$$T = \frac{W}{\sin\theta}$$

$$= \frac{1.13\,\mathrm{N}}{\sin(5.61°)}$$

5.18 (continued)

$$= 11.6N$$ ✓

5.20



$$220\,\frac{km}{h}\left(\frac{1\,h}{3600\,s}\right)\left(\frac{1000\,m}{1\,km}\right) = 61.1\,\frac{m}{s}$$

Var	Given value	Units	Description
a_c		$\frac{m}{s^2}$	centripetal acc. of pilot
v	61.1	$\frac{m}{s}$	speed of pilot
r	180	m	radius of pilot's path
$g's$			ratio of a_c to acc. due to grav.
g	9.80	$\frac{m}{s^2}$	acc. due to gravity

$$a_c = \frac{v^2}{r}$$

$$= \frac{\left(61.1\,\frac{m}{s}\right)^2}{180\,m}$$

$$= 20.7\,\frac{m}{s^2}$$ ✔

5.20 (continued)

$$g\text{'s} = \frac{a_c}{g}$$

$$= \frac{20.7\ \frac{\text{m}}{\text{s}^2}}{9.80\ \frac{\text{m}}{\text{s}^2}}$$

$$= 2.11$$ ✓

Var	Given value	Units	Description
F_c		N	centripetal force on pilot
W		N	weight of pilot
N		N	normal force or apparent weight of pilot
m		kg	mass of pilot

$$F_c = N - W$$

$$N = F_c + W$$

$$N = m\,a_c + m\,g$$

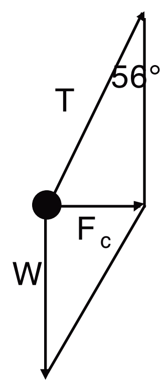
$$N = (a_c + g)\,m$$

$$(2.11\,g + g)\,m = 3.11\,m\,g$$

5.20 (continued)

Normal force is 3.11 times the actual weight of the pilot.

5.22



Var	Given value	Units	Description
θ	56	°	angle of chain with vertical
F_c		N	centripetal force
W		N	weight of plane
v		$\frac{m}{s}$	plane speed
r	46	m	radius of path
g	9.80	$\frac{m}{s^2}$	acc. due to gravity

$$\tan\theta = \frac{F_c}{W}$$

$$\tan\theta = \frac{v^2}{rg}$$

$$\sqrt{\tan\theta\, r\, g} = v$$

5.22 (continued)

$$v = \sqrt{\tan\theta\, r\, g}$$

$$= \sqrt{\tan(56°)(46\,\text{m})\left(9.80\,\frac{\text{m}}{\text{s}^2}\right)}$$

$$= 25.9\,\frac{\text{m}}{\text{s}}$$

✓