GIANCOLI HOMEWORK SOLUTIONS
Section 5-1 to 5-3, #1-20

1. GIVEN

$r = 1.10m$

$v = 1.25\, m/s$

$m = 25.0kg$

SOLUTION

a. $a_c = \frac{v^2}{r} = \frac{(1.25)^2}{(1.10)} = 1.42\, m/s^2$

b. $\sum F = ma$

$$F = ma_c = m\frac{v^2}{r} = (25)\frac{(1.25)^2}{(1.10)} = 35.5N$$

2. GIVEN

$v = 1890\, km/h = 525\, m/s$

$r = 6.00km = 6000m$

KNOWN

$1g = 9.81\, m/s^2$

SOLUTION

$$a_c = \frac{v^2}{r} = \frac{(525)^2}{(6000)} = 45.9\, m/s^2 \left(\frac{1g}{9.81\, m/s^2}\right) = 4.68g's$$

3. GIVEN

$r = 1.5x10^{11}m$

assume earth's orbit is a circle

KNOWN

$m_{earth} = 5.98x10^{24}kg$

$$T_{earth} = 365days\left(\frac{24hr}{day}\right)\left(\frac{60min}{hr}\right)\left(\frac{60s}{min}\right) = 3.15x10^7 s$$

SOLUTION

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

$$v = \frac{2\pi r}{T} = \frac{2\pi(1.5x10^{11})}{3.15x10^7} = 2.99x10^4\, m/s$$

$$a_c = \frac{v^2}{r} = \frac{(2.99x10^4)^2}{(1.5x10^{11})} = 5.97x10^{-3}\, m/s^2$$

$$F = ma_c = m\frac{v^2}{r} = (5.98x10^{24})\frac{(2.99x10^4)^2}{(1.5x10^{11})} = 3.57x10^{22} N$$

The gravitational attraction of the sun exerts this force.

4. GIVEN

$F = 210N$

$m = 2.0kg$

$r = 0.90m$

horizontal circle

SOLUTION

$F = ma_c$

$$\frac{F}{m} = a_c = \frac{(210)}{(2.0)} = 105\, m/s^2$$

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

$a_c r = v^2$

$$\sqrt{a_c r} = v = \sqrt{(105)(0.90)} = 9.7\, m/s$$

5. GIVEN

$h = 400km = 400{,}000m$

$T = 90min = 5400s$

KNOWN

$r_{earth} = 6.38x10^3 km = 6.38x10^6 m$ inside front cover of book

radius of orbit is from the center of the earth so $r = r_{earth} + h$

$1g = 9.81\, m/s^2$

SOLUTION

$r = r_{earth} + h = 6.38x10^6 m + 400{,}000m = 6.78x10^6 m$

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

$$v = \frac{2\pi r}{T} = \frac{2\pi(6.78x10^6)}{5400} = 7.89x10^3\, m/s$$

$$a_c = \frac{v^2}{r} = \frac{(7.89x10^3)^2}{(6.78x10^6)} = 9.18\,m/s^2\left(\frac{1g}{9.81\,m/s^2}\right) = 0.936g's$$

6. GIVEN

$$f = \frac{45rev}{min}\left(\frac{min}{60s}\right) = \frac{0.75rev}{s}$$

$$d = 32cm = 0.32m$$

SOLUTION

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

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

$$r = \frac{d}{2} = \frac{0.32}{2} = 0.16m$$

$$T = \frac{1}{f} = \frac{1}{\frac{0.75rev}{s}} = \frac{1s}{0.75rev} = 1.33\,s/rev$$

$$v = \frac{2\pi r}{T} = \frac{2\pi(0.16)}{1.33} = 0.756\,m/s$$

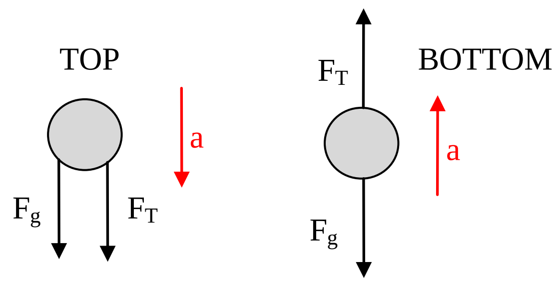
$$a_c = \frac{v^2}{r} = \frac{(0.756)^2}{(0.16)} = 3.57\,m/s^2$$

7. GIVEN

$$r = 72.0cm = 0.720m$$

$$v = 4.00\,m/s$$

$$m = 0.300kg$$



KNOWN

acceleration is always toward the center

SOLUTION

a. Top

$$\sum F = ma$$

$$F_g + F_T = ma_c$$

$$mg + F_T = m\frac{v^2}{r}$$

$$F_T = m\frac{v^2}{r} - mg = (0.3)\left(\frac{(4)^2}{(0.72)}\right) - (0.3)(9.81) = 3.72N$$

b. Bottom

$$\sum F = ma$$

$$F_T - F_g = ma_c$$

$$F_T - mg = m\frac{v^2}{r}$$

$$F_T = m\frac{v^2}{r} + mg = (0.3)\left(\frac{(4)^2}{(0.72)}\right) + (0.3)(9.81) = 9.61N$$

8. <u>GIVEN</u>

$m = 0.45kg$

$r = 1.3m$

$F_{T-max} = 75N$

horizontal frictionless surface so gravity and friction not a factor

<u>SOLUTION</u>

$$\sum F = ma$$

$$F_{T-max} = ma_c$$

$$F_{T-max} = m\frac{v^2}{r}$$

$$\frac{(F_{T-max})(r)}{m} = v^2$$

$$\sqrt{\frac{(F_{T-max})(r)}{m}} = v = \sqrt{\frac{(75)(1.3)}{(0.45)}} = 14.7\, m/s$$

9. <u>GIVEN</u>

$m = 1050kg$

$r = 77m$

$\mu_s = 0.80$

<u>KNOWN</u>

The static friction between the tires and the road provides the centripetal force for the car to turn.

<u>SOLUTION</u>

$$\sum F = ma$$

$$F_f = ma_c$$

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

$$\frac{(F_f)(r)}{m} = v^2$$

$$F_f = F_N\mu_s = mg\mu_s$$

$$\sqrt{\frac{\cancel{m}g\mu_s(r)}{\cancel{m}}} = \sqrt{g\mu_s(r)} = v = \sqrt{(9.81)(0.8)(77)} = 24.6\,m/s$$

Mass is not a factor since it cancels out.

10. GIVEN

$r = 85m$

$v = 95\,km/h = 26.4\,m/s$

KNOWN

The static friction between the tires and the road provides the centripetal force for the car to turn.

Mass is not a factor since it cancels out.

SOLUTION

$$\sum F = ma$$

$$F_f = ma_c$$

$$F_f = F_N\mu_s = \cancel{m}g\mu_s = \cancel{m}\frac{v^2}{r}$$

$$\mu_s = \frac{v^2}{gr} = \frac{(26.4)^2}{(9.81)(85)} = 0.835$$

11. GIVEN

$r = 12.0m$

$F_N = 7.85mg$

The normal force is the force the astronaut is sensing and it is the same as the centripetal force -- i.e., it is the force that is making her turn in a circle.

SOLUTION

a. Speed in m/s

$$\sum F = ma$$

$$F_N = F_c = 7.85mg = ma_c$$

$$7.85\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$(7.85g)(r) = v^2$$

$$\sqrt{(7.85g)(r)} = v = \sqrt{(7.85)(9.81)(12)} = 30.4\,m/s$$

b. Speed in rev/s (rev/s are the units for frequency)

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

$$T = \frac{2\pi r}{v} = \frac{2\pi(12)}{30.4} = 2.48s$$

$$f = \frac{1}{T} = \frac{1}{2.48} = .0403\, rev/s$$

12. GIVEN

$$r = 11.0cm = 0.11m$$

$$f_{max} = \frac{36rev}{min}\left(\frac{min}{60s}\right) = \frac{0.6rev}{min}$$

KNOWN

Friction is supplying the centripetal force. Maximum static friction is overcome when the turntable reaches 36 rpm which corresponds to the velocity which gives maximum centripetal acceleration for the maximum available centripetal force.

SOLUTION

$$\sum F = ma$$

$$F_f = ma_c$$

$$F_f = F_N\mu_s = \cancel{m}g\mu_s = \cancel{m}\frac{v^2}{r}$$

$$\mu_s = \frac{v^2}{gr}$$

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

$$T = \frac{1}{f} = \frac{1}{0.6} = 1.67\, s/rev$$

$$v = \frac{2\pi r}{T} = \frac{2\pi(0.11)}{1.67} = 0.415\, m/s$$

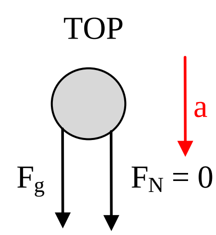
$$\mu_s = \frac{v^2}{gr} = \frac{(0.415)^2}{(9.81)(0.11)} = 0.159$$

13. GIVEN

$$r = 7.4m$$

KNOWN

At the minimum speed, the centripetal force is provided by the force of gravity alone, the track does not have to provide any of the centripetal force.



SOLUTION

$$\sum F = ma$$

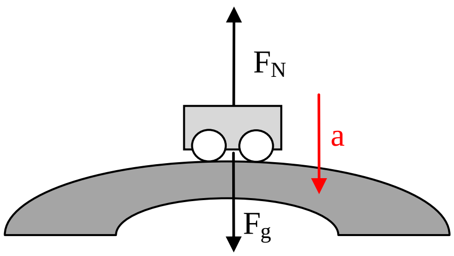
$$F_g = F_c = mg = ma_c$$

$$\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$gr = v^2$$

$$\sqrt{(gr)} = v = \sqrt{(9.81)(7.4)} = 8.52\,m/s$$

14. GIVEN



$m = 950kg$

$r = 95m$

$v = 22\,m/s$

SOLUTION

a. $\sum F = ma$

$$F_N - F_g = -ma_c$$

$$F_N - mg = -ma_c$$

$$F_N = mg - m\frac{v^2}{r} = (950)(9.81) - (950)\left(\frac{(22)^2}{(95)}\right) = 4480N$$

b. $m_{driver} = 72kg$

$$\sum F = ma$$

$$F_N - F_g = -ma_c$$

$$F_N - mg = -ma_c$$

$$F_N = mg - m\frac{v^2}{r} = (72)(9.81) - (72)\left(\frac{(22)^2}{(95)}\right) = 339N$$

c. speed at which normal force equals zero

$$\sum F = ma$$

$$F_N - F_g = -ma_c$$

$$0 - mg = -ma_c$$

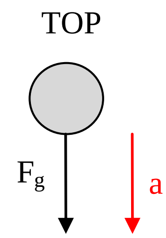
$$\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$\sqrt{gr} = v = \sqrt{(9.81)(95)} = 30.5\,m/s$$

15. GIVEN

$d = 15m$

$r = \frac{d}{2} = 7.5m$



KNOWN

Passengers feel weightless when the gravity force (weight) supplies all the centripetal force.

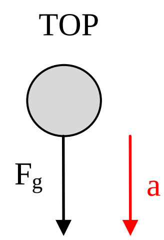
SOLUTION

$$\sum F = ma$$

$$F_g = ma_c$$

$$\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$\sqrt{gr} = v = \sqrt{(9.81)(7.5)} = 8.58\, m/s$$



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

$$T = \frac{2\pi r}{v} = \frac{2\pi(7.5)}{8.58} = 5.49s$$

$$f = \frac{1}{T} = \frac{1}{5.49} = 0.182\frac{rev}{s}\left(\frac{60s}{min}\right) = 10.9\frac{rev}{min}$$

16. GIVEN

$m = 2.00kg$

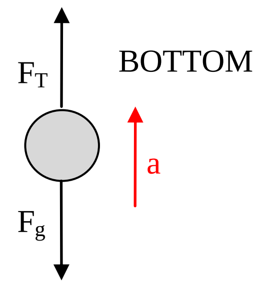
$r = 1.10m$

$F_{T-bottom} = 25.0N$

Vertical circle

SOLUTION

a. Bottom



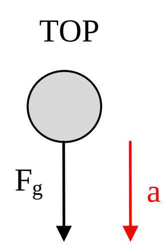
$$\sum F = ma$$

$$F_T - F_g = ma_c$$

$$F_T - mg = m\frac{v^2}{r}$$

$$\sqrt{\frac{(F_T - mg)r}{m}} = v = \sqrt{\frac{(25-[2][9.81])(1.1)}{(2)}} = 1.72\, m/s$$

b. At the minimum speed, the centripetal force is provided by the force of gravity alone, the rope does not have to provide any of the centripetal force.



$$\sum F = ma$$

$$F_g = F_c = mg = ma_c$$

$$\cancel{m}g = \cancel{m}\frac{v^2}{r}$$

$$gr = v^2$$

$$\sqrt{(gr)} = v = \sqrt{(9.81)(1.1)} = 3.28\, m/s$$

17. GIVEN

$$r = 9.00cm = 0.09m$$

$$a = 115000g\left(\frac{9.81\, m/s^2}{1g}\right) = 1.13x10^6\, m/s^2$$

SOLUTION

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

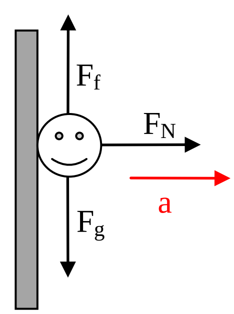
$$\sqrt{a_c r} = v = \sqrt{(1.13x10^6)(0.09)} = 319\, m/s$$

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

$$T = \frac{2\pi r}{v} = \frac{2\pi(0.09)}{319} = 0.00177s$$

$$f = \frac{1}{T} = \frac{1}{0.00177} = 563\frac{rev}{s}\left(\frac{60s}{min}\right) = 3.38x10^4\,\frac{rev}{min}$$

18. GIVEN



$$r = 4.6m$$

$$f = 0.5\frac{rev}{s}$$

KNOWN

- To keep from sliding down, force of friction must equal weight
- Friction force is dependent on normal force
- Normal force is equal to centripetal force which is dependent on centripetal acceleration

SOLUTION

$$\sum F_y = 0$$

$$F_g = F_f$$

$$mg = F_N\mu$$

$$F_N = F_c = ma_c$$

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

$$\cancel{m}g = \cancel{m}\frac{v^2}{r}\mu$$

$$g = \frac{v^2}{r}\mu$$

$$\frac{gr}{v^2} = \mu$$

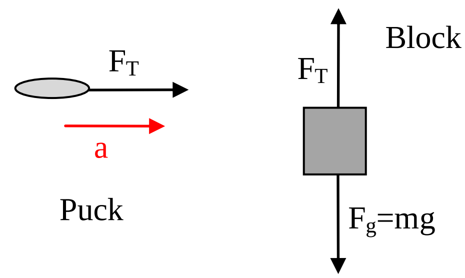
$$v = \frac{2\pi r}{T}$$

$$T = \frac{1}{f} = \frac{1}{0.5} = 2\frac{s}{rev}$$

$$v = \frac{2\pi r}{T} = \frac{2\pi(4.6)}{2} = 14.5\,m/s$$

$$\frac{(9.81)(4.6)}{(14.5)^2} = \mu = 0.216$$

19. GIVEN



$$m_{puck} = M$$

$$m_{block} = m$$

$$r = R$$

SOLUTION

a. Puck

$$\sum F = Ma$$

$$F_T = Ma_c$$

$$F_T = M\frac{v^2}{R}$$

b. Block

$$\sum F = ma = 0$$

$$F_T - F_g = 0$$

$$F_T = F_g = mg$$

$$F_T = F_T$$

$$M\frac{v^2}{R} = mg$$

$$v^2 = \frac{Rmg}{M}$$

$$v = \sqrt{\frac{Rmg}{M}}$$

20. <u>GIVEN</u>

$r = 0.600m$

$m = 0.150kg$

$T = 0.500s$

<u>KNOWN</u>

- The vertical component of the tension force must support the weight of the ball
- The horizontal component of the tension force must provide the centripetal force
- The tension force is the vector sum of the horizontal and vertical components

<u>SOLUTION</u>

$$F_{T-y} = F_g = mg = (0.15)(9.81) = 1.47N$$

$$F_{T-x} = m\frac{v^2}{r}$$

$$v = \frac{2\pi r}{T} = \frac{2\pi(0.6)}{0.5} = 7.54\, m/s$$

$$F_{T-x} = (0.15)\frac{(7.54)^2}{(0.6)} = 14.2N$$

$$F_T = \sqrt{{F_{T-x}}^2 + {F_{T-y}}^2} = \sqrt{(14.2)^2 + (1.47)^2} = 14.3N$$