This print-out should have 18 questions. Check that it is complete before leaving the printer. Also, multiple-choice questions may continue on the next column or page: find all choices before making your selection.

Note that only a few (usually 4) of the problems will have their scores kept for a grade. You may make multiple tries to get a problem right, although it's worth less each time. Worked solutions to a number of these problems (even some of the scored ones) may be found on the Ph211 home page.

Falling Apple

02:05, trigonometry, numeric, > 1 min.

001

An apple falls from a tree and hits the ground 10.5 m below.

With what speed will it hit the ground?

Correct answer: 14.3457 m/s.

Explanation:

When an object undergoes free fall from rest, its final speed is given by

$$v = \sqrt{2gh}$$

Algorithm

$$h = 10.5 \text{ m} \left\{ {6.1 \atop 15} \right\} \tag{1}$$

$$g = 9.8 \text{ m/s}^2 \tag{2}$$

$$\begin{aligned} v &= \sqrt{2.0\ g\ h} \\ &= \sqrt{2.0 \langle 9.8 \rangle \langle 10.5 \rangle} \\ &= 14.3457 \text{ m/s} \end{aligned} \tag{3}$$

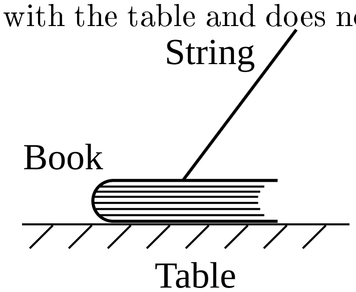
$$\langle \text{m/s} \rangle = \sqrt{\langle\rangle \langle \text{m/s}^2 \rangle \langle \text{m} \rangle} \qquad \text{units}$$

P303k conc forces1

05:01, noArithmetic, multiple choice, < 1 min.

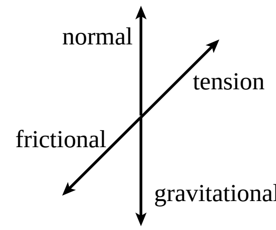
002

A string is tied to a book and pulled at an angle as shown in the figure. The book remains in contact with the table and does not move.



Which of the following best describes a free body diagram for the book?

1.



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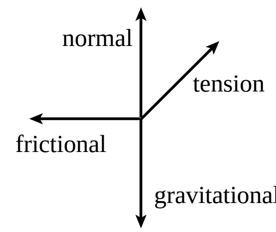
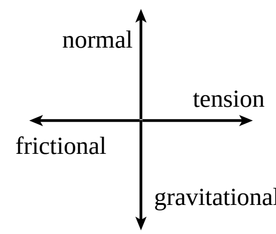


correct

3.



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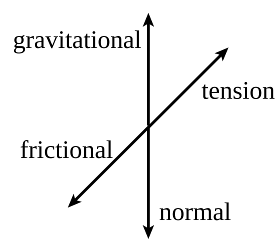
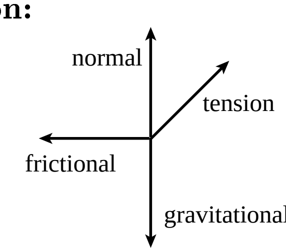


Explanation:



The gravitational force points down. The frictional forces points to the left. The normal force points up. The tension in the string points in the direction the string is pulling.

003

Which forces on the book would change if the string were pulled twice as hard?

1. normal

2. gravitational

3. tension in string

4. friction

5. normal and gravitational

6. normal, tension and friction **correct**

7. tension and friction

8. normal and friction

9. gravitational, tension and friction

Explanation:

The force the table exerts on the book (the normal force) is less when the string is taut.

The book will slide easier since the normal force has decreased. Thus the frictional force has also decreased.

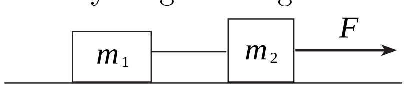
The string is taut indicating a tension that is not there when the string is not there.

Pulling Two Blocks

05:04, calculus, numeric, > 1 min.

004

Two blocks on a frictionless horizontal surface are connected by a light string.



$m_1 = 14.7$ kg and $m_2 = 20$ kg. A force of 49.8 N is applied toward the right on the 20 kg block.

Find the acceleration of the system.

Correct answer: 1.43516 m/s^2.

Explanation:

Let the tension in the string between the blocks be T, and apply Newton's second law to the each block:

$$F_{1net} = m_1\, a = T \qquad (1),$$

$$F_{2net} = m_2\, a = F - T \qquad (2),$$

Adding these equations gives us

$$(m_1 + m_2)a = F$$

$$a = \frac{F}{m_1 + m_2}$$

008

A 89.8 kg boxer has his first match in the Canal Zone with gravitational acceleration 9.782 m/s^2 and his second match at the North Pole with gravitational acceleration 9.832 m/s^2.

a) What is his mass in the Canal Zone?

Correct answer: 89.8 kg.

Explanation:

Basic Concept

An object's mass is constant, regardless of the gravitational acceleration.

Solution

An object's weight varies with gravitational position and is given by

$$W = mg$$

009

b) What is his weight in the Canal Zone?

Correct answer: 878.424 N.

Explanation:

$$W = mg$$

010

c) What is his mass at the North Pole?

Correct answer: 89.8 kg.

Explanation:

$$m = \frac{W}{g}$$

Weight of a Boxer

05:05, calculus, numeric, > 1 min.

011

d) What is his weight at the North Pole?

Correct answer: 882.914 N.

Explanation:

$$W = mg$$

Algorithm

$$m = 89.8 \text{ kg} \left\{ {80 \atop 100} \right\} \qquad (1)$$

$$g_C = 9.782 \text{ m/s}^2 \qquad (2)$$

$$g_N = 9.832 \text{ m/s}^2 \qquad (3)$$

$$W_C = m\, g_C \qquad (4)$$

$$= \langle 89.8 \rangle \langle 9.782 \rangle$$

$$= 878.424 \text{ N}$$
$$\langle \text{N} \rangle = \langle \text{kg} \rangle \, \langle \text{m/s}^2 \rangle \qquad \text{units}$$
$$m_N = m \qquad (5)$$
$$= 89.8 \text{ kg}$$
$$W_N = m \, g_N \qquad (6)$$
$$= \langle 89.8 \rangle \, \langle 9.832 \rangle$$
$$= 882.914 \text{ N}$$
$$\langle \text{N} \rangle = \langle \text{kg} \rangle \, \langle \text{m/s}^2 \rangle \qquad \text{units}$$

012

Find the weight in pounds of $M = 694$ grams of salami.

Correct answer: 1.52891 lb.

Explanation:

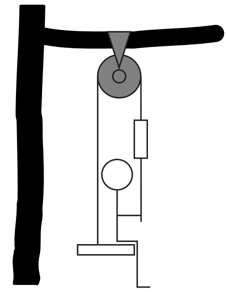
$$W = Mg$$
$$= 694 \text{ grams} \frac{1 \text{ kg}}{1000 \text{ g}} 9.8 \text{ m/s}^2$$
$$= 6.8012 \text{ N}$$
$$= 6.8012 \text{ N} \cdot 0.2248 \text{ lb/N}$$
$$= 1.52891 \text{ lb}$$

Algorithm

$$\left\langle \tfrac{\text{kg}}{\text{g}} \right\rangle = 0.001 \text{ kg/g} \qquad (1)$$
$$\left\langle \tfrac{\text{lb}}{\text{N}} \right\rangle = 0.2248 \text{ lb/N} \qquad (2)$$
$$g = 9.8 \text{ m/s}^2 \qquad (3)$$
$$M = 694 \text{ grams} \left\{ {400 \atop 1000} \right\} \qquad (4)$$
$$W_N = M \left\langle \tfrac{\text{kg}}{\text{g}} \right\rangle g \qquad (5)$$
$$= \langle 694 \rangle \, \langle 0.001 \rangle \, \langle 9.8 \rangle$$
$$= 6.8012 \text{ N}$$
$$\langle \text{N} \rangle = \langle \text{grams} \rangle \, \langle \text{kg/g} \rangle \, \langle \text{m/s}^2 \rangle \qquad \text{units}$$
$$W_{lb} = W_N \left\langle \tfrac{\text{lb}}{\text{N}} \right\rangle \qquad (6)$$
$$= \langle 6.8012 \rangle \, \langle 0.2248 \rangle$$
$$= 1.52891 \text{ lb}$$
$$\langle \text{lb} \rangle = \langle \text{N} \rangle \, \langle \text{lb/N} \rangle \qquad \text{units}$$

014

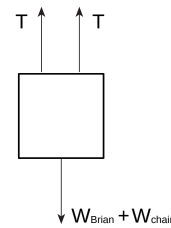
An inventive child named Brian wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected to a rope that passes over a frictionless pulley, he pulls on the loose end of the rope with such a force that the spring scale reads 309.5 N. His true weight is 370 N, and the chair weighs 238 N.



What is the magnitude of the acceleration of the system?

Correct answer: 0.177303 m/s^2.

Explanation:



Consider the system of Brian and the chair. Note that *two* ropes support the system. Let T be the tension in the ropes. Hence applying Newton's law to the system gives

$$\sum F = 2T - W_{Brian} - W_{chair} = Ma$$

where M represents the total mass of the system.

$$M = \frac{W_{Brian} + W_{chair}}{g} = 62.0408 \text{ kg}$$

Hence solving for a,

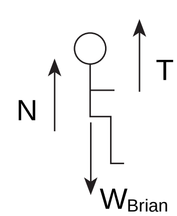
$$a = \frac{2T - W_{Brian} - W_{chair}}{M}$$
$$= \frac{(2 \cdot 309.5 \text{ N} - 370 \text{ N} - 238 \text{ N})}{62.0408 \text{ kg}}$$
$$= 0.177303 \text{ m/s}^2$$

015

What is the force that Brian exerts on the chair?

Correct answer: 67.1941 N.

Explanation:



Applying Newton's law to Brian only yields

$$\sum F = T + N - W_{Brian} = m_{Brian} a$$

where N is the force exerted on Brian by the chair. Since $m_{Brian} = W_{Brian}/g = 37.7551$ kg, we obtain for N,

$$\begin{aligned} N &= m_{Brian} a + W_{Brian} - T \\ &= 37.7551 \text{ kg} \cdot (0.177303 \text{ m/s}^2 \\ ) &\quad + 370 \text{ N} - 309.5 \text{ N} \\ &= 67.1941 \text{ N} \end{aligned}$$

N is the force the chair exerts on Brian, but by Newton's third law, N is also the magnitude of the force Brian exerts on the chair.

Algorithm

$$g = 9.8 \text{ m/s}^2 \tag{1}$$

$$W_{Brian} = 370 \text{ N} \left\{\begin{smallmatrix} 260 \\ 512 \end{smallmatrix}\right\} \tag{2}$$

$$W_{chair} = 238 \text{ N} \left\{\begin{smallmatrix} 64 \\ 256 \end{smallmatrix}\right\} \tag{3}$$

$$\delta = 11 \ \left\{\begin{smallmatrix} 10 \\ 20 \end{smallmatrix}\right\} \tag{4}$$

$$\begin{aligned} T &= 0.5 \ (W_{Brian} + W_{chair} + \delta) \\ &= 0.5 \ (\langle 370\rangle + \langle 238\rangle + \langle 11\rangle) \\ &= 309.5 \text{ N} \end{aligned} \tag{5}$$

$$\langle \text{N}\rangle = \langle\rangle \ (\langle \text{N}\rangle + \langle \text{N}\rangle + \langle\rangle) \qquad \text{units}$$

$$\begin{aligned} M &= \frac{W_{Brian} + W_{chair}}{g} \\ &= \frac{\langle 370\rangle + \langle 238\rangle}{\langle 9.8\rangle} \\ &= 62.0408 \text{ kg} \end{aligned} \tag{6}$$

$$\langle \text{kg}\rangle = \frac{\langle \text{N}\rangle + \langle \text{N}\rangle}{\langle \text{m/s}^2\rangle} \qquad \text{units}$$

$$\begin{aligned} a &= \frac{2.0\, T - W_{Brian} - W_{chair}}{M} \\ &= \frac{2.0 \ \langle 309.5\rangle - \langle 370\rangle - \langle 238\rangle}{\langle 62.0408\rangle} \\ &= 0.177303 \text{ m/s}^2 \end{aligned} \tag{7}$$

$$\langle \text{m/s}^2\rangle = \frac{\langle\rangle \ \langle \text{N}\rangle - \langle \text{N}\rangle - \langle \text{N}\rangle}{\langle \text{kg}\rangle} \qquad \text{units}$$

$$\begin{aligned} m_{Brian} &= \frac{W_{Brian}}{g} \\ &= \frac{\langle 370\rangle}{\langle 9.8\rangle} \\ &= 37.7551 \text{ kg} \end{aligned} \tag{8}$$

$$\langle \text{kg}\rangle = \frac{\langle \text{N}\rangle}{\langle \text{m/s}^2\rangle} \qquad \text{units}$$

$$\begin{aligned} N &= m_{Brian} \ a + W_{Brian} - T \\ &= \langle 37.7551\rangle \ \langle 0.177303\rangle + \langle 370\rangle - \langle 309.5\rangle \\ &= 67.1941 \text{ N} \end{aligned} \tag{9}$$

$$\langle \text{N}\rangle = \langle \text{kg}\rangle \ \langle \text{m/s}^2\rangle + \langle \text{N}\rangle - \langle \text{N}\rangle \qquad \text{units}$$

Suspended in an Elevator

05:05, calculus, numeric, > 1 min.

016

The tension in a string from which a 7.9 kg object is suspended in an elevator is equal to 46 N.

What is magnitude of the acceleration a of the elevator?

Correct answer: -3.97722 m/s^2.

Explanation:

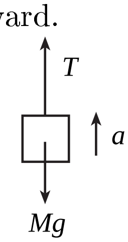
Basic Concepts:

$$\mathbf{F}_{net} = m\, \mathbf{a} = \sum \mathbf{F}$$

$$\mathbf{W} = m\, \mathbf{g}$$

Solution:

The weight $W = mg$ of the object is less than the tension in the string, so assume the acceleration is upward.



$$\Longrightarrow a = \frac{T - mg}{m}$$

Suspended in an Elevator

05:07, trigonometry, numeric, > 1 min.

017

What is its direction?

1. upward **correct**

2. downward

3. not moving

Explanation:

The acceleration, assumed upward, was positive, so the upward assumption was correct.

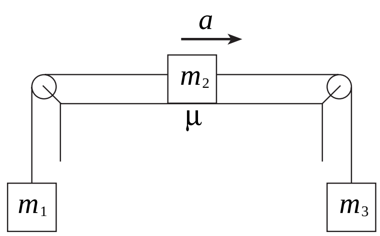
Algorithm

$$g = 9.8 \text{ m/s}^2 \quad (1)$$
$$m = 7.9 \text{ kg } \left\{ {4 \atop 8} \right\} \quad (2)$$
$$T = 46 \text{ N } \left\{ {20 \atop 50} \right\} \quad (3)$$
$$a = \frac{T - m\, g}{m} \quad (4)$$
$$= \frac{\langle 46\rangle - \langle 7.9\rangle\, \langle 9.8\rangle}{\langle 7.9\rangle}$$
$$= -3.97722 \text{ m/s}^2$$
$$\langle \text{m/s}^2\rangle = \frac{\langle \text{N}\rangle - \langle \text{kg}\rangle\, \langle \text{m/s}^2\rangle}{\langle \text{kg}\rangle} \quad \text{units}$$

Acceleration with Friction

05:08, calculus, numeric, > 1 min.

018



The suspended 3.95 kg mass on the left is accelerating up, the 2.4 kg mass slides to the right on the table, and the suspended mass 7.3 kg on the right is accelerating down. If the coefficient of friction is 0.109, what will be the acceleration of the system?

Correct answer: 2.21731 m/s^2.

Explanation:

Basic Concepts:

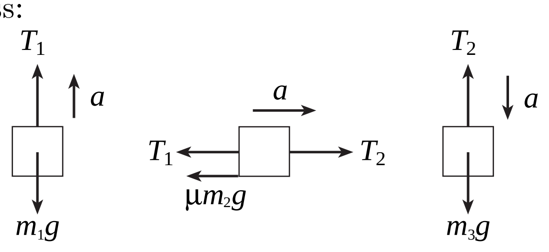
$$F_{net} = ma \neq 0$$

The acceleration a of each mass is the same, but the tensions in the two strings will be different.

Solution:

Let T_1 be the tension in the left string and T_2 be the tension in the right string.

Consider the free body diagrams for each mass:



For the mass m_1, T_1 acts up and the weight $m_1 g$ acts down, with the acceleration a directed upward:

$$F_{net1} = m_1 a = T_1 - m_1 g \quad (1)$$

For the mass on the table, a is directed to the right, T_2 acts to the right, T_1 acts to the left, and the motion is to the right so that the frictional force $\mu m_2 g$ acts to the left:

$$F_{net2} = m_2 a = T_2 - T_1 - \mu m_2 g \quad (2)$$

For the mass m_3, T_2 acts up and the weight $m_3 g$ acts down, with the acceleration a directed downward:

$$F_{net3} = m_3 a = m_3 g - T_2 \quad (3)$$

Adding these equations yields

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

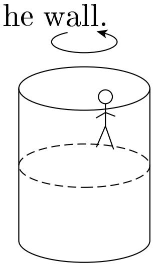
$$a = \frac{(m_3 - \mu m_2 - m_1)g}{(m_1 + m_2 + m_3)}$$

Algorithm

$$g = 9.8 \text{ m/s}^2 \quad (1)$$
$$m_1 = 3.95 \text{ kg } \left\{ {2 \atop 4} \right\} \quad (2)$$
$$m_2 = 2.4 \text{ kg } \left\{ {1.2 \atop 3.5} \right\} \quad (3)$$
$$m_3 = 7.3 \text{ kg } \left\{ {6 \atop 9} \right\} \quad (4)$$
$$\mu = 0.109 \left\{ {0.1 \atop 0.2} \right\} \quad (5)$$
$$a = \frac{(m_3 - \mu\, m_2 - m_1)\ g}{m_1 + m_2 + m_3} \quad (6)$$
$$= \frac{(\langle 7.3\rangle - \langle 0.109\rangle\, \langle 2.4\rangle - \langle 3.95\rangle)\ \langle 9.8\rangle}{\langle 3.95\rangle + \langle 2.4\rangle + \langle 7.3\rangle}$$
$$= 2.21731 \text{ m/s}^2$$
$$\langle \text{m/s}^2\rangle = \frac{(\langle \text{kg}\rangle - \langle\rangle\, \langle \text{kg}\rangle - \langle \text{kg}\rangle)\ \langle \text{m/s}^2\rangle}{\langle \text{kg}\rangle + \langle \text{kg}\rangle + \langle \text{kg}\rangle} \quad \text{units}$$

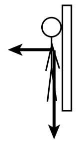
021

A rider in a "barrel of fun" finds herself stuck with her back to the wall.

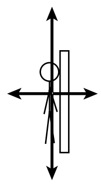


Which diagram correctly shows the forces acting on her?

1.



2.



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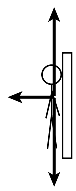
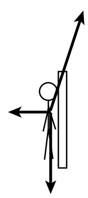
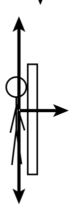


correct

4.



5.



6. None of the others

Explanation:

The normal force of the wall on the rider provides the centripetal acceleration necessary to keep her going around in a circle. The downward force of gravity is equal and opposite to the upward frictional force on her.

Car on a Banked Curve

05:08, trigonometry, numeric, > 1 min.

022

A curve of radius r is banked at angle θ so that a car traveling with uniform speed v can round the curve without relying on friction to keep it from slipping to its left or right.

Find the component of the net force parallel to the incline $\left(\sum \vec{F}_{\|}\right)$.

1. $F = mg\cot\theta$

2. $F = \dfrac{m\,v^2}{r}\,\sin\theta$

3. $F = \dfrac{m\,v^2}{r}\,\tan\theta$

4. $F = \dfrac{m\,v^2}{r\,\cos\theta}$

5. $F = \dfrac{m\,v^2}{r\,\sin\theta}$

6. $F = \dfrac{m\,v^2}{r\,\tan\theta}$

7. $F = m\,g\,\tan\theta$

8. $F = m\,g\,\cos\theta$

9. $F = \dfrac{m\,v^2}{r}\,\cos\theta$ **correct**

10. $F = m\sqrt{g^2 + \dfrac{v^4}{r^2}}$

Explanation:

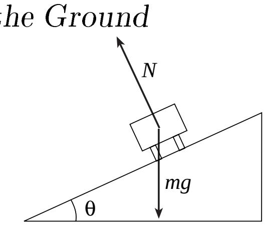
Basic Concepts: To keep an object moving in a circle requires a force directed toward the center of the circle; the magnitude of the force is

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

Also remember:

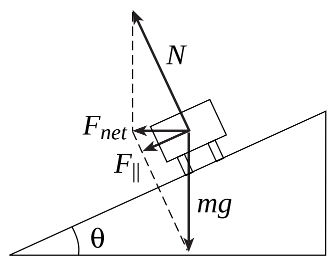
$$\vec{F} = \sum_i \vec{F}_i$$

Solution: *Solution in an Inertial Frame: Watching from the Point of View of Someone Standing on the Ground*



The car is performing circular motion with a constant speed, thus its acceleration is just the centripetal acceleration, $a_c = v^2/r$. The net force on the car is:

$$F_{net} = m\,a_c = m\frac{v^2}{r}$$



The component of this force parallel to the incline is

$$\begin{aligned}\sum \vec{F}_{||} &= m\,g\,\sin\theta \\ &= F_{net}\cos\theta \\ &= \frac{m\,v^2}{r}\cos\theta\end{aligned}$$

In this reference frame, the car is at rest, which means that the net force on the car (taking in consideration the centrifugal force) is zero. Thus the component of the net "real" force parallel to the incline is equal to the component of the centrifugal force along that direction. Now, the magnitude of the centrifugal force is equal to $F_c = m\,\frac{v^2}{r}$, so

$$F_{||} = F_{net}\,\cos\theta = F_c\,\cos\theta = \frac{m\,v^2}{r}\,\cos\theta$$

023

If $r = 71.8$ m and $v = 150$ km/hr, what is θ?
Correct answer: 67.9375 °.

Explanation:

$F_{||}$ is the component of the weight of the car parallel to the incline. Thus

$$m\,g\sin\theta = F_{||} = \frac{m\,v^2}{r}\cos\theta$$

$$\begin{aligned}\tan\theta &= \frac{v^2}{g\,r} \\ &= \frac{(150\text{ km/hr})^2}{(9.8\text{ m/s}^2)(71.8\text{ m})} \\ &\quad\times\left(\frac{1000\,\text{m}}{\text{km}}\right)^2\left(\frac{\text{hr}}{3600\,\text{s}}\right)^2 \\ &= 2.46733 \\ \theta &= \arctan(2.46733) = 67.9375^\circ\end{aligned}$$

Car on a Banked Curve

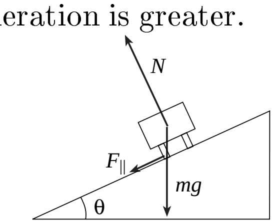
05:09, trigonometry, numeric, > 1 min.

024

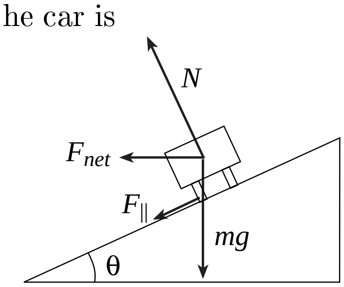
With what frictional force must the road push on a 1200 kg car if the driver exceeds the speed for which the curve was designed by $\Delta v = 11$ km/hr?
Correct answer: 1657.11 N.

Explanation:

The speed of the car is greater, so its centripetal acceleration is greater.



The free body diagram showing the forces acting on the car is



Thus, the net force parallel to the incline is

$$F_{||} = m\,g\sin\theta + F_{fr}$$

where F_{fr} is the friction force. On the other hand, the component of the acceleration parallel to the incline is still

$$a_{||} = \frac{(v+\Delta v)^2}{r}\cos\theta$$

Then,

$$m\,g\sin\theta + F_{fr} = m\,a_{||} = m\,\frac{(v+\Delta v)^2}{r}\,\cos\theta$$

or

$$\begin{aligned}F_{fr} &= m\left(\frac{(v+\Delta v)^2}{r}\,\cos\theta - g\,\sin\theta\right) \\ &= 1657.11\text{ N}\,.\end{aligned}$$

Alternative Solution: *Solution in a Non-inertial Frame: Watching from the Driver's Point of View.*

Note: The centrifugal "force" is a "fictitious force" that comes from the accelerating car being a non-inertial frame.

When the velocity is increased to $v + \Delta v$, the "no sliding" implies that

$$(mg)_{\parallel} + F_{fr} = \frac{m(v+\Delta v)^2}{r}\cos\theta$$

Using: $(m\,g)_{\parallel} = \dfrac{m\,v^2}{r}\cos\theta$,

$$F_{fr} = m\left[\frac{(v+\Delta v)^2}{r}\cos\theta - g\,\sin\theta\right].$$

Algorithm

$$\langle{\textstyle\frac{\text{deg}}{\text{rad}}}\rangle = 57.2958\text{ deg/rad} \tag{1}$$

$$g = 9.8\text{ m/s}^2 \tag{2}$$

$$r = 71.8\text{ m}\ \left\{{}^{50}_{100}\right\} \tag{3}$$

$$v = 150\text{ km/hr}\ \left\{{}^{90}_{160}\right\} \tag{4}$$

$$\begin{aligned} v_u &= \frac{1000.0\,v}{3600.0} \\ &= \frac{1000.0\,\langle 150\rangle}{3600.0} \\ &= 41.6667\text{ m/s} \end{aligned} \tag{5}$$

$$\langle\text{m/s}\rangle = \frac{\langle\rangle\,\langle\text{km/hr}\rangle}{\langle\rangle} \qquad \text{units}$$

$$\begin{aligned} p &= \frac{v_u^{2.0}}{r\,g} \\ &= \frac{\langle 41.6667\rangle^{2.0}}{\langle 71.8\rangle\,\langle 9.8\rangle} \\ &= 2.46733 \end{aligned} \tag{6}$$

$$\langle\rangle = \frac{\langle\text{m/s}\rangle^{2.0}}{\langle\text{m}\rangle\,\langle\text{m/s}^2\rangle} \qquad \text{units}$$

$$\begin{aligned} \theta_r &= \arctan(p) \\ &= \arctan(\langle 2.46733\rangle) \\ &= 1.18573\text{ rad} \end{aligned} \tag{7}$$

$$\langle\text{rad}\rangle = \arctan(\langle\rangle) \qquad \text{units}$$

$$\begin{aligned} \theta &= \theta_r\,\langle{\textstyle\frac{\text{deg}}{\text{rad}}}\rangle \\ &= \langle 1.18573\rangle\,\langle 57.2958\rangle \\ &= 67.9375^\circ \end{aligned} \tag{8}$$

$$\langle^\circ\rangle = \langle\text{rad}\rangle\,\langle\text{deg/rad}\rangle \qquad \text{units}$$

$$\Delta v = 11\text{ km/hr}\ \left\{{}^{10}_{20}\right\} \tag{9}$$

$$\begin{aligned} \Delta v_u &= \frac{1000.0\,\Delta v}{3600.0} \\ &= \frac{1000.0\,\langle 11\rangle}{3600.0} \\ &= 3.05556\text{ m/s} \end{aligned} \tag{10}$$

$$\langle\text{m/s}\rangle = \frac{\langle\rangle\,\langle\text{km/hr}\rangle}{\langle\rangle} \qquad \text{units}$$

$$m = 1200.0\text{ kg} \tag{11}$$

$$\begin{aligned} \delta_v &= (v_u + \Delta v_u)^{2.0} - v_u^{2.0} \\ &= (\langle 41.6667\rangle + \langle 3.05556\rangle)^{2.0} - \langle 41.6667\rangle^{2.0} \\ &= 263.966\text{ m}^2/\text{s}^2 \end{aligned} \tag{12}$$

$$\langle\text{m}^2/\text{s}^2\rangle = (\langle\text{m/s}\rangle + \langle\text{m/s}\rangle)^{2.0} - \langle\text{m/s}\rangle^{2.0} \qquad \text{units}$$

$$\begin{aligned} f &= \frac{m\,\delta_v\ \cos(\theta_r)}{r} \\ &= \frac{\langle 1200\rangle\,\langle 263.966\rangle\ \cos(\langle 1.18573\rangle)}{\langle 71.8\rangle} \\ &= 1657.11\text{ N} \end{aligned} \tag{13}$$

$$\langle\text{N}\rangle = \frac{\langle\text{kg}\rangle\,\langle\text{m}^2/\text{s}^2\rangle\ \cos(\langle\text{rad}\rangle)}{\langle\text{m}\rangle} \qquad \text{units}$$