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Chapter 6 homework [Edit]

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Chapter 6 homework

Due: 8:40am on Friday, November 15, 2013

You will receive no credit for items you complete after the assignment is due. Grading Policy

Video Tutor: Ball Leaves Circular Track

Description: Ball is rolled around circular track that has a gap. What path does it follow when it reaches the gap?

First, launch the video below. You will be asked to use your knowledge of physics to predict the outcome of an experiment. Then, close the video window and answer the questions at right. You can watch the video again at any point.

Part A

Consider the video demonstration that you just watched. Which of the following changes would make it more likely for the ball to hit both the white can *and* the green can?

Hint 1. How to approach the problem

To answer this question, you first have to decide whether changing the ball's mass or its speed can change the path it follows after it leaves the track.

Newton's second law says that a *net* force acting on the ball will change the ball's motion—that is, its speed and/or direction. Newton's first law says that, in the absence of a net force, the ball's motion won't change.

After the ball leaves the track, does a net force act on it? Draw a free-body diagram for the ball if you're not sure.

To hit the green can, the ball must continue following a curved path. What would be needed to make that happen?

ANSWER:

- ○ Roll the ball faster.
- ○ Use a ball that is lighter than the original ball, but still heavier than an empty can.
- ○ Roll the ball slower.
- ○ Use a ball that is heavier than the original ball.
- ● None of the above

By Newton's first law, after it has left the circular track, the ball will travel in a straight line until it is subject to a nonzero net force. Thus, the ball can only hit the white can, because that is the only can in the ball's straight-line path.

Multiple Choice Problem 6.02

Description: (a) If the earth had twice its present mass, its orbital period around the sun (at our present distance from the sun) would be...

Part A

If the earth had twice its present mass, its orbital period around the sun (at our present distance from the sun) would be

ANSWER:

- ◯ $\sqrt{2}$ years.
- ◉ 1 year.
- ◯ $\frac{1}{\sqrt{2}}$ year.
- ◯ $\frac{1}{2}$ year.

$\Sigma F = F_c$

$F_g = F_c$

$\frac{G m_s \cancel{m_E}}{r^2} = \frac{\cancel{m_E} v^2}{r}$

B/c mass of Earth cancels, it is not a factor!

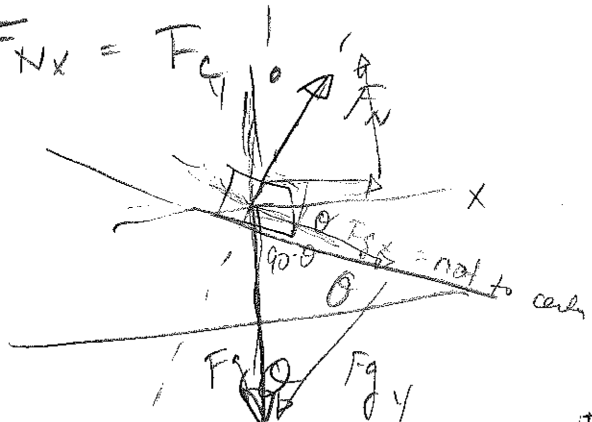
± Banked Frictionless Curve, and Flat Curve with Friction

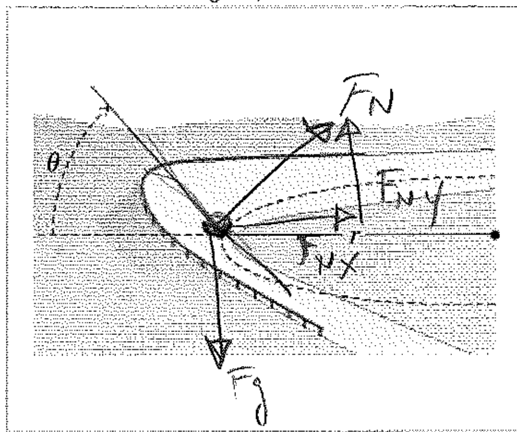
Description: ± Includes Math Remediation. Examine the motion of a car under two different circumstances–a banked zero-friction road and a flat road with friction.

$u = 0$

A car of mass M = 900kg traveling at 60.0km/hour enters a banked turn covered with ice. The road is banked at an angle θ, and there is no friction between the ~~road and the~~ car's tires. . Use g = 9.80m/s^2 throughout this problem.

$F_{Nx} = F_c$





$\Sigma F_y = 0$

$F_{Ny} - F_g = 0$

Part A

What is the radius r of the turn if θ = 20.0° (assuming the car continues in uniform circular motion around the turn)?

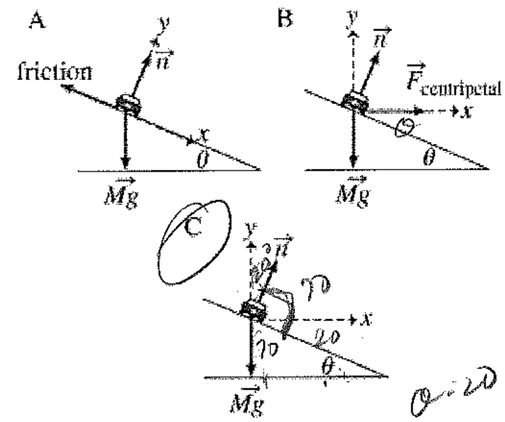
Express your answer in meters.

Hint 1. How to approach the problem

You need to apply Newton's 2nd law to the car. Because you do not want the car to slip as it goes around the curve, the car needs to have a net acceleration of magnitude v^2/r pointing radially inward (toward the center of the curve).

Hint 2. Identify the free-body diagram and coordinate system

Which of the following diagrams represents the forces acting on the car and the most appropriate choice of coordinate axes?



θ = 20

ANSWER:

- ○ Figure A
- ○ Figure B
- ● Figure C

The choice of coordinate system shown in this free-body diagram is the most appropriate for this problem. The car must have a net acceleration toward the center of the curve to maintain its motion and not slip. This implies that the net force must be along the *x* axis.

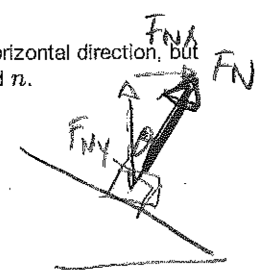
Hint 3. Calculate the normal force

Find n, the magnitude of the normal force between the car and the road. Take the positive *x* axis to point horizontally toward the center of the curve and the positive *y* axis to point vertically upward.

Express your answer in newtons.

Hint 1. Consider the net force

The only forces acting on the car are the normal force and gravity. There must be a net acceleration in the horizontal direction, but because the car does not slip, the net acceleration in the *vertical* direction must be zero. Use this fact to find n.



Hint 2. Apply Newton's 2nd law to the car in the *y* direction

Which equation accurately describes the equation for the net force acting on the car in the *y* direction?

ANSWER:

- ○ $\sum F_y = n\cos\theta + Mg$
- ○ $\sum F_y = n\sin\theta + Mg$
- ● $\sum F_y = n\cos\theta - Mg$
- ○ $\sum F_y = n\sin\theta - Mg$

$\Sigma F_y = 0$

$F_{Ny} - F_g = 0$

$\cos\theta \, F_N - F_g = 0$

ANSWER:

$n = \dfrac{Mg}{\cos(\theta)} = 9390$ N

$F_N = \dfrac{F_g}{\cos 20} = \dfrac{mg}{\cos 20} = \dfrac{900kg(9.81)}{\cos 20°}$

$\boxed{F_N = 9386N}$

Hint 4. Determine the acceleration in the horizontal plane

Take the *y* axis to be vertical and let the *x* axis point horizontally toward the center of the curve. By applying $\sum F_x = Ma$ in the horizontal direction, determine a, the magnitude of the acceleration, using your result for the normal force.

Express your answer in meters per second squared.

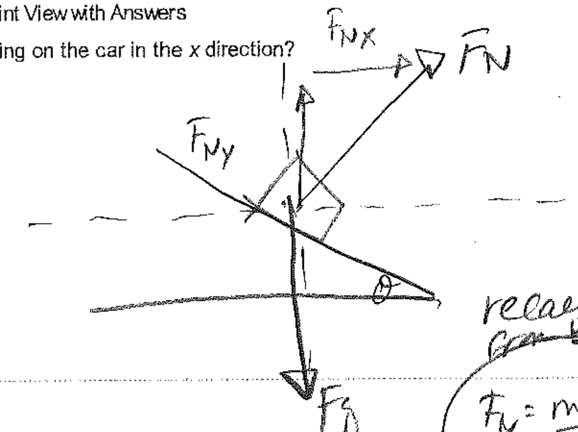
$\Sigma F_x = F_c$ $\qquad a_c = \dfrac{\sin\theta \, F_N}{m}$

$F_{Nx} = m a_c$ $\qquad a_c = \dfrac{\sin 20° \, 9386N}{900kg}$

$\sin\theta \, F_N = m a_c$ $\qquad a_c = 3.57 \, m/s^2$

Hint 1. Apply Newton's 2nd law to the car in the *x* direction

Which equation accurately describes the equation for the net force acting on the car in the x direction?



ANSWER:

- ○ $\sum F_x = n\cos\theta$
- ● $\sum F_x = n\sin\theta$
- ○ $\sum F_x = n\cos\theta + \frac{Mv^2}{r}$
- ○ $\sum F_x = n\cos\theta - \frac{Mv^2}{r}$

recall from before!

$F_N = \frac{mg}{\cos 20°}$

ANSWER:

$a = g\tan(\theta) = 3.57 \ \mathrm{m/s^2}$

$\Sigma F_x = F_c$

Now use this result and the fact that $a = v^2/r$ to solve for r.

$F_{Nx} = \frac{mv^2}{r}$

ANSWER:

$r = \frac{v_c^2}{g\tan(\theta)} = 77.9 \ \mathrm{m}$

$m = 900kg$

$v = 16.7 m/s$

$r \cdot \sin 20° F_N = \frac{mv^2}{r} \cdot r$

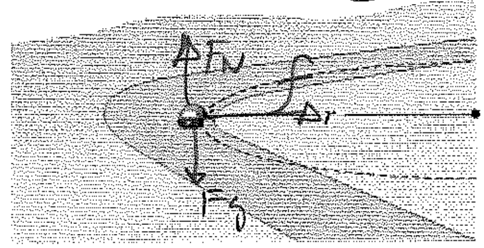
$r \cdot \frac{\sin 20° mg}{\cos 20°} = mv^2$ = tan 20°!

$v = \frac{60km}{1hr} \times \frac{1000m}{1km} \times \frac{1hr}{3600s} =$

$r = \frac{v^2}{\tan 20° (g)} = \boxed{78.2 \ m}$

Part B

Now, suppose that the curve is level ($\theta = 0$) and that the ice has melted, so that there is a coefficient of static friction μ between the road and the car's tires. What is $\mu_{\min}$, the minimum value of the coefficient of static friction between the tires and the road required to prevent the car from slipping? Assume that the car's speed is still 60.0$\mathrm{km/hour}$ and that the radius of the curve is given by the value you found for r in Part A. → 16.7 m/s   r = 78m



Express your answer numerically.

$\Sigma F_y = 0$

$F_N - F_g = 0$

$F_N = F_g$

$F_N = mg$

$\Sigma F_x = F_c$

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

$\mu F_N = \frac{mv^2}{r}$

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

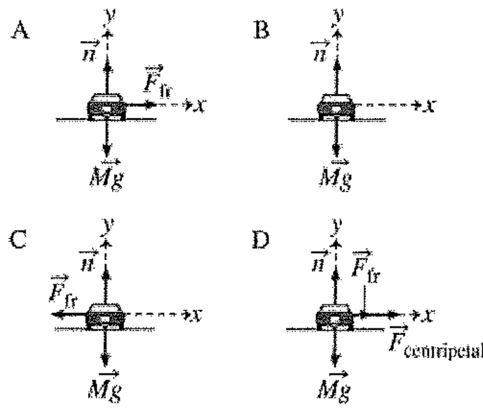
$\mu = \frac{v^2}{g \cdot r} = \frac{(16.7 m/s)^2}{78m (9.8 m/s^2)} = \boxed{0.365}$

Hint 1. How to approach the problem

You need to apply Newton's 2nd law to the car. Because you do not want the car to slip as it goes around the curve, the car needs to have a net acceleration of magnitude v^2/r pointing radially inward (toward the center of the curve).

Hint 2. Identify the correct free-body diagram

Which of the following diagrams represents the forces acting on the car as it goes around the curve? F_{fr} represents the friction force.



ANSWER:

- ● Figure A
- ○ Figure B
- ○ Figure C
- ○ Figure D

This diagram indicates that the net force acting on the car in the *x* direction is equal to the force of friction.

Hint 3. Calculate the net force

What is the net force F_{net} that acts on the car?

Express your answer in newtons.

Hint 1. How to determine the net force

Newton's 2nd law tells you that

$$\sum \vec{F} = m\vec{a}.$$

Because you do not want the car to slip as it goes around the curve, the car needs to have a net acceleration of magnitude v^2/r pointing radially inward (toward the center of the curve).

ANSWER:

$F_{net} = \frac{M{v_c}^2}{\frac{{v_c}^2}{g\tan(\theta)}}$ = 3210 N

Hint 4. Calculate the friction force

If the coefficient of friction were equal to μ_{min}, what would be F_{fr}, the magnitude of the force provided by friction? Let m be the mass of the car and g be the acceleration due to gravity.

Hint 1. Equation for the force of friction

The force of friction is given by

$$F_{fr} = \mu n.$$

Hint 2. Find the normal force

What is the normal force n acting on the car?

Enter your answer in newtons.

Hint 1. Acceleration in the *y* direction

Because the car is neither sinking into the road nor levitating, you can conclude that $a_y = 0$.

ANSWER:

$n =$ Mg = 8820 N

$\Sigma F_y = 0$

$F_N - F_g = 0$

$F_N = F_g$

$F_N = mg$

ANSWER:

- ○ $F_{fr} = \frac{\mu_{min}}{Mg}$
- ● $F_{fr} = \mu_{min} Mg$

$\Sigma F_x = F_c$

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

$\mu F_N = \frac{mv^2}{r}$

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

ANSWER:

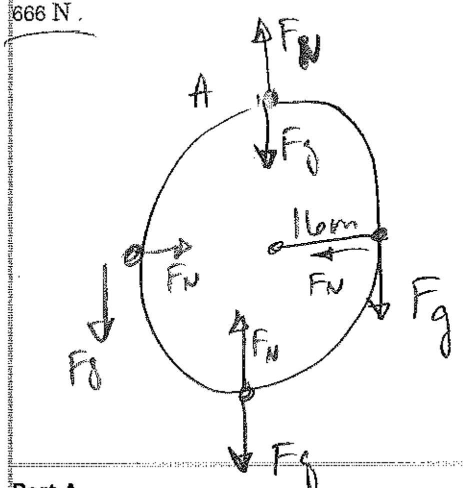
$\mu_{min} = \frac{\frac{v_c^2}{\frac{v_c^2}{g\tan(\theta)}}}{g} = 0.364$

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

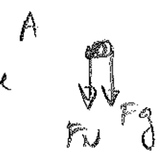
± A Ride on the Ferris Wheel

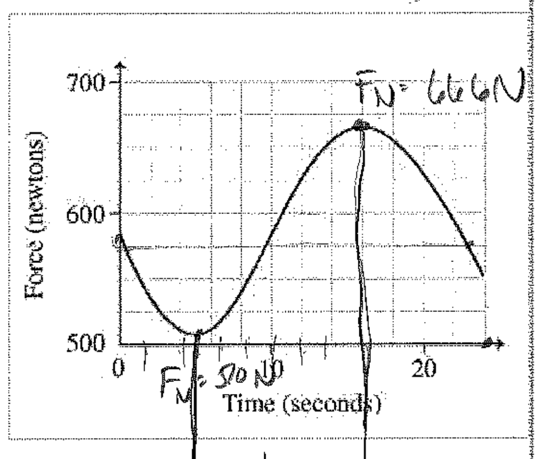
Description: ± Includes Math Remediation. Students must find the mass of a woman from a plot of her apparent weight at various times on a Ferris wheel.

A woman rides on a Ferris wheel of radius 16 m that maintains the same speed throughout its motion. To better understand physics, she takes along a digital bathroom scale (with memory) and sits on it. When she gets off the ride, she uploads the scale readings to a computer and creates a graph of scale reading versus time. Note that the graph has a minimum value of 510 N and a maximum value of 666 N.



Should be





$\frac{1}{2}$ Trip 16s − 5s = 11s

1 Trip = 22s!

T = 22s!

Part A

What is the woman's mass?

Express your answer in kilograms.

Hint 1. How to approach the problem

The woman is moving in a circle with constant speed. To maintain this motion she must experience a net acceleration (called centripetal acceleration) directed toward the center of the Ferris wheel.

Draw and analyze the woman's free-body diagram at a wisely chosen point on the circular path and use Newton's 2nd law to determine her mass.

Hint 2. Find the extreme points on the circular path

The bathroom scale does not record the gravitational force acting on the woman. If it did, the reading would not vary as she rides the Ferris wheel. Instead, the scale records the normal force acting on the woman, which can vary as she moves along the circular path and experiences different accelerations. This normal force is sometimes referred to as an *apparent weight*, because it mimics the feelings of being heavier or lighter.

Note that the normal force is equal in magnitude to the gravitational force on the flat surface of the earth, so the *apparent weight* is just called the *weight* in this static situation.

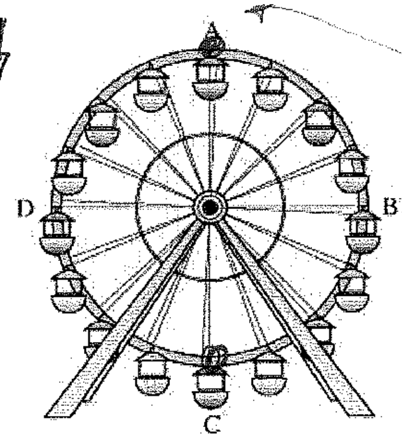
As the woman travels along the circular path, her apparent weight fluctuates between a maximum value and a minimum value. At what location (A - D) will the apparent weight be a maximum? Where will it be a minimum?

C A

$F_c = F_{net} = \downarrow$

F_N

F_g



from book

$F_{net} = \uparrow$ (F_c)

F_N

B

F_g

Enter the letters that correspond to the correct positions separated by a comma.

Hint 1. Analyze the free-body diagram

Draw a free-body diagram for the woman. Assume that the $+y$ direction points vertically upward. Which of the following statements are true for *every* point on the circle traveled by the woman?

Check all that apply.

ANSWER:

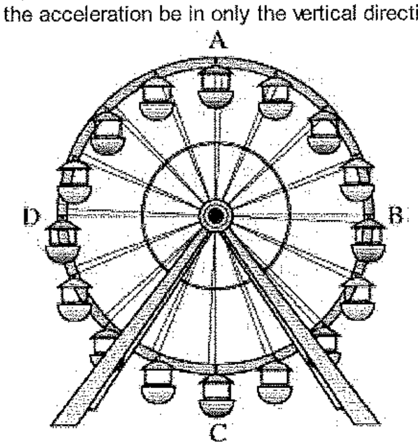
- [ ] The gravitational force acting on the woman points in the $+y$ direction.
- [x] The gravitational force acting on the woman points in the $-y$ direction.
- [x] The magnitude of the gravitational force acting on the woman is constant.
- [x] The normal force points in the $+y$ direction.
- [ ] The normal force points in the $-y$ direction.
- [ ] The magnitude of the normal force is constant.

$F_g = \downarrow$

$F_N = \uparrow$

Hint 2. Analyze the acceleration

At all times during the woman's motion, she experiences a net acceleration (called centripetal acceleration) directed toward the center of the Ferris wheel. At what location (A - D) will the acceleration be in only the vertical direction?



Check all that apply.

ANSWER:

- [x] A
- [ ] B
- [x] C
- [ ] D

Hint 3. Applying Newton's 2nd law

Since the normal force and gravitational force are the only forces acting on the woman in the vertical (y) direction,

$$\left(\sum F\right)_y = n - mg = ma_y,$$

where n and mg are the magnitudes of the normal force and the gravitational force, respectively.

Apply what you know about the acceleration of the woman in the y direction at certain points along the circular path to determine when n will be a maximum or minimum.

ANSWER:

C,A

You can read the value of the woman's apparent weight from the graph at either of these locations. Pick one of these locations and apply Newton's 2nd law to the woman at that point to solve for her mass m.

Hint 3. Find the acceleration of the woman

What is the acceleration a_c of the woman?

Express your answer in meters per second squared.

F_N $\Sigma F_y = F_c$ $F_N = 510/666N$

F_g

$F_g - F_N = \frac{mv^2}{r}$ don't know!

$F_g = \frac{mv^2}{r} + F_N$

Hint 1. How to approach the problem

You can use the information from the problem statement and the graph to determine the woman's speed. This can be used to find her centripetal acceleration:

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

$mg = \frac{m(4.57m/s)^2}{16m} + 510N$

Hint 2. Find the woman's speed

What is the speed v of the woman?

Express your answer in meters per second.

$m(9.8m/s^2) = 1.31m + 510$

$-1.31m \quad -1.31m$

$\frac{8.49m}{8.49} = \frac{510}{8.49} = \boxed{60kg}$

Hint 1. Determining the speed

Since the Ferris wheel turns at constant speed, the distance d the woman travels during some time interval is given by $d = vt$, where v is the speed and t is the time. For a complete cycle, the distance traveled is the circumference of the Ferris wheel and the time required is one period T. Thus for a Ferris wheel of radius R,

$r = 16m$

$$v = \frac{(2\pi R)}{T}. = \frac{2\pi(16m)}{22s} = \boxed{4.57m/s}$$

Hint 2. Find the period

The easiest way to determine the speed of the woman is to calculate the distance she travels during one complete cycle of motion and divide this by the time that it takes to complete this cycle. The time for a complete cycle is called the period T. What is the period of the Ferris wheel?

Express your answer in seconds.

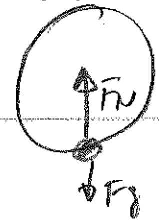
other page →

ANSWER:

T = 22 s

ANSWER:

v = 4.57 m/s



If using System:

$\Sigma F = F_c$

$F_N - F_g = F_c$

$666N - mg = \frac{mv^2}{r}$

ANSWER:

a_c = 1.31 m/s^2

$666 = mg + \frac{mv^2}{r}$

ANSWER:

m = 60 kg

$666 = 9.8 m/s^2\, m + \frac{(4.57 m/s)^2}{16m} m$

$666 = 9.8m + 1.31m$

$11.1m = 666$ $m = 60kg$

Problem 6.43: Artificial gravity

Description: Artificial gravity. One way to create artificial gravity in a space station is to spin it. (a) If a cylindrical space station ##m in diameter is to spin about its central axis, at how many revolutions per minute (rpm) must it turn so that the...

Artificial gravity. One way to create artificial gravity in a space station is to spin it.

$F_N = F_c$!

Part A

$r = 162.5 m$

If a cylindrical space station 325m in diameter is to spin about its central axis, at how many revolutions per minute (rpm) must it turn so that the outermost points have an acceleration equal to g?

$\Sigma F = F_c$

F_N provides $F_g = mg$!

ANSWER:

$f = \frac{\frac{\sqrt{\frac{2g}{D}}}{2}}{\pi} \cdot 60 = 2.35$ rpm

$F_N = F_c$

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

$V = \sqrt{(162.5 m)(9.8 m/s^2)}$

$V = \sqrt{r \cdot g}$

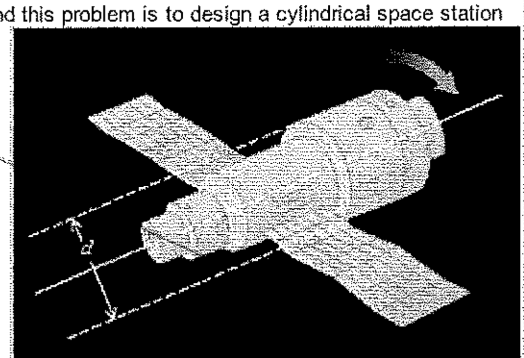
$V = 39.9 m/s$

~~$V = \frac{2\pi r}{T}$ $T = \frac{2\pi r}{V}$~~

~~Problem 6.56~~: Artificial gravity in space stations.

Description: One problem for humans living in outer space is that they are apparently weightless. One way around this problem is to design a cylindrical space station that spins about an axis through its center at a constant rate. (See the figure below.) This...

One problem for humans living in outer space is that they are apparently weightless. One way around this problem is to design a cylindrical space station that spins about an axis through its center at a constant rate. (See the figure below.) This spin creates "artificial gravity" at the outside rim of the station.



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

Can't do in computer!

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

$T = \frac{2\pi(162.5 m)}{39.9 m/s} = 25.6 s$ = 1 revolution

1 rev = 25.6s = 0.43 min

$f = \frac{1}{T} = \frac{1}{0.43 min} = 2.34$ rev/min

~~**Part A**~~

If the diameter of the space station is d = 660m , how fast must the rim be moving in order for the "artificial gravity" acceleration to be g at the outer rim?

ANSWER:

~~$\omega = \sqrt{\frac{g \cdot 2}{d}} = 0.172$ rad/s~~

~~$V = \omega r$~~

$V = 56.8 m/s$

answer

$\Sigma F = F_c$ $F_g = F_N = mg = F_c$!

$F_N = F_c$

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

$v = \sqrt{gr}$

$v = \sqrt{9.8 m/s^2 (330m)} = 56.87 m/s$

Part B

If the space station is a waiting area for travelers going to Mars, it might be desirable to simulate the acceleration due to gravity on the Martian surface. How fast must the rim move in this case?

ANSWER:

$$\omega = \sqrt{\frac{\frac{6.42\cdot10^{23}\cdot6.67\cdot10^{-11}}{(3.40\cdot10^{6})^2}\cdot 2}{d}} = 0.106 \ \ \mathrm{rad/s}$$

mass of mars → $F_g = F_c$

$$\frac{Gm_1 \cancel{m_2}}{r^2} = \frac{\cancel{m}v^2}{r}$$

radius of mars → r^2

(in book - back cover!)

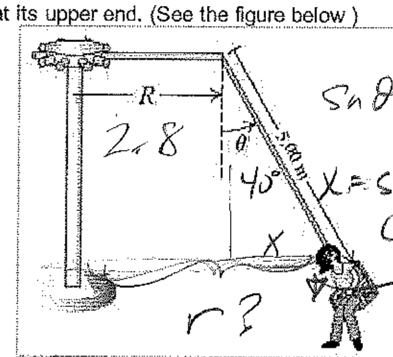
$$V = \sqrt{\frac{Gm_1 r}{r^2}}$$

$$\boxed{V = \sqrt{\frac{Gm_1}{r}}}$$

Problem 6.05

Description: The "Giant Swing" at a county fair consists of a vertical central shaft with a number of horizontal arms attached at its upper end. (See the figure below) Each arm supports a seat suspended from a ## m-long cable, the upper end of which is fastened...

The "Giant Swing" at a county fair consists of a vertical central shaft with a number of horizontal arms attached at its upper end. (See the figure below) Each arm supports a seat suspended from a 5.00m -long cable, the upper end of which is fastened to the arm. Take R = 2.80m .



$\sin\theta = \frac{X}{H}$

$X = \sin 40°(5m)$

$X = 3.21m$

$\Sigma F_y = 0$

$T_y - F_g = 0$

$T_y = F_g$

$T = mg$

$\cos\theta\, T = mg$

$T = \frac{mg}{\cos\theta}$

$\Sigma F_x = F_c$

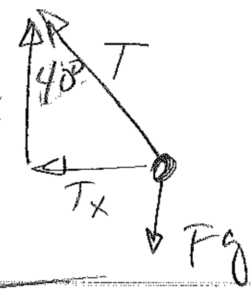
$T_x = F_c$

$\sin\theta\, T = \frac{mv^2}{r}$

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

$\tan\theta\, g = \frac{v^2}{r}$

$V = \sqrt{\tan\theta g r}$



Part A

Find the time of one revolution of the swing if the cable supporting the seat makes an angle of θ = 40.0° with the vertical.

ANSWER:

$$t = 2\pi\sqrt{\frac{R+L\sin\theta}{9.81\tan\theta}} = 5.37 \ \ \mathrm{s}$$

$r = R + X$

$r = 2.8m + 3.21 m$

$r = 6.01 m$

$V = \sqrt{\tan 40°(9.8 m/s^2)(6.01m)}$

$V = 7.03 m/s$

$V = \frac{2\pi r}{T}$ $\quad T = \frac{2\pi r}{V}$

$T = \frac{2\pi(6.01m)}{7.03 m/s}$

$T = 5.37s$

Part B

Does the angle depend on the weight of the passenger for a given rate of revolution?

ANSWER:

- ○ Yes
- ● No

mass cancelled

Problem 6.11

Description: The Cosmoclock 21 Ferris wheel in Yokohama City, Japan, has a diameter of 100 m . Its name comes from its 60 arms, each of which can function as a second hand (so that it makes one revolution every 60 s).(a) Find the speed of the passengers when the ...

r = 50m

1rev = 60s = T

The Cosmoclock 21 Ferris wheel in Yokohama City, Japan, has a diameter of 100 m . Its name comes from its 60 arms, each of which can function as a second hand (so that it makes one revolution every 60 s).

Part A

Find the speed of the passengers when the Ferris wheel is rotating at this rate.

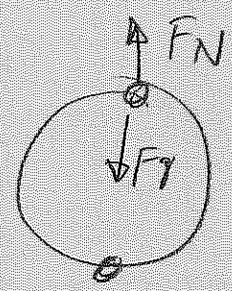
ANSWER:

$$V = \frac{2\pi r}{T} = \frac{2\pi(50m)}{60s}$$

$V = 5.24 m/s$

Problem 6.11 r = 50m

Part D m = 89.6kg (from earlier)



$\Sigma F = F_c$

$\cancel{F_N}^{\to 0} - F_g = F_c$

$0 = F_c - F_g$

$\frac{mv^2}{r} - mg = 0$

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

$\sqrt{v^2} = \sqrt{gr}$

$r = \sqrt{9.8 m/s^2 (50m)}$

$v = 22.14 m/s$

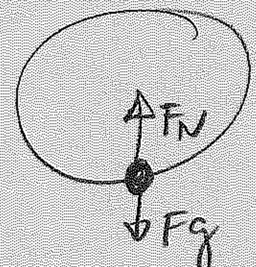
$V = \frac{2\pi r}{T}$

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

$T = \frac{2\pi (50m)}{22.14 m/s} =$

$T = 14.2s$

Part E



$\Sigma F = F_c$

$F_N - F_g = F_c$

$F_N = F_c + F_g$

$F_N = \frac{mv^2}{r} + mg$

$F_N = \frac{(89.6kg)(22.14 m/s)^2}{50m} +$ 878 N

apparent weight!

$\boxed{F_N = 1756 N}$

$v =$ 5.24 m/s

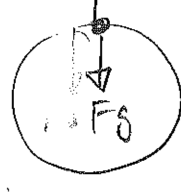
Part B

$F_g = mg$ $m = \frac{878\,N}{9.8\,m/s^2} = 89.6\,kg$

A passenger weighs $878\mathrm{N}$ at the weight-guessing booth on the ground. What is his apparent weight at the highest point on the Ferris wheel?

ANSWER:

$w = w\left(1 - \frac{\frac{5.24^2}{50}}{9.81}\right) =$ 829 N



(B) $\Sigma F_y = F_c$

$F_g - F_N = F_c$

$-F_N = F_c - F_g$

$F_N = -\left(\frac{mv^2}{r} - mg\right)$

$F_N = -\left(\frac{89.6\,kg(5.24\,m/s)^2}{50\,m} - 878\,N\right)$

$F_N = 829\,N$

Part C

What is his apparent weight at the lowest point on the Ferris wheel?

ANSWER:

$w = w\left(1 + \frac{\frac{5.24^2}{50}}{9.81}\right) =$ 927 N

Part D

Other page

What would be the time for one revolution if the passenger's apparent weight at the highest point were zero?

ANSWER:

$t =$ 14.2 s

(C) $\Sigma F = F_c$

$F_N - F_g = F_c$

$F_N = F_c + F_g$

$F_N = \frac{mv^2}{r} + mg$

$F_N = \frac{89.6\,kg(5.24\,m/s)^2}{50\,m} + 878\,N$

$F_N = 927\,N$

Part E

Other page

What then would be the passenger's apparent weight at the lowest point?

ANSWER:

$w = 2w =$ 1760 N

Problem 6.14: Stay Dry!

Description: You tie a cord to a pail of water, and you swing the pail in a vertical circle of radius ## m. (a) What minimum speed must you give the pail at the highest point of the circle if no water is to spill from it?

You tie a cord to a pail of water, and you swing the pail in a vertical circle of radius $0.800\mathrm{m}$.

$\Sigma F = F_c$

Part A

$F_N = 0$

What minimum speed must you give the pail at the highest point of the circle if no water is to spill from it?

ANSWER:

$v_{\min} = \sqrt{gR} =$ 2.80 m/s

$\cancel{F_N} + F_g = F_c$

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

$v = \sqrt{gr} = \sqrt{9.8\,m/s^2(0.8\,m)}$

$v = 2.8\,m/s$

Problem 6.18: Rendezvous In Space!

Description: A couple of astronauts agree to rendezvous in space after hours. Their plan is to let gravity bring them together. She has a mass of ## kg and he a mass of ## kg, and they start from rest ## m apart. (a) Find his initial acceleration. (b) Find her...

A couple of astronauts agree to rendezvous in space after hours. Their plan is to let gravity bring them together. She has a mass of $66.0\mathrm{kg}$ and he a mass of $76.0\mathrm{kg}$, and they start from rest $23.0\mathrm{m}$ apart.

Part A

Find his initial acceleration.

ANSWER:

$a = \frac{6.673\cdot 10^{-11} m1}{d^2} = 8.33\times 10^{-12}$ $\mathrm{m/s^2}$

$= M2$

$m_1 = 66kg$ $\Delta x = 23m$ $F_g = \frac{Gm_1m_2}{r^2}$

$m_2 = 76kg$

Part A

$\Sigma F = ma$

$F_g = m_2 a$

$\frac{Gm_1\cancel{m_2}}{r^2} = \cancel{m_2} a$

$\frac{(6.67\times 10^{-11} \frac{N\cdot m^2}{Kg^2})(66kg)}{(23m)^2} = a$

$a = 8.32\times 10^{-12} m/s^2$

Part B

$\Sigma F = m_1 a$

$\frac{G\cancel{m_1}m_2}{r^2} = \cancel{m_1} a$

$a = \frac{6.67\times 10^{-11} \frac{Nm^2}{Kg^2}\cdot 76kg}{(23m)^2}$

$a = 9.58\times 10^{-12} m/s^2$

Part B

Find her initial acceleration.

ANSWER:

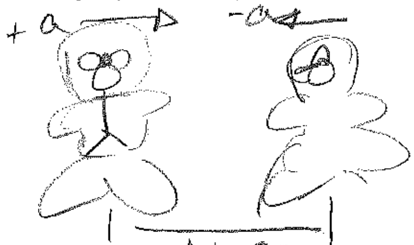
$a = \frac{6.673\cdot 10^{-11} m2}{d^2} = 9.59\times 10^{-12}$ $\mathrm{m/s^2}$

Part C

If the astronauts' acceleration remained constant, how many days would they have to wait before reaching each other? (~~Careful! They both~~ have acceleration toward each other.)

ANSWER:

$t = \frac{\frac{\sqrt{\frac{1}{\frac{6.673\cdot 10^{-11}}{m1+m2}} d^3\cdot 2}}{3600}}{24} = 18.5$ days



$x = \cancel{x_0} + \cancel{v_0 t} + \frac{1}{2}at^2$ $x = x_0 + \cancel{v_0 t} + \frac{1}{2}at^2$

$x = x$

Part D

Would their acceleration, in fact, remain constant?

ANSWER:

- ○ Yes, it would remain costant
- ● No,it would increase
- ○ No, it would decrease

as $r\downarrow$, $F_g \uparrow$!

$\cancel{x_0} + \frac{1}{2}a_1 t^2 = \frac{1}{2}a_2 t^2 + x_0$

$\frac{1}{2}(9.58\times 10^{-12} m/s^2)t^2 = \frac{1}{2}(-8.32\times 10^{-12} m/s)t^2 + 23m$

$4.79\times 10^{-12} t^2 = -4.16\times 10^{-12} t^2 + 23$

$8.95\times 10^{-12} t^2 = 23$ $t = 1603070s$

$\frac{t}{3600\cdot 24} = \boxed{18.5d}$

Problem 6.30

Description: The mass of the s is about m the mass of the earth, its radius is r that of the earth, and the acceleration due to gravity at the earth's surface is ## m/s^2. (a) Without looking up either body's mass, use this information to compute the acceleration ...

The mass of the Mars is about 0.11 the mass of the earth, its radius is 0.53 that of the earth, and the acceleration due to gravity at the earth's surface is $9.80\mathrm{m/s^2}$.

Part A

Without looking up either body's mass, use this information to compute the acceleration due to gravity on the Mars's surface.

Express your answer using two significant figures.

ANSWER:

$a = \frac{m}{r^2}\cdot 9.8 = 3.8$ $\mathrm{m/s^2}$

$g = \frac{Gm}{r^2} = \frac{1\cdot(0.11)}{(0.53)^2} = 0.392g$

$0.392(9.8)$

$= \boxed{3.84 m/s^2}$

Problem 6.40: Apparent weightlessness in a satellite.

Description: You have probably seen films of astronauts floating weightless in orbiting satellites. People often get the idea that the astronauts are weightless because they are so far from the gravity of the earth. Let us see if that explanation is correct. (a)...

You have probably seen films of astronauts floating weightless in orbiting satellites. People often get the idea that the astronauts are weightless because they are so far from the gravity of the earth. Let us see if that explanation is correct.

Part A

r of earth = 6.38×10^6 m $M_E = 6 \times 10^{24}$ Kg

Typically, such satellites orbit around 400 km above the *surface* of the earth. If an astronaut weighs 720N on the ground, what will he weigh if he is 400 km above the surface?

= 400,000 m

$F = mg$ $m = \frac{F}{g} = \frac{720}{9.8}$

$F_g = \frac{Gm_1m_2}{r^2}$

$F_g = \frac{(6.67 \times 10^{-11} \frac{Nm^2}{Kg^2})(6 \times 10^{24} kg)(73.5 kg)}{(400,000 + 6.38 \times 10^6 m)^2}$

$.4 \times 10^6 + 6.4 \times 10^6 = 6.8 \times 10^6 m$

$\boxed{F_g = 636 N}$

ANSWER:

$w = w\left(\frac{6.38}{6.78}\right)^2 = 638$ N

Part B

In light of your answer to part A, are the astronauts weightless because gravity is so weak? Why are they weightless?

ANSWER:

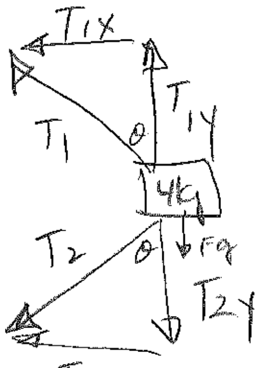
3731 Character(s) remaining

No, because they and the satellite are in free fall toward the earth.

Problem 6.54

Description: (a) What is the tension in the lower cord? (b) What is the speed of the block?

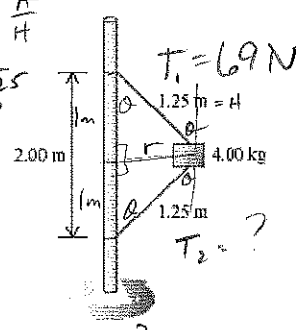
The 4.00 kg block in the figure is attached to a vertical rod by means of two strings. When the system rotates about the axis of the rod, the strings are extended as shown in figure and the tension in the upper string is 69.0N. $= T_1$



$\cos\theta = \frac{A}{H}$

$\theta = \cos^{-1}\frac{1}{1.25}$

$\theta = 37°$



$\Sigma F_y = 0$ (no circle!)

$T_{1y} - T_{2y} - F_g = 0$

$T_{1y} = T_{2y} + F_g$

$\cos\theta T_1 = \cos\theta T_2 + mg$

$\frac{\cos\theta T_1 - mg}{\cos\theta} = \frac{\cos\theta T_2}{\cos\theta}$

$T_2 = \frac{\cos\theta T_1 - mg}{\cos\theta}$

$T_2 = \frac{\cos 37°(69N) - 4kg(9.8 m/s^2)}{\cos 37°}$

$\boxed{T_2 = 19.9 N}$

Part A

What is the tension in the lower cord?

ANSWER:

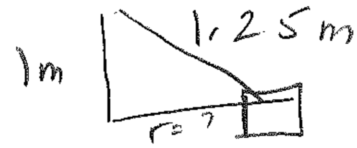
$T_l = T - \frac{2 \cdot 4 g \cdot 1.25}{2} = 20.0$ N

Part B

What is the speed of the block?

ANSWER:

$$v = \sqrt{\frac{\frac{1.25^2-1}{1.25}}{4}\left(2T - \frac{2\cdot 4g\cdot 1.25}{2}\right)} = 3.16 \ \ \mathrm{m/s}$$



$$\Sigma F_x = F_c$$

$$T_{1x} + T_{2x} = \frac{mv^2}{r}$$

$$\frac{r\left(\sin\theta T_1 + \sin\theta T_2\right)}{m} = \frac{mv^2}{r} \cdot \frac{r}{m}$$

$$1.25^2 = r^2 + 1^2$$

$$r = \sqrt{1.25^2 - 1^2}$$

$$r = 0.75$$

$$v = \sqrt{\frac{r\left(\sin\theta T_1 + \sin\theta T_2\right)}{m}}$$

$$v = \sqrt{\frac{0.75\,m\left[(\sin 37^\circ)(69\,N) + (\sin 37^\circ)(20\,N)\right]}{4\,kg}}$$

$$\boxed{v = 3.16\ m/s}$$