Name: ______________________

Class: ______________________

Due Date: ______________________

A.2 – Forces and Momentum

Understandings

- Newton's three laws of motion.
- Forces as interactions between bodies.
- Forces acting on a body can be represented in a free-body diagram.
- Free-body diagrams can be analyzed to find the resultant force on a system.
- The nature and use of the following contact forces:
  - The normal force F_{N} is the component of the contact force acting perpendicular to the surface that counteracts the body
  - The surface frictional force F_{F} acting in a direction parallel to the plane of contact between a body and a surface, on a stationary body as given by $F_{\mathrm{f}} \leq \mu_{\mathrm{s}} F_{\mathrm{N}}$ or a body in motion as given by $F_{\mathrm{f}} = \mu_{\mathrm{d}} F_{\mathrm{N}}$ where μ_{s} and μ_{d} are the coefficients of static and dynamic friction respectively.
  - The elastic restoring force F_{H} following Hooke's law as given by $F_{\mathrm{H}} = -kx$ where k is the spring constant.
  - The viscous drag force F_{d} acting on a small sphere opposing its motion through a fluid as given by $F_{\mathrm{d}} = 6\pi\eta r v$ where η is the fluid viscosity, r is the radius of the sphere, and v is the velocity of the sphere through the fluid.
  - The buoyancy F_{b} acting on a body due to the displacement of the fluid as given by $F_{\mathrm{b}} = \rho V g$ where V is the volume of the fluid displaced.
- The nature and use of the following field forces:
  - The gravitational force F_{g} as the weight of the body and calculated as given by $F_{\mathrm{g}} = mg$.
  - The electric force F_{e}.
  - The magnetic force F_{m}.
- Linear momentum is given by $p = mv$ remains constant unless the system is acted upon by a resultant external force.
- A resultant external force applied to a system constitutes an impulse J as given by $J = F\Delta t$ where F is the average resultant force and Δt is the time of contact.
- The applied external impulse equals the change in momentum of the system.

- Newton's second law in the form $F = ma$ assumes mass is constant whereas $F = \frac{\Delta p}{\Delta t}$ allows for situations where mass is changing.
- The elastic and inelastic collisions of two bodies.
- Explosions.
- Energy considerations in elastic collisions, inelastic collisions, and explosions.
- Bodies moving along a circular trajectory at a constant speed experience an acceleration that is directed radially towards the center of the circle – known as centripetal acceleration as given by $a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$.
- Circular motion is caused by a centripetal force acting perpendicular to the velocity.
- A centripetal force causes the body to change direction even if its magnitude of velocity may remain constant.
- The motion along a circular trajectory can be described in terms of the angular velocity ω which is related to the linear speed v by the equation as given by $v = \frac{2\pi r}{T} = \omega r$.

Equations

$F_\mathrm{f} \leq \mu_\mathrm{s} F_\mathrm{N}$

$F_\mathrm{f} = \mu_\mathrm{d} F_\mathrm{N}$

$F_\mathrm{H} = -kx$

$F_\mathrm{d} = 6\pi\eta r v$

$F_\mathrm{b} = \rho V g$

$F_\mathrm{g} = mg$

$p = mv$

$J = F\Delta t$

$F = ma = \frac{\Delta p}{\Delta t}$

$a = \frac{v^2}{r} = \omega^2 r = \frac{4\pi^2 r}{T^2}$

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

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. C: What is the meaning and equation of *directly proportional*? *Inversely proportional*? Give an example of each.

2. C: What is *mass*? What are its units? Is it a scalar or vector?

3. C: What is a *force*? What are its units? Is it a scalar or vector? How many objects are needed for a *force*?

4. C: What is the *force of gravity*? This is also called *weight*.

5. C: What are the equations for the *force of gravity*
   a. if we are near the surface of a planet?
   b. in general (this is called *Newton's Law of Gravitation*)?

6. C: What are some differences between *mass* and *weight*?

7. C: What is the *normal force*? In which direction does it point? Draw an image.

8. C: What is the *force of friction*? In which direction does it point? Draw an image.

9. C: What is the equation for *surface friction*? Define each variable.

10. C: What is the meaning of *dynamic/kinetic*? *Static*? Which is greater: *kinetic friction* or *static friction*?

11. C: What is the meaning of a *rough surface*? A *smooth surface*?

12. C: For which object do we observe the *force of tension*? Draw an image.

13. C: What is the equation for the *spring force*? Define each variable. What is the name and what are the units of *k* in the spring force equation?

14.C: **Use a pencil and ruler!** Draw a *force vs. displacement* graph for a mass on a spring. What does the slope of a *force vs. displacement* graph tell us? What does the area under a *force vs. displacement* graph tell us?

15.C: What is the *buoyant force*? State its equation and define each variable.

16.C: State the equation for the viscous drag force acting on a small sphere opposing its motion through a fluid. Define each variable.

17.E: The coefficient of viscosity of blood at 37.0°C is approximately $4.00 \times 10^{-3}\ \frac{\text{kg}}{\text{m}\times\text{s}}$. What will be the acceleration of a metal sphere with a mass of 0.500 g and a diameter of 1.00 cm when it is falling vertically down a tube of blood with a speed of 0.200 m/s? The density of blood is approximately $1{,}025\ \frac{\text{kg}}{\text{m}^3}$.

18.C: How do we draw a *free body diagram*? Here are the steps:

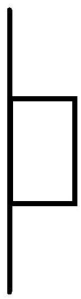
a. Circle the object (or objects) in question
b. Label all the external/outside forces on the object (or objects) with an arrow to show the direction and magnitude of each force
c. Draw a convenient axis to minimize vector components
d. For each object apply Newton's second law of motion for each axis

19.C: Label the forces on the following diagrams.

a. A block is at rest on a horizontal surface.

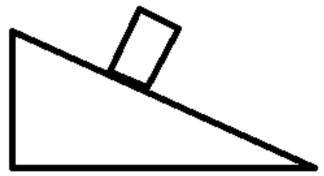
b. A man is pushing a block to the left with a horizontal force on a rough horizontal surface. The block does not move.

c. An object is being pushed to the left on a wall.

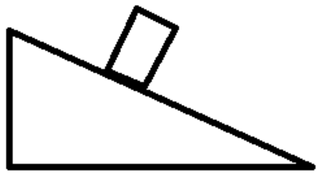


d. A man is pushing a block on a slope which is 20° from the horizontal on a rough horizontal surface. The block does not move.

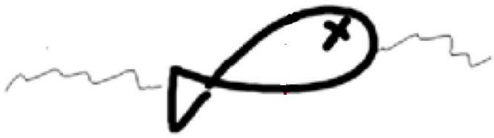
The man is pushing the block downwards. The push is parallel to the slope.



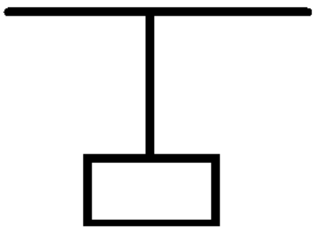
The man is pushing the block upwards. The push is parallel to the slope.



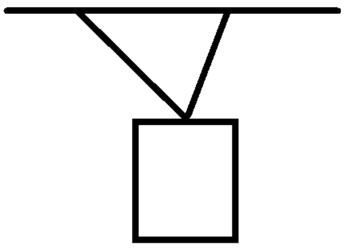
e. A dead fish is floating on top of the plastic radioactive ocean water.



f. A block is at rest and is hanging from the ceiling by one massless string.

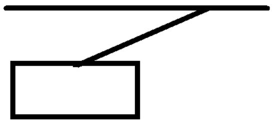


g. A block is at rest and is hanging from the ceiling by two massless strings.

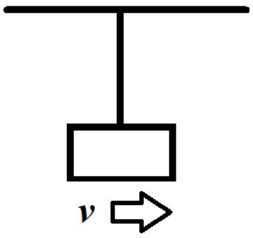


h. A block is tied to a massless string and is raised up at an angle θ from the vertical.

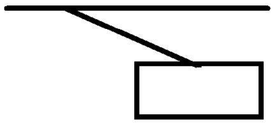
The block is released from rest.



The block is now at the bottom of its motion.



The block is now at the top of its motion.



i. A car is moving in a straight line to the right with a constant speed

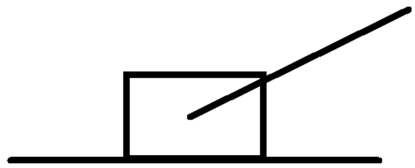
on a smooth horizontal surface.

on a rough horizontal surface.

j. A car is moving in a straight line to the right on a rough horizontal surface.

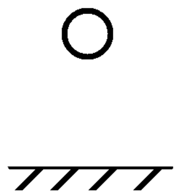
The car is slowing down (decelerating).	The car is speeding up (accelerating).
 You can also add force of brakes F_B pointing to the left.	 You can also call the force of push F_P the driving force F_D

k. A man pulls a massless string which is attached to a block with a constant speed at an angle θ above the horizontal on a rough surface. Label the forces on the block, not the man.

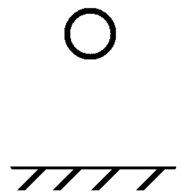


l. A ball is thrown vertically up and is moving upwards.

There is **no** force of air friction.

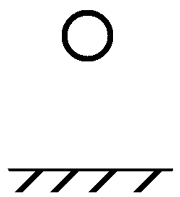


There **is** a force of air friction.

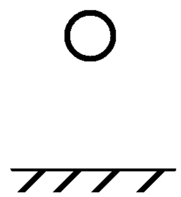


m. A ball is thrown vertically up and is at its maximum height.

There is **no** force of air friction.

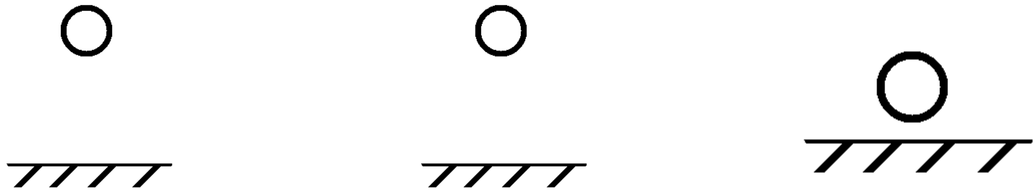


There **is** a force of air friction.



n. A ball is **dropped** from rest from the top of a very tall building. There is no force of air friction. Draw a free body diagram of the ball ….

the moment the ball is dropped.	when the ball is halfway down.	just before ball strikes the ground.

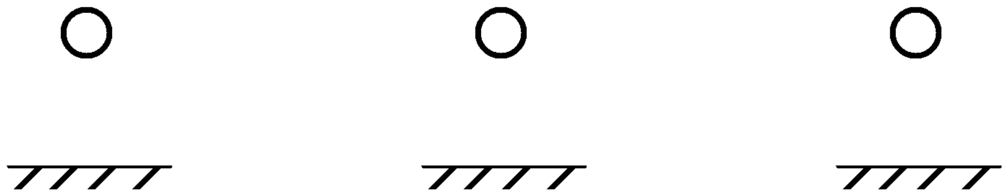


o. A ball is **thrown** downwards from the top of a tall building. Draw a free body diagram of the ball the moment after the ball is thrown when ….

there is **no** force of air friction.	there **is** a force of air friction.

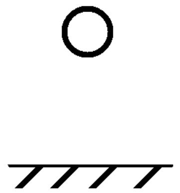
p. A ball is released from rest from the top of a very tall building. There is air friction. Draw a free body diagram of the ball….

a few seconds before the ball reaches its terminal velocity.	the exact moment the ball reaches its terminal velocity.	a few seconds after the ball reaches its terminal velocity.

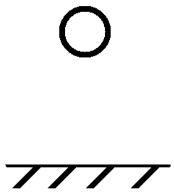


q. A ball is thrown at an angle $\theta = 45°$ north of east from a horizontal surface. Draw a free body diagram of the ball the moment the ball is thrown when ….

there is **no** force of air friction.

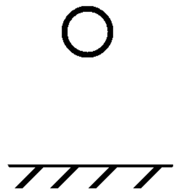


there **is** a force of air friction.

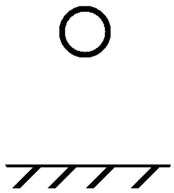


r. A ball is thrown at an angle $\theta = 45.0°$ north of east from a horizontal surface. The ball is at its maximum vertical height.

There is **no** force of air friction.

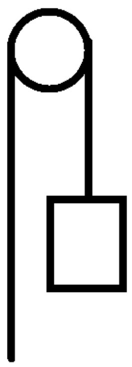


There **is** a force of air friction.

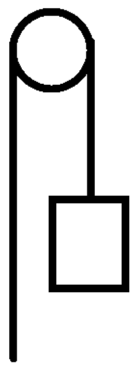


s. A block is being pulled vertically upwards by a massless string pulley.

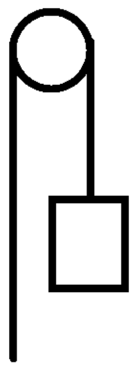
The speed of the block is constant.



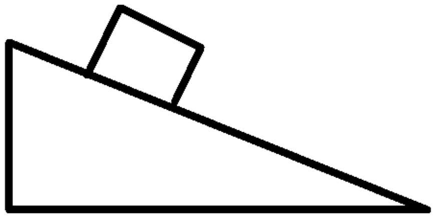
The block is accelerating.



The block is slowing down (decelerating).

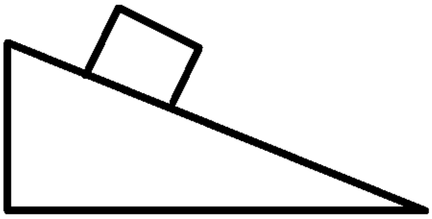


t. A block is at rest on an incline. There is surface friction.

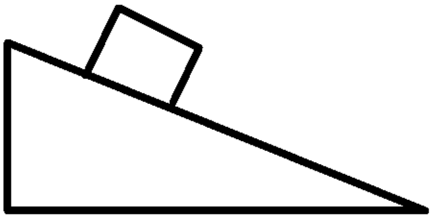


u. A block moves down an incline. There is surface friction.

The speed of the block is constant.

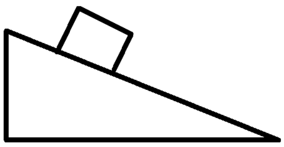


The block accelerates.

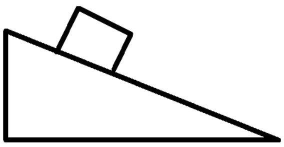


v. A block is pushed up an incline. There is surface friction.

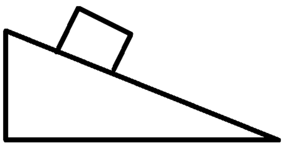
The block slows down (decelerates).



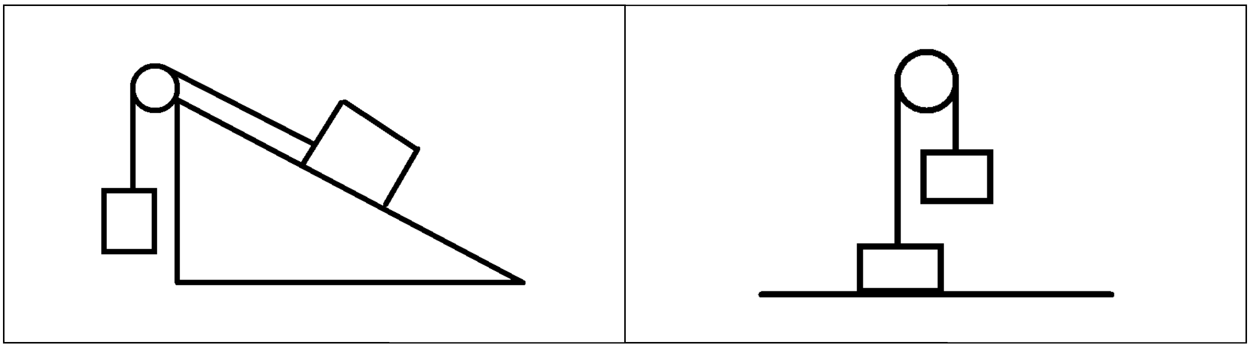
The speed of the block is constant.



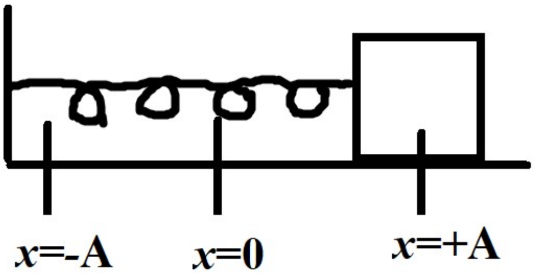
The block speeds up (accelerates).



w. Two blocks are attached to each other by a common string. There is surface friction.



x. A mass lying on a rough horizontal surface is attached to a spring and is stretched from its equilibrium position. It is then released.



20.C: What is the meaning of *inertia*? What is *inertia* directly proportional to?

21.C: State the name of *Newton's first law of motion*. State the definition/meaning of *Newton's first law of motion*.

22.C: Why is it not safe to stand up when a bus, plane, or subway is moving?

23.C: State the name of *Newton's second law of motion*. Give the equation for *Newton's second law of motion*.

24.C: True or false:

a. According to Newton's second law of motion $\sum \vec{F}$ and $\vec{a}$ will always point in the same direction.

b. According to Newton's second law of motion $\sum \vec{F}$ and $\vec{v}$ will always point in the same direction. In other words, there must be a net force in the same direction as the motion of the object.

c. According to Newton's second law of motion $\vec{v}$ and $\vec{a}$ will always point in the same direction.

25.C: Give an example of an object when its net force (or acceleration) and velocity point in opposite directions.

26.C: What is the meaning of *static equilibrium*? What is the meaning of *translational/dynamic equilibrium*?

27.E: A 14.0 kg mass is at rest on a horizontal surface.

a. Draw a free body diagram.

b. What is the force of gravity acting on the object?

c. What is the normal force acting on the object?

28.E: Ishmael pushes a 16.0 kg block to the left on a rough horizontal surface with a force of 70.0 N. The block does not move.

a. Draw a free body diagram.

b. What is the force of gravity acting on the object?

c. What is the normal force acting on the object?

d. What is the force of friction exerted on the block?

e. What is the coefficient of static friction?

29. E: Isaac pushes a 18.0 kg block to the left on a smooth horizontal surface with a force of 70.0 N.

a. Draw a free body diagram.

b. What is the force of gravity acting on the object?

c. What is the normal force acting on the object?

d. What is the horizontal acceleration of the block?

e. What is the vertical acceleration of the block?

30. E: Jacob pushes a 20.0 kg block to the left on a rough horizontal surface with a force of 70.0 N. The block moves at a constant speed of 2.00 m/s.

a. Draw a free body diagram.

b. What is the force of gravity acting on the object?

c. What is the normal force acting on the object?

d. What is the horizontal acceleration of the block?

e. What is the vertical acceleration of the block?

f. What is the force of friction exerted on the block?

g. What is the coefficient of friction μ between the block and the surface?

31.E: Adam pushes a block with a mass of 24.0 kg to the right on a rough horizontal surface with a coefficient of kinetic friction of 0.300. The block moves with a constant acceleration of $2.00\ \frac{\mathrm{m}}{\mathrm{s}^2}$.

a. Draw a free body diagram.

b. What is the force of gravity acting on the object?

c. What is the normal force acting on the object?

d. What is the force of friction exerted on the block?

e. What is the force of push given to the block?

32.E: Joseph is pulling a 65.0 kg block with a force of 800. N at an angle of 45.0° north of east above the horizontal of a rough horizontal surface. The coefficient of friction between the block and the surface is $\mu = 0.300$.

a. Draw a free body diagram.

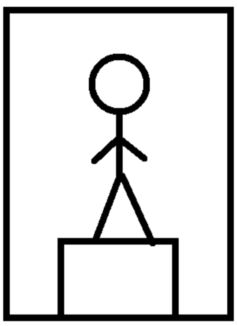
b. What is the vertical acceleration of the block?

c. What is the normal force acting on the block?

d. What is the horizontal acceleration of the block?

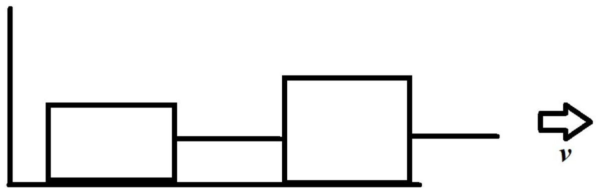
33.E: An 80.0 kg man is standing on a scale in an elevator. Determine the reading on the scale when

a. the elevator is at rest.
b. the elevator is moving up with a constant speed of 2.00 $\frac{\text{m}}{\text{s}}$.
c. the elevator is moving down with a constant speed of 2.00 $\frac{\text{m}}{\text{s}}$.
d. the elevator moves upwards with a constant acceleration of $2.00\ \frac{\text{m}}{\text{s}^2}$.
e. the elevator moves downwards with a constant acceleration of $2.00\ \frac{\text{m}}{\text{s}^2}$.



34. E: A block with a mass $m_2 = 20.0$ kg is on a rough horizontal surface with a coefficient of friction of $\mu = 0.400$. Attached to the right of m_2 is a massless string which is pulling m_2 to the right with a force of tension F_T. Attached to the right of the massless string is another block of mass $m_1 = 30.0$ kg. Attached to the right of m_1 is another massless string which pulls the whole system with a constant pulling force $F_\text{pull} = 800.$ N and constant acceleration a.

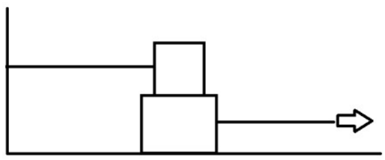
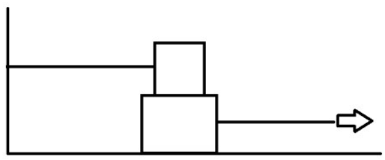
a. Draw a free body diagram.



b. Find the acceleration of the whole system a.
c. Find the force of tension F_T of the massless string which attaches both masses.

35.E: A block with a mass $m_2 = 15.0$ kg is on a rough horizontal surface. There is a string pulling it to the right with a force F_P at a constant speed. Above m_2 there is a block with a mass $m_1 = 12.0$ kg. There is a string attached to the left of m_1 which is attached to a wall which has a force of tension F_T. The coefficient of friction between m_1 and m_2 is $\mu_{1,2} = 0.250$ and the coefficient of friction between m_2 and the surface is $\mu_{2,\text{surface}} = 0.350$.

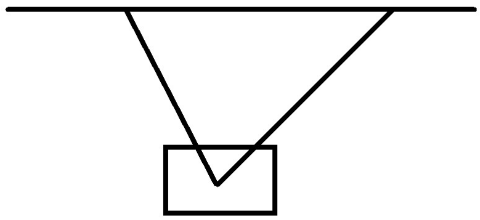
a. Draw a free body diagram.

For m_1:	For m_2:
	

b. Determine the force of tension F_T.
c. Determine the pulling force F_P.

36.E: A 12.0 kg block is held in the air by two strings attached to the wall. The first string makes an angle of $\theta_1 = 60.0°$ north of west. The second string makes an angle of $\theta_2 = 45.0°$ north of east.

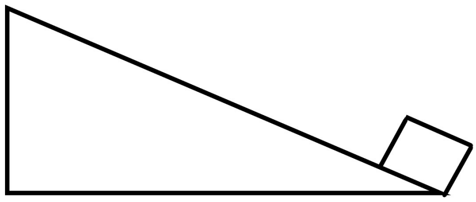
a. Draw a free body diagram.



b. Find the force of tension on each string.

37.E: A block with mass 15.0 kg is at rest on the bottom of an incline with $\theta = 25.0°$ which is 35.0 m long. The coefficient of friction between the block and the surface is $\mu = 0.450$. A man pushes the block up parallel to the incline with a force of 155 N.

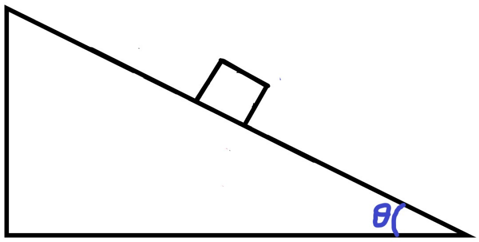
a. Draw a free body diagram.



b. What is the acceleration of the block?
c. What will be the final speed of the block when it reaches the top of the incline?
d. How long will it take for the block to reach the top of the incline?

38.E: A block with mass 65.0 kg is initially at rest in the middle of an incline with $\theta = 25.0°$ which is 40.0 m long. The coefficient of friction between the block and the surface is $\mu = 0.450$. A man pushes the block down parallel to the incline with a force of 60.0 N. The block accelerates downwards at a constant rate. Let the acceleration from gravity be $\vec{g} = 9.81\,\frac{\text{m}}{\text{s}^2}$.

a. Draw a free body diagram.



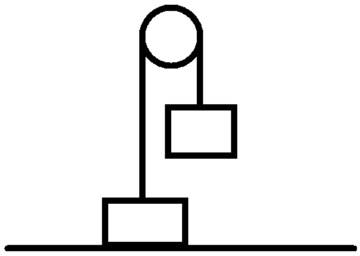
b. What is the magnitude of the acceleration of the block?

c. What will be the final speed of the block when it reaches the bottom of the incline?

d. How long will it take for the block to reach the bottom of the incline?

39.E: A massless frictionless pulley is attached to a ceiling. Mass $m_1 = 16.0$ kg is at rest on the ground. It is attached to a massless string which goes over the massless frictionless pulley and is attached to another mass $m_2 = 46.0$ kg which is also initially at rest in the air. m_2 is released from rest and both masses accelerate at a constant rate.

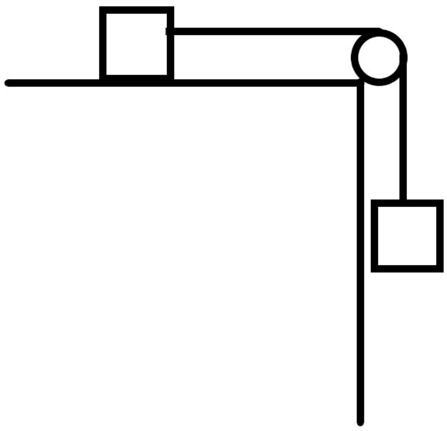
a. Draw a free body diagram.



b. Find the common acceleration of the system.
c. Find the force of tension F_{tension} of the massless string.

40.E: A block of mass $m_1 = 12.0$ kg sits at rest on a horizontal surface with $\mu = 0.240$. Mass m_1 is attached to a massless string which goes over a massless pulley which is attached to another block of mass $m_2 = 36.0$ kg.

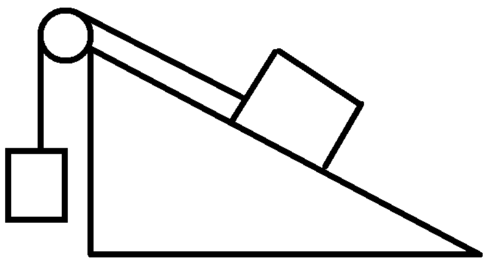
a. Draw a free body diagram.



b. What is the common acceleration of the blocks?
c. What is the force of tension on the string?

41.E: A 4.00 kg mass m_1 is initially at rest on a $\theta = 30.0°$ incline. The surface has a coefficient of friction $\mu = 0.400$. The 4.00 kg mass has a massless string attached to it which goes over the top of the incline above a frictionless pulley to another mass m_2 of 18.0 kg which is hanging in the air. Both objects are released from rest and move with a constant acceleration. m_2 moves down while m_1 moves up the incline.

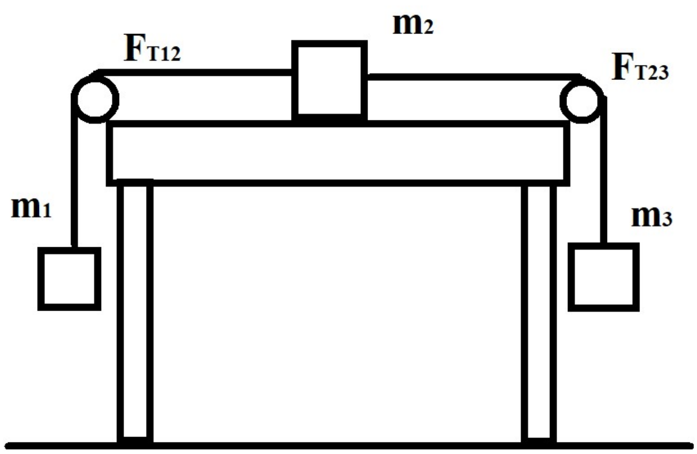
a. Draw a free body diagram.



b. What will be the common acceleration of each object?
c. What will be the force of tension on the string?

42.E: A block with mass $m_2 = 8.00$ kg is held at rest on a rough horizontal table which has a coefficient of friction of $\mu = 0.200$. It is attached by a string to a mass $m_3 = 14.0$ kg which hangs to the right of the table and another string to a mass $m_1 = 2.00$ kg which hangs to the left of table as shown below. Mass m_2 is released from rest and the whole system accelerates with a constant rate.

a. Draw a free body diagram.



b. Determine the acceleration of the system.
c. Determine the force of tension of string F_{T12} and the force of tension of string F_{T23}.

43.C: State the name of *Newton's third law of motion*. State the equation for *Newton's third law of motion*.

44.C: Give three examples of *Newton's third law of motion* (For each example you need two sentences: one for the action and one for the reaction.). Three examples have been given to you:

a. Man pushes wall forward. Wall pushes man backwards.

b. Fish pushes water backwards. Water pushes fish forwards.

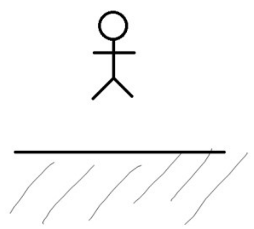
c. Earth pulls man down. Man pulls Earth up.

d.

e.

f.

45.E: An 80.0 kg man on Earth jumps vertically upwards. The acceleration due to gravity near the surface of the Earth is approximately $9.81\ \frac{\text{m}}{\text{s}^2}$. The mass of the Earth is approximately 5.97×10^{24} kg. Use Newton's third law of motion to determine the acceleration of the Earth after the man jumps.



46.C: **Use a pencil and ruler!** Define *free fall*. Draw a *displacement vs. time* graph, a *distance vs. time* graph, a *velocity vs. time* graph, a *speed vs. time* graph, and an *acceleration vs. time* graph for an object dropped from rest in free fall.

47.C: **Use a pencil and ruler!** Define *terminal velocity*. What is the relationship between speed and the force of friction? Draw a *distance vs. time* graph, a *speed vs. time* graph, and an *acceleration vs. time* graph of an object being dropped from rest from a very high height above the surface of the Earth with both the force of friction and the force of gravity acting on it.

48.C: Use Newton's third law of motion to complete the next sentence: Man throws rock forward.

49.C: What is the meaning and equation for *impulse* $\vec{J}$? Do not confuse impulse $\vec{J}$ with current I!

50.C: What is the meaning, symbol, equation, and fundamental units for *momentum* $\vec{p}$? Momentum is also called "*inertia in motion*." Why? Do not confuse momentum $\vec{p}$ with pressure P or power P or density ρ!

51.C: Why are the front of cars built so weak? Why are cars so easy to damage during an accident?
https://www.youtube.com/watch?v=v9ML4GA47Rg

52.C: Why do athletes have their elbows bent when catching a ball? Why do athletes have their knees bent when coming down after jumping?

53.C: What common mistake do people make when firing/shooting a gun? https://www.youtube.com/watch?v=bYWzMDVgweg

54.C: What does the law of *conservation of momentum* tell us? What is the equation for the law of conservation of momentum?

55.C: What is an *elastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?

56.C: What is an *inelastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?

57.C: What is a *perfectly inelastic collision*? Is momentum conserved? Is kinetic energy conserved? Is total energy conserved?

58.C: What does the area under a *force vs. time graph* tell us?

59.C: What does the slope of a line on a *force vs. time graph* tell us?

60.E: A 2.00 kg block is moving east with a speed of 5.00 m/s. It hits a wall and rebounds to the west at a speed of 4.00 m/s. What is the magnitude and direction of the change in momentum of the block?

61. E: A 2.00 kg block is moving east on a frictionless surface with a speed of 5.00 m/s. It then moves on a rough surface for three seconds. Finally it continues to move east on a frictionless surface with a new speed of 1.00 m/s. What is the force of friction of the rough surface?

62. E: A 3.00 kg block is moving west at 4.00 m/s on a frictionless horizontal surface. A 5.00 kg block is moving east at 6.00 m/s on the same surface. Both of them collide and stick together.

a. What is the final speed and direction of the block?

b. Is momentum conserved?

c. What is the original total kinetic energy?

d. What is the final total kinetic energy?

e. Is kinetic energy conserved?

f. Is this an elastic or inelastic collision?

g. Is total energy conserved?

63.E: A 7.00 kg block is moving north at 8 m/s on a frictionless horizontal surface. A 9.00 kg block is moving south at 10.0 m/s on the same surface. They collide. The 7.00 kg block is now moving south at 4.00 m/s.

a. What is the final speed and direction of the 9 kg block?

b. Is momentum conserved?

c. What is the original total kinetic energy?

d. What is the final total kinetic energy?

e. Is kinetic energy conserved?

f. Is this an elastic or inelastic collision?

g. Is total energy conserved?

64. E: A 12.0 kg block is initially at rest on a frictionless horizontal surface. It then explodes into three pieces. A 3.00 kg block moves west at 4.00 m/s. A 5.00 kg block moves east at 6.00 m/s.

a. What is the final speed and direction of the 4.00 kg block?

b. Is momentum conserved?

c. What is the original total kinetic energy?

d. What is the final total kinetic energy?

e. Is kinetic energy conserved?

f. Is total energy conserved?

65. E: A 12.0 kg block is moving east at 13.0 m/s on a frictionless horizontal surface. It then explodes into three pieces. A 4.00 kg block moves west at 5.00 m/s. A 6.00 kg block moves east at 7.00 m/s.

a. What is the final speed and direction of the 2.00 kg block?

b. Is momentum conserved?

c. What is the original total kinetic energy?

d. What is the final total kinetic energy?

e. Is kinetic energy conserved?

f. Is total energy conserved?

66.E: A 4.00 kg block is moving east at 5.00 m/s on a frictionless horizontal surface. It collides with a 6.00 kg block initially at rest. The 4.00 kg block then moves northeast at 3.00 m/s at an angle of 30.0° above the horizontal.

a. **Use a pencil!** Draw an initial and final figure.

Initial	Final

b. Use the law of conservation of momentum for each axis to determine the final speed (in m/s) and direction (in degrees) of the 6.00 kg block.

c. Is momentum conserved?

d. What is the original total kinetic energy?

e. What is the final total kinetic energy?

f. Is kinetic energy conserved?

g. Is this an elastic or inelastic collision?

h. Is total energy conserved?

67.C: Define *centripetal.*

68.C: Define *centrifugal.*

69.C: Are there *centripetal forces*?

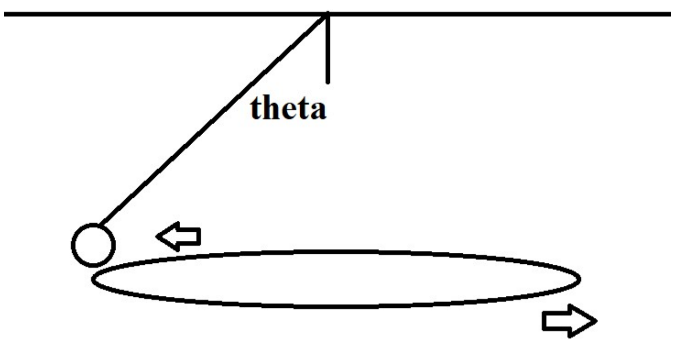
70.C: Are there *centrifugal forces*?

71.C: Imagine driving in a straight line with a constant speed of 60 km/h. You then quickly make a right turn. Do you feel a force? In which direction? Is it a centripetal force or a centrifugal force? Is it a real force? Why?

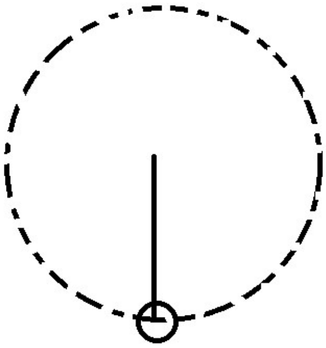
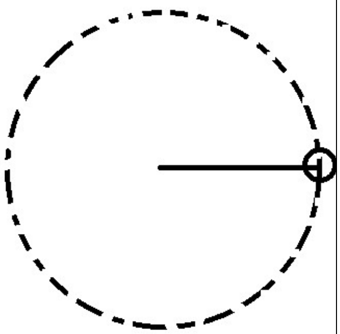
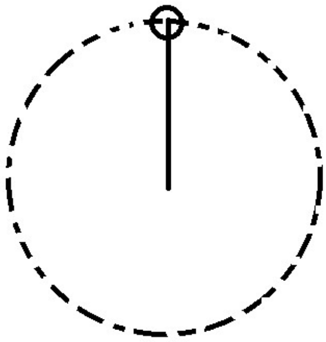
72.C: In circular motion how much work does the centripetal force do? Use the equation $W = Fs\cos\theta$.

73.C: Label the forces on the following diagrams.

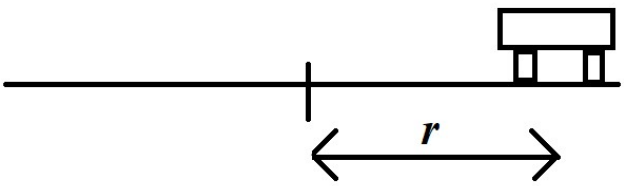
a. An object is attached to a string. The object moves in a horizontal circle at an angle θ from the vertical.



b. An object is attached to a string. The object moves in a vertical loop. Draw a free body diagram when the object is

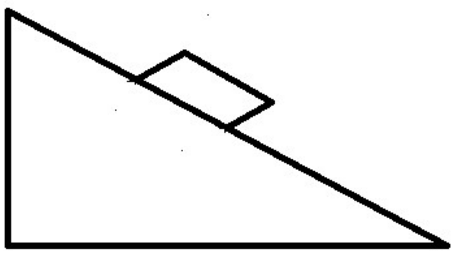
at the bottom.	halfway to the top.	at the top.
		

c. A car moves in a horizontal circle at a constant speed with a radius *r*.

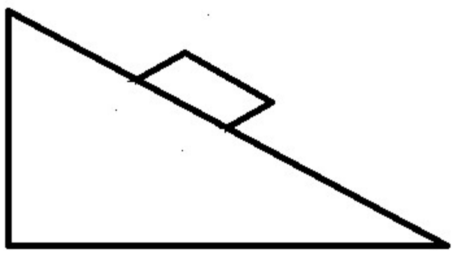


d. A car moves in a circle on a banked road (cone) with a constant radius *r*. There is force of friction.

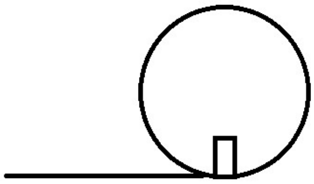
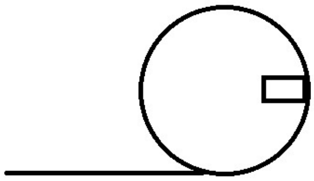
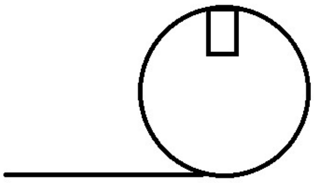
a. The car is moving slow.



b. The car is moving fast.

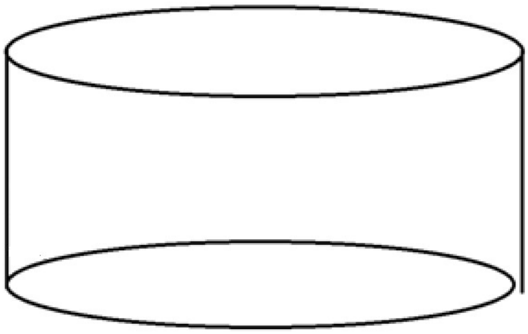


e. A cart is moving up on a vertically circular roller coaster with a radius r. There is no force of friction.

The cart is at the bottom.	The cart is at a height r.	The cart is at the top.
		

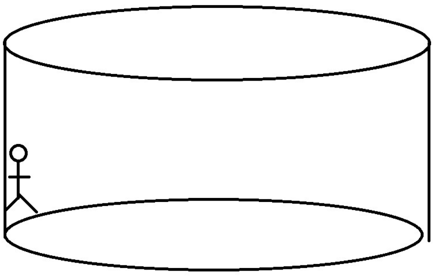
f. A fast motorcycle moves around a nonmoving cylindrical wall.

"Mauth Ka Kua" (The Well Of Death): Basic physics at its best!
Swastik Ghosh
https://www.youtube.com/watch?v=cFLNknvi7QE

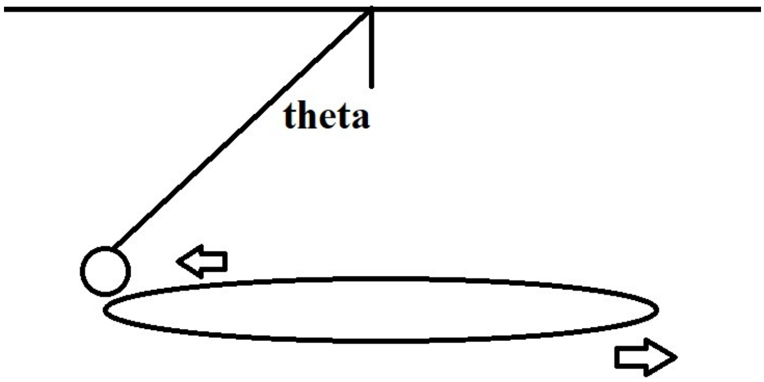


g. A man is on the edge of a moving cylindrical wall.

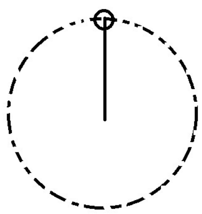
CENTRIFUGEUSE - ROTOR @ FOIRE DU TRONE (GoPro)
josselinz86
https://www.youtube.com/watch?v=GspwbZSjABA

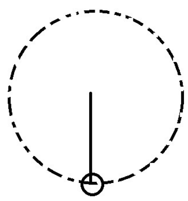


74. E: Draw a free body diagram and use Newton's second law of motion to obtain an equation for the force of tension and then the speed of a mass on a string in horizontal circular motion which makes an angle θ from the vertical. Your answer should be in terms of the mass of the object m, the length of the string l, the angle from the vertical θ, and the acceleration from gravity g.

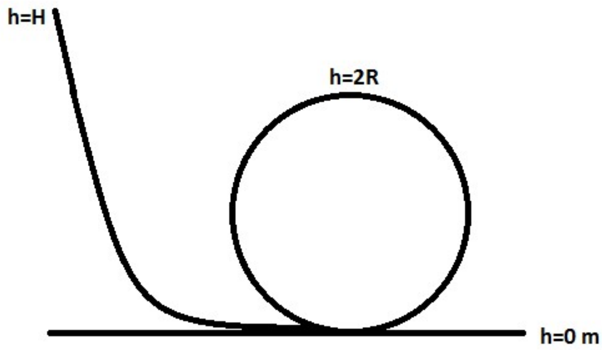


75.E: A point mass is attached to a massless string with length *r*. The mass and string are moving in vertical circular motion with a constant speed *v*. Draw free body diagrams and use Newton's second law of motion to obtain equations of the force of tension at the top and bottom of the string. Where is the force of tension greater? Your answers should be in terms of the mass of the object *m*, the radius of the string *r*, the speed of the point mass *v*, and the acceleration from gravity *g*.



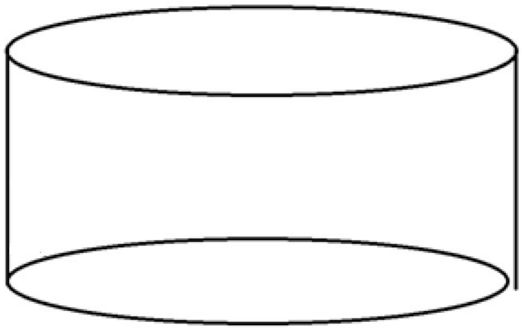


76.E: An object is released from rest from a height H. First use the law of conservation of energy to obtain an equation for the speed of the object when it has reached the top of the loop of the roller coaster. Then use Newton's second law of motion to obtain an equation for the normal force on the object when it has reached the top of the loop of the roller coaster. Your answer for the normal force should be in terms of the mass of the object m, the initial height of the object H, the radius of the loop r, and the acceleration from gravity g.



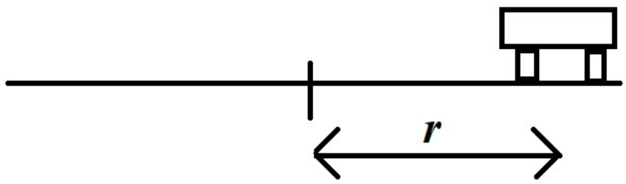
77.E: Draw a free body diagram and use Newton's second law of motion to obtain an equation for the speed of an object in the amusement park ride "The Well of Death." Your answer should be in terms of the radius of the cylinder/well R, the coefficient of friction μ, and the acceleration from gravity g.

"Mauth Ka Kua" (The Well Of Death): Basic physics at its best!
Swastik Ghosh
https://www.youtube.com/watch?v=cFLNknvi7QE

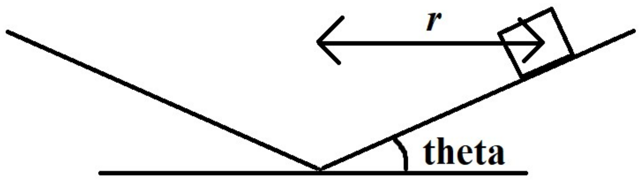


78.E: Cars

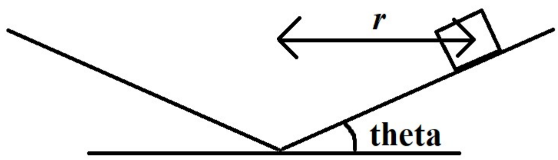
a. Use Newton's second law of motion to find an equation for the speed of a car moving in circular motion on a horizontal road with surface friction. Your answer should be in terms of the radius of the track r, the coefficient of friction μ, and the acceleration from gravity g.



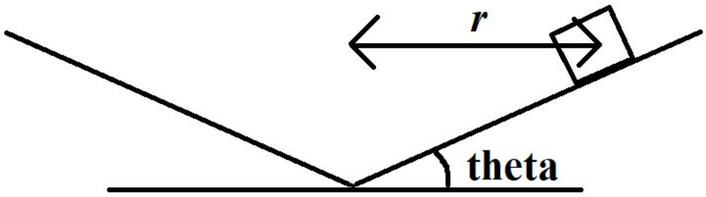
b. Use Newton's second law of motion to find an equation for the <u>speed</u> of a car moving at an angle θ to the horizontal in circular motion on a banked/angled road with no friction. Your answer should be in terms of the radius of the track r, the angle of the banked road θ, and the acceleration from gravity g.



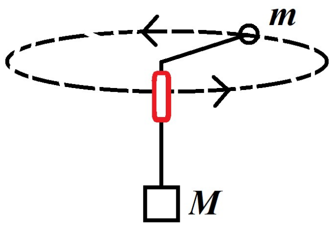
c. Use Newton's second law of motion to find an equation for the speed of a **slow moving car** moving at an angle θ to the horizontal in circular motion on a banked/angled road with surface friction. Your answer should be in terms of the radius of the track r, the angle of the banked road θ, the coefficient of friction μ, and the acceleration from gravity g.



d. Use Newton's second law of motion to find an equation for the speed of a **fast moving car** moving at an angle θ to the horizontal in circular motion on a banked/angled road with surface friction. Your answer should be in terms of the radius of the track r, the angle of the banked road θ, the coefficient of friction μ, and the acceleration from gravity g.



79. You are holding a red hollow cylinder and spinning a rubber stopper over your head. The rubber stopper has a mass of 18.5 g and is moving in a circle which has a radius of 110 cm. You measure that the rubber stopper moves 10 times around your head every 9.00 s.



a. What is the distance once around this circular path?

b. What is the distance ten times around this circular path?

c. What is the average speed of this rubber stopper as it circles above your head?

d. What is the direction of the centripetal acceleration of the stopper as it circles above your head?

e. What is the magnitude of the centripetal acceleration of the stopper as it circles over your head?

f. What is the direction of the velocity of this stopper when in the position shown in the diagram?

g. How much force would be required to keep this stopper moving in the given circular path?

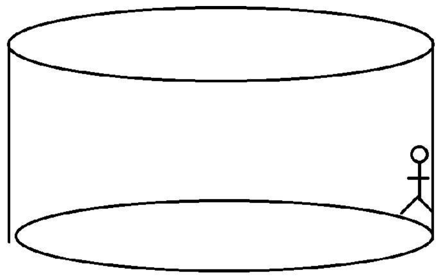
h. How much mass M must be hung on the lower end of the string to keep the stopper moving in the given circular path?

80. There is an amusement ride called the “ROTOR” where you enter a cylindrical room. The room begins to spin very fast until at some point the floor beneath you “falls out.” Suppose this that room has a radius of 4.20 m and that the room rotates such that you make one complete revolution in 3.65 s.

a. What will be your linear speed as the room spins at this speed?

b. What is the magnitude of your centripetal acceleration? How many “g’s” is this?

c. Label all of the forces acting on the rider.



d. What will be the magnitude of the centripetal force acting on a 50.0 kg person on this ride?

e. What will be the magnitude of the normal force acting on this person?

f. What will be the minimum frictional force acting on this person?

g. What is the minimum coefficient of friction between the rider and the wall?

81. Write down the common terms and equations for circular motion.