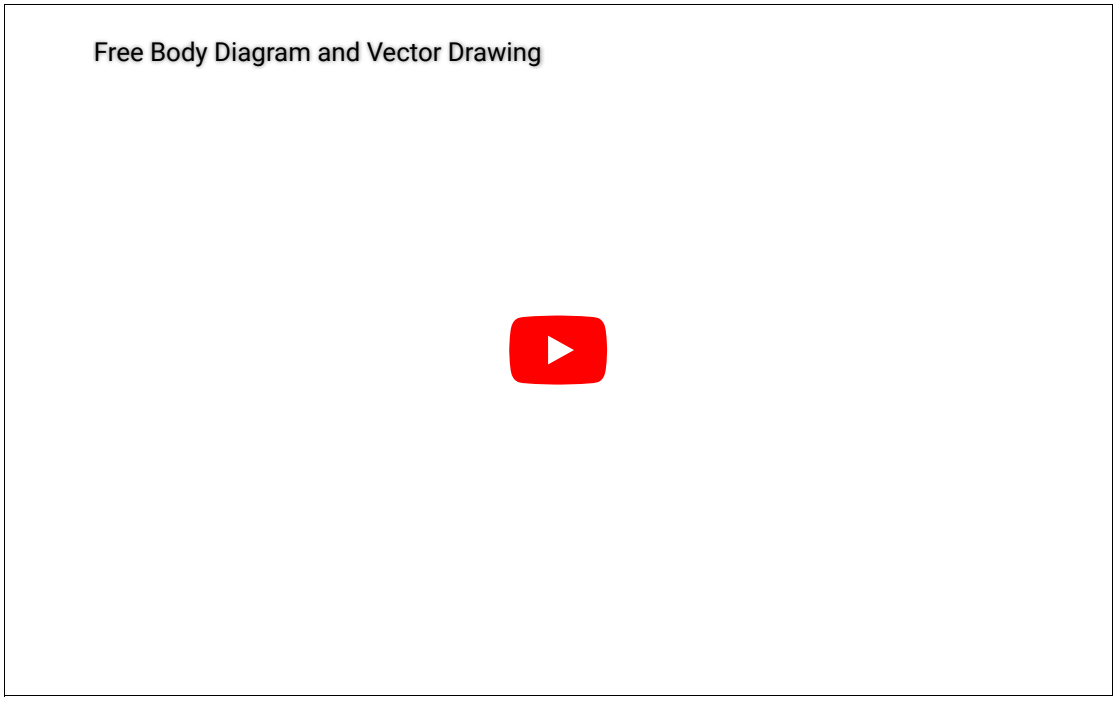
Problem 1:

This problem is designed to introduce you to Expert TA's Free Body Diagram question type. Please watch the following brief video and then complete Part (a) of this problem. The video will show you how to enter the correct answer for Part (a).



Please use the interactive area below to recreate the Free Body Diagram from the video. The video shows the case where a man is pulling the crate and where friction is involved. You can pause the video around 1 min and 35 seconds in to see the correct FBD.

FBD :

Force Labels: F, Fk, Fn, Fg, Fs, a, v

Angle Labels: 45, 0, 90, 135, 180, 225, 270, 315, θ

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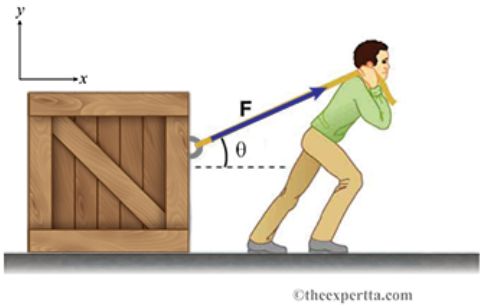
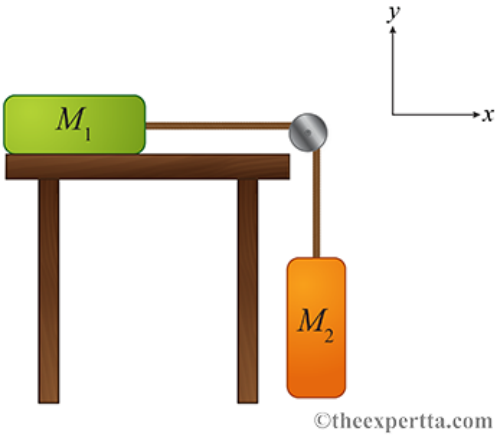
Problem 2: A crate sits on a rough surface. Using a rope, a man applies a force to the crate, as shown in the figure. The force is not enough to move the crate, however, and it remains stationary. Use *f* to represent the force of friction.



Please use the interactive area below to draw the Free Body Diagram for the crate.
FBD :
Force Labels: F, f, Fn, Fg, a, v
Angle Labels: 45, 0, 90, 135, 180, 225, 270, 315, θ

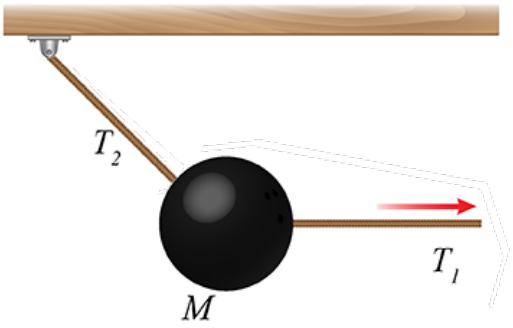
Problem 3: Two blocks are tied together with a massless string that does not stretch and connected via a frictionless and massless pulley. Mass one, M_1, rests on a table top and is stationary. Denote the force for static friction as *Fs* and the tension in the string by *T*.



Part (a) Please use the interactive area below to draw the Free Body Diagram for the mass M_1.
FBD :
Force Labels: Fn, Fs, Fg,1, T, a, v
Angle Labels: 45, 0, 90, 135, 180, 225, 270, 315, θ

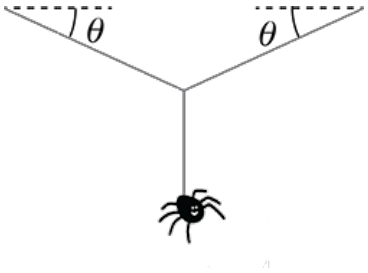
Part (b) Please use the interactive area below to draw the Free Body Diagram for the mass M_2.
FBD :
Force Labels: Fg,2, T, a, v, Fn, Fs
Angle Labels: 45, 0, 90, 135, 180, 225, 270, 315, θ

Problem 4: Consider a bowling ball of mass M attached to two ropes. One rope is being pulled horizontally. The second rope is tied to the ceiling (see figure) and is at a 45° with respect to the ceiling.The bowling ball is stationary.



Please use the interactive area below to draw the Free Body Diagram for the bowling ball.
FBD :
Force Labels: T1, T2, Fg, a, v
Angle Labels: 45, 0, 90, 135, 180, 225, 270, 315, θ

Problem 5: A spider with a mass of $m = 2.32 \times 10^{-5}$ kg hangs motionless from three stands of web. One strand is vertical, and the other two each make an angle of $\theta = 15.2^\circ$ with the horizontal ceiling, as shown in the diagram. Let T_v be the tension in the vertical strand of the web, and let T_o be the tension in either of the other strands. In numeric responses, use $9.80\ \mathrm{m/s^2}$ for the acceleration due to gravity.



Part (a) Write an expression for the tension in the vertical strand, T_v.
Expression :
T_v = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **γ**, **θ**, **b**, **c**, **d**, **e**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **S**

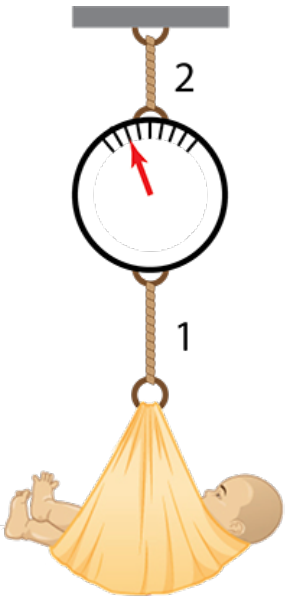
Part (b) What is the numeric value, in newtons, of the tension in the vertical vertical strand, T_v?
Numeric : A numeric value is expected and not an expression.
T_v = _____ N

Part (c) Write an expression for the tension in a strand that attaches to the ceiling, T_o.
Expression :
T_o = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(θ), **sin(θ)**, **β**, **γ**, **θ**, **b**, **d**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **S**

Part (d) What is the numeric value, in newtons, of the tension T_o?
Numeric : A numeric value is expected and not an expression.
T_o = _____ N

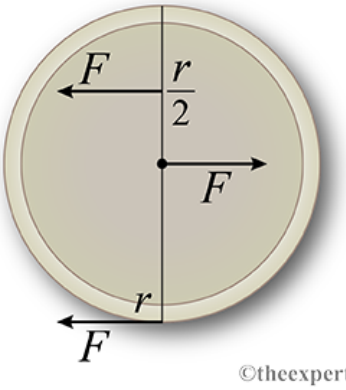
Problem 6: A baby is being weighed in the the manner depicted in the figure. The upper end of rope 1 is connected to the bottom of the scale, and the baby and basket are attached to the lower end of the same rope. The scale, which has a mass ***1.2*** kg, hangs from rope 2, whose upper end is connected to the ceiling. The scale reads ***67.7*** N.



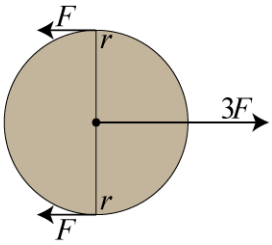
Part (a) What is the tension, in newtons, in rope 1?
Numeric : A numeric value is expected and not an expression.
T_1 = _____ N

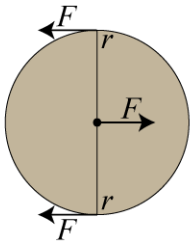
Part (b) What is the tension, in newtons, in rope 2?
Numeric : A numeric value is expected and not an expression.
T_2 = _____ N

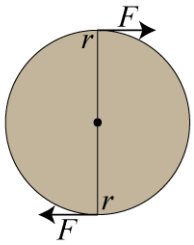
Problem 7: A circular air hockey puck of radius r slides across a frictionless air hockey table and is subjected to several forces as shown below. The magnitude and direction of each force is given. Forces are applied at either the center of mass of the puck, the outer edge (a distance *r* from the center), or a distance halfway (*r*/2) between the center and the outer edge.

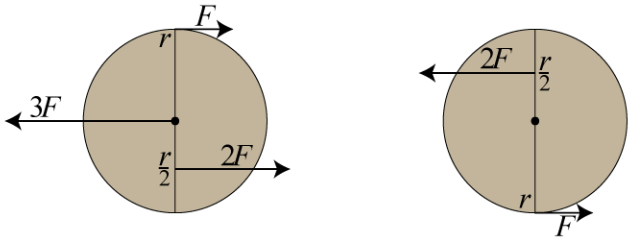


Select the examples below that have a net torque of zero about the axis perpendicular to the page and extending from the center of the puck.
SchematicSelect :





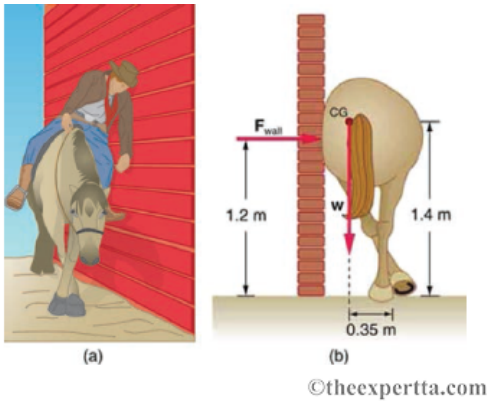




Problem 8: Two children push on opposite sides of a door during play. Both push horizontally and perpendicular to the surface of the door. One child pushes with a force of ***19.5*** N at a distance of ***0.585*** m from the hinges, and the second child pushes at a distance of ***0.47*** m.

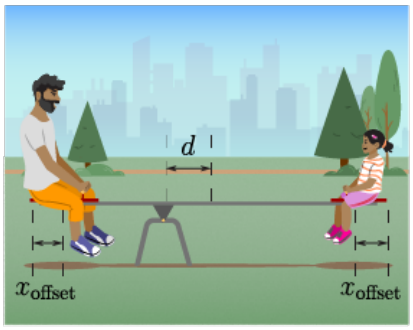
What is the magnitude of the force, in newtons, the second child must exert to keep the door from moving? Assume friction is negligible.
Numeric : A numeric value is expected and not an expression.
F_2 = _____

Problem 9: Suppose a horse leans against a wall as shown in the figure. The total mass of the horse and rider is ***525*** kg.



Calculate the force, in newtons, exerted on the wall, assuming that force is horizontal and using the data in the schematic representation of the situation.
Numeric : A numeric value is expected and not an expression.
F_{wall} = _____

Problem 10: You have been hired to design a family-friendly see-saw. Your design will feature a uniform board of mass $M = 12.16$ kg and length $L = 12.07$ m that can be moved so that the pivot is a distance d from the center of the board. This will allow riders to achieve static equilibrium even if they are of different mass, as most people are. You have decided that each rider will be positioned so that his/her center of mass will be a distance $x_{\text{offset}} = 28.93$ cm from the end of the board when seated, as shown.

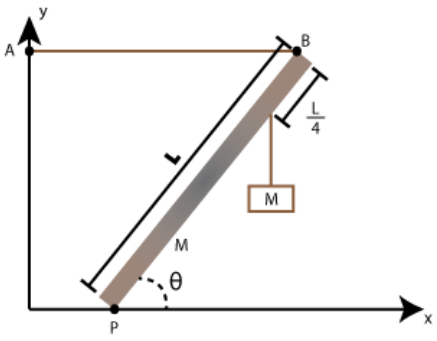


You have selected a child of mass $m = 26.9$ kg and an adult of mass $n = 4$ times the mass of the child to test out your prototype.

Part (a) Determine the distance d, in meters.
Numeric : A numeric value is expected and not an expression.
d = _____ m

Part (b) Determine the magnitude, in newtons, of the force exerted on the pivot point by the see-saw.
Numeric : A numeric value is expected and not an expression.
F_b = _____ N

Problem 11: A uniform beam of length L and mass M has its lower end pivoted at P on the floor, making an angle θ with the floor. A horizontal cable is attached at its upper end B to a point A on a wall. A box of mass M is suspended from a rope that is attached to the beam one-fourth L from its upper end.



Part (a) Write an expression for the y-component P_y of the force exerted by the pivot on the beam.
Expression :
P_y = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(α), **cos(φ)**, **cos(θ)**, **cotan(θ)**, **sin(α)**, **sin(φ)**, **sin(θ)**, **tan(θ)**, **α**, **θ**, **c**, **d**, **g**, **M**, **T**

Part (b) Write an expression for the tension T in the horizontal cable AB
Expression :
T = _____

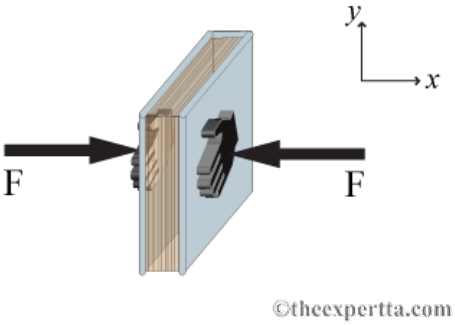
Select from the variables below to write your expression. Note that all variables may not be required.
cocotan(θ), **cos(α)**, **cos(φ)**, **cos(θ)**, **cotan(θ)**, **sin(α)**, **sin(φ)**, **sin(θ)**, **tan(θ)**, **α**, **c**, **d**, **g**, **M**, **q**

Part (c) Write an expression for the x-component P_x of the force exerted by the pivot on the beam, in terms of T.
Expression :
P_x = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(θ), **cotan(θ)**, **sin(θ)**, **tan(θ)**, **α**, **β**, **θ**, **d**, **h**, **j**, **k**, **P**, **q**, **T**, **z**

Part (d) What is the tension in the horizontal cable, in newtons, if the mass of the beam is *49* kg, the length of the beam is *6* m, and the angle is *24*°?
Numeric : A numeric value is expected and not an expression.
T = _____

Problem 12: A woman holds a book by placing it between her hands such that she presses at right angles to the front and back covers. The book has a mass of m = *0.75* kg and the coefficient of static friction between her hand and the book is μ_s = *0.57*.



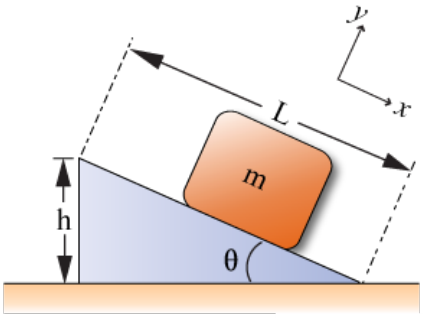
Randomized Variables

m = *0.75* kg
μ_s = *0.57*

Part (a) What is the weight of the book, F_{gb} in Newtons?
Numeric : A numeric value is expected and not an expression.
F_{gb} = _____

Part (b) What is the minimum force she must apply with each of her hands, F_{min} in Newtons, to keep the book from falling?
Numeric : A numeric value is expected and not an expression.
F_{min} = _____

Problem 13: A block of mass $m = 12.2$ kg rests on an inclined plane with a coefficient of static friction of $\mu_s = 0.15$ between the block and the plane. The inclined plane has length $L = 6.03$ m and height $h = 3.89$ m as indicated in the drawing.



Part (a) What is the angle, in degrees, between the surface of the plane and the horizontal?
Numeric : A numeric value is expected and not an expression.
θ = _____ °

Part (b) What is the magnitude, in newtons, of the normal force that acts on the block?
Numeric : A numeric value is expected and not an expression.
F_N = _____ N

Part (c) What is the x component, in newtons, of the force of gravity acting on the block?
Numeric : A numeric value is expected and not an expression.
$F_{g,x}$ = _____ N

Part (d) Will the block slide?
MultipleChoice :

1) emsp;There is not enough information, to determine if the block will slide.
2) emsp;No, the block will not slide.emsp;
3) emsp;Yes, the block will slide.

Problem 14: A book is placed on a table, and the table is placed on the floor.

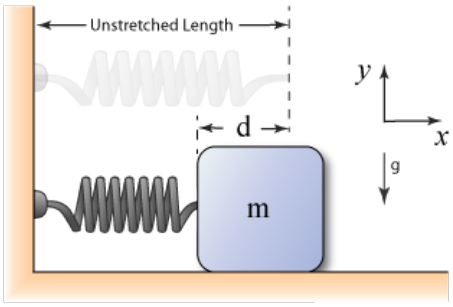
Part (a) On what does the floor exert a normal force?
MultipleChoice :

1) both the book and the table
2) the book only
3) neither the book nor the table
4) the table only

Part (b) On what does the table exert a normal force?
MultipleChoice :

1) neither the floor nor the book
2) the book only
3) both the floor and the book
4) the floor only

Problem 15: A spring with a spring constant of $k = 197$ N/m is initially compressed by a block a distance $d = 0.42$ m from its unstretched length. The block is on a horizontal surface with coefficients of static and kinetic friction μ_s and μ_k, respectively, and it has a mass of $m = 7.8$ kg. Refer to the figure.



Part (a) The block is released from the initial position and begins to move to the right. Enter an expression for the sum of the forces in the x direction in the configuration shown above, in terms of defined quantities and the acceleration due to gravity, g.
Expression :
$\sum_i F_{x,i}$ = _____

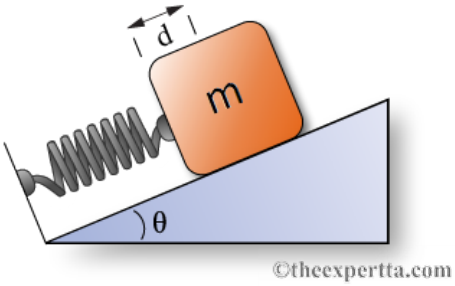
Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **μ_k**, **θ**, **a**, **d**, **g**, **h**, **i**, **j**, **k**, **m**, **P**, **S**, **t**

Part (b) Calculate the smallest value for the coefficient of static friction, μ_s, that would keep the block from moving.
Numeric : A numeric value is expected and not an expression.
μ_s = _____

Part (c) Assuming the block has just begun to move and the coefficient of kinetic friction is $\mu_s = 0.2$, what is the block's acceleration in meters per squared second?

Numeric : A numeric value is expected and not an expression.
a = _____ $\mathrm{m/s^2}$

Problem 16: A block of mass $m = 259$ kg rests against a spring with a spring constant of $k = 915$ $\mathrm{N/m}$ on an inclined plane which makes an angle of θ with the horizontal. Assume the spring has been compressed a distance d from its neutral position. Refer to the figure.



Part (a) Set your coordinates to have the x axis along the surface of the plane, with up the plane as positive, and the y axis normal to the plane, with out of the plane as positive. Enter an expression for the normal force, F_{N}, that the plane exerts on the block in terms of quantities defined in the problem statement, and use g for the acceleration due to gravity.
Expression :
F_{N} = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(α), **cos(φ)**, **cos(θ)**, **sin(α)**, **sin(φ)**, **sin(θ)**, **α**, **β**, **μ_s**, **θ**, **d**, **g**, **k**, **m**, **t**

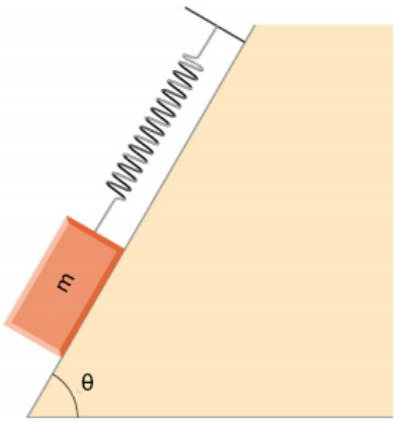
Part (b) Denoting the coefficient of static friction by μ_{s}, write an expression for the sum of the forces in the x direction just before the block begins to slide up the inclined plane in terms of quantities defined in the problem statement, and use g for the acceleration due to gravity.
Expression :
$\sum_i F_{i,x}$ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(α), **cos(φ)**, **cos(θ)**, **sin(α)**, **sin(φ)**, **sin(θ)**, **α**, **β**, **μ_s**, **θ**, **d**, **g**, **k**, **m**, **t**

Part (c) Assuming the plane is frictionless, what will be the angle, in degrees, of the plane if the spring is compressed by gravity a distance 0.1 m?
Numeric : A numeric value is expected and not an expression.
θ = _____ °

Part (d) Assuming $\theta = 45^\circ$ and the surface is frictionless, how far, in meters, will the spring be compressed?
Numeric : A numeric value is expected and not an expression.
d = _____ m

Problem 17: Shown to the right is a block of mass $m = 34.6$ kg resting on a frictionless ramp inclined at $\theta = 51.6^\circ$ to the horizontal. The block is held by a spring that is stretched by a distance $d = 6.09$ cm after the block is attached to it.



Part (a) Write an equation for the force constant of the spring in terms of the variables from the problem statement, and use g for the acceleration due to gravity.
Expression :
k = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(α), **cos(φ)**, **cos(θ)**, **sin(α)**, **sin(φ)**, **sin(θ)**, **β**, **γ**, **θ**, **d**, **g**, **h**, **m**, **n**, **P**

Part (b) Calculate the force constant of the spring in newtons per meter.
Numeric : A numeric value is expected and not an expression.
k = _____ $\mathrm{N/m}$

Problem 18: A rod is laid out along the x-axis with one end at the origin and the other end at $x = L$. The linear density is given by the following:
$\rho(x) = \rho_0+(\rho_1-\rho_0)(x/L)^2$,
where ρ_0 and ρ_1 are constant values.

For L = ***1.15*** m, ρ_0 = ***2.9*** kg/m, and ρ_1 = ***9.9*** kg/m, determine the center of mass of the rod, in meters.
Numeric : A numeric value is expected and not an expression.
$X_{\mathbf{CoM}}$ = _____

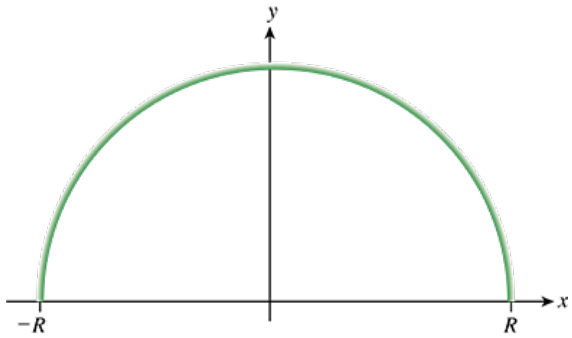
Problem 19: A certain carbon monoxide molecule consists of a carbon atom of mass m_c = ***13*** u and an oxygen atom of mass m_o = ***18*** u that are separated by a distance of d = ***112*** pm, where "u" is an atomic unit of mass.

Part (a) Write a symbolic equation for the location of the center of mass of the carbon monoxide molecule relative to the position of the oxygen atom. This expression should be in terms of the masses of the atoms and the distance between them.
Expression :
x_{cm} = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **θ**, **a**, **d**, **g**, **h**, **j**, **k**, **m**, $\mathbf{m_c}$, $\mathbf{m_o}$, **P**, **S**, **t**

Part (b) Calculate the numeric value for the center of mass of carbon monoxide in units of pm.
Numeric : A numeric value is expected and not an expression.
x_{cm} = _____

Problem 20: A thin wire is bent into a semicircle of radius *R*. As shown in the diagram, its center is at the origin and the two ends of the wire are on the *x* axis at *x* = R and *x* = -*R*.



Write an expression for the *y* coordinate of the center of mass of the wire.
Expression :
y_{cm} = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **γ**, **π**, **θ**, **b**, **d**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **R**, **S**