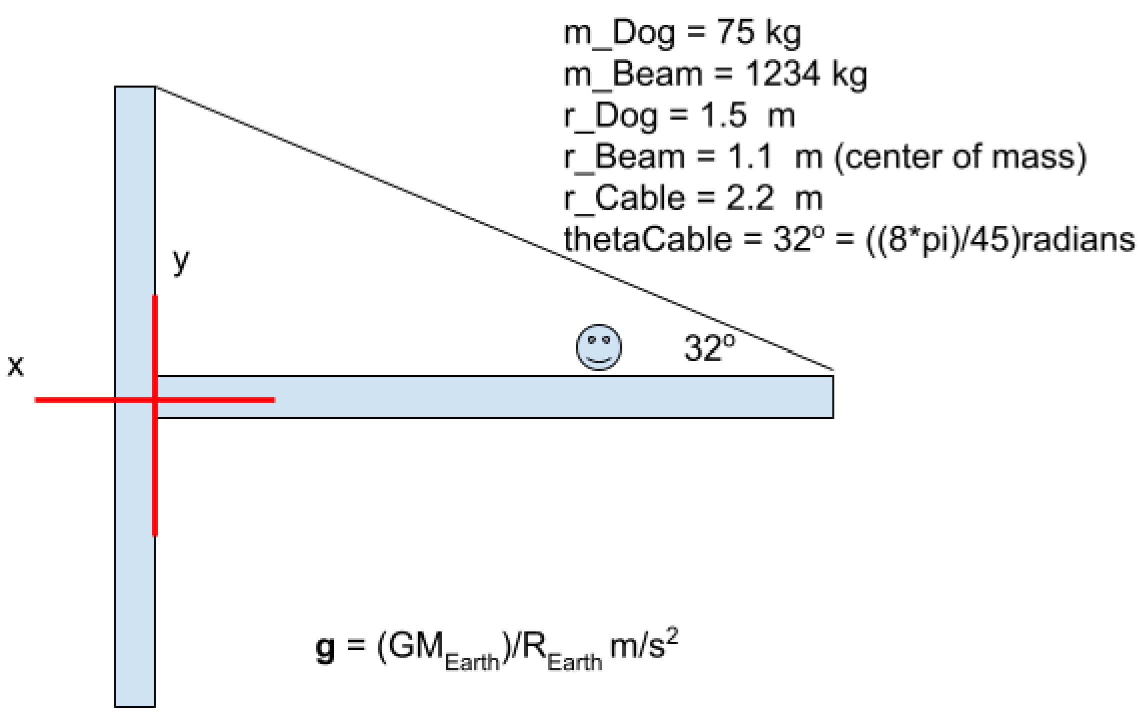
Christopher Hunt
PH 212

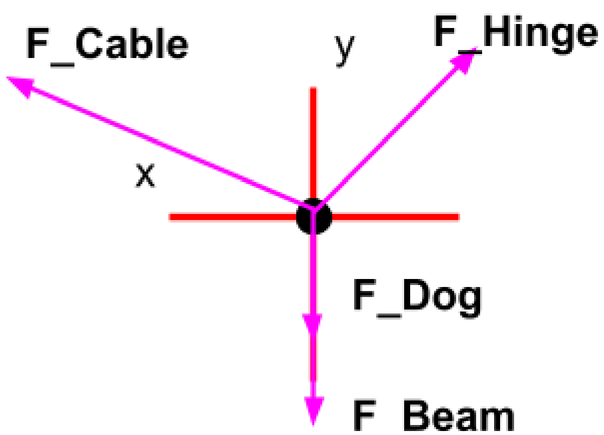
HIP 2

A 75kg dog sits down 1.5 meters of the way down a 2.2 meter long extended platform which is suspended from the end by a cable as shown. The platform has a mass of 1234kg. What is the Tension in the cable?

For this problem we assume that the beam, it's pivot point, the dog, and the cable are a closed system that are at static equilibrium - there is no acceleration occurring in the system. We will begin by drawing a picture of the scenario, and then creating a free body diagram with the coordinate system centered at the pivot point of the platform. Since this problem also includes rotational forces we will then draw a torque diagram. From here we will derive our equations and compute the answers.

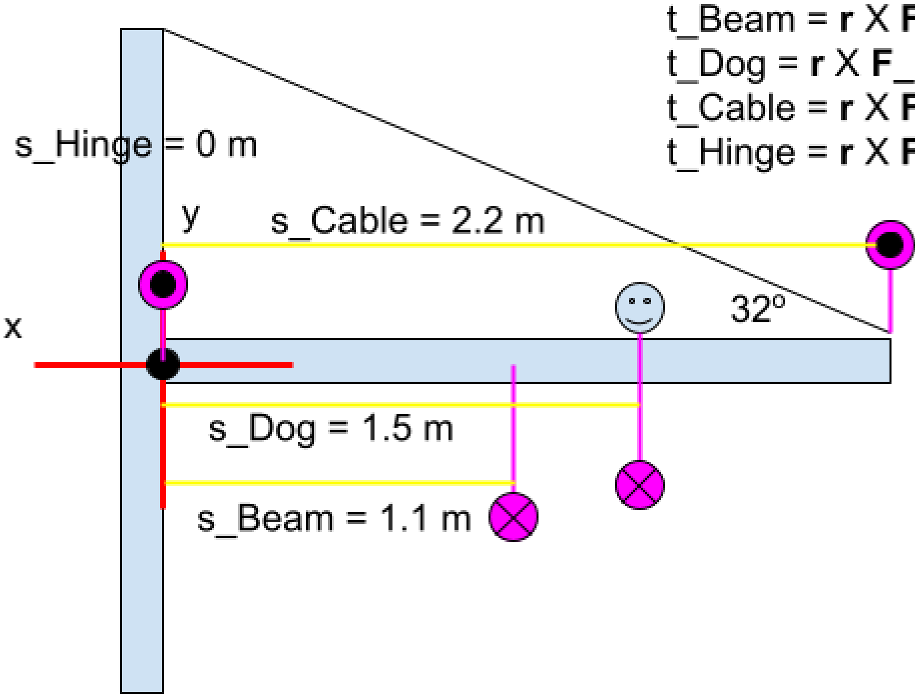


FBD of Pivot Point



F_Beam = m_Beam***g** N
F_Dog = m_Dog***g** N
F_Cable = ? N
F_Hinge = ? N

Torque Diagram of Pivot Point



t_Beam = **r** X **F_Beam** Nm
t_Dog = **r** X **F_Dog** Nm
t_Cable = **r** X **F_Cable** Nm
t_Hinge = **r** X **F_Hinge** Nm

Since we are assuming that the system is in static equilibrium we know that our sum of forces in the x and y directions will equal zero and we know that the sum of our torques will equal zero

$\sum F_x$ = **F_HingeMag*cos(thetaHinge)** + **F_CableMag*cos((8*pi)/45)** = 0 N

$\sum F_y$ = **F_Dog** + **F_Beam** + **F_HingeMag*sin(thetaHinge)** +

F_CableMag*sin((8*pi)/45) = 0 N

$\sum \tau$= **t_Dog** + **t_Beam** + **t_Cable** + **t_Hinge** = 0 Nm

Since we know that the hinge has a position vector of **s_Hinge** = <0, 0, 0>, if we attempt to find the torque caused by this force it will equal zero because taking the cross product of a zero vector will give us a zero vector.

$\sum \tau$= **t_Dog** + **t_Beam** + **t_Cable** + **t_Hinge** = 0 Nm → **t_Dog** + **t_Beam** + **t_Cable** = 0

→ solve for **t_Cable** → **t_Cable** = - (**t_Dog** + **t_Beam**)

From this we can use the torque formula to find the magnitude of the force the cable is exerting and thus the tension on the cable.

|**t_Cable**| =|**r_Cable**|*F_CableMag*sinϕ → solve for F_CableMag →
F_CableMag = |**t_Cable**|/(|**r_Cable**|*sinϕ)

F_CableMag = 1.23813e+4 N → 1.2e+4 N

This answer seems reasonable. The net force in the y direction is approximately -1.28e+4 N. Since the cable is acting at a longer lever length it is able to exert more torque for less force. The power of the force is reduced though due to the angle at which it is acting, but nevertheless, this answer seems reasonable.

Now we have the magnitude of the Force from the cable, which is the tension on the cable, our problem is solved.

We can use this to find the forces acting at the hinge.

Forces at hinge on beam = < 1.04999e+4, 6293.27, 0 > N

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GlowScript 3.0 VPython

## Begin by defining all of my variables. Begin with defining the scalars and the define the vectors

## Scalars
G = 6.67408E-11 # Nm^2/(kg)^2
r_Earth = 6371000 # m
m_Earth = 5.9722E24 # kg
g = -((G*m_Earth)/(r_Earth)**2) # m/s**2
m_Dog = 75 # kg
m_Beam = 1234 #kg
r_Dog = 1.5 # m
r_Beam = 1.1 # m - The beam is 2.2 m long but since we assume the mass is evening distributed across a perfectly even beam the center of mass will be 1.1 m
r_Cable = 2.2 # m - Since the cable is attached at the very end of the beam, it's distance from the pivot point is the length of the beam
r_Hinge = 0 # m
theta_Cable = ((8*pi)/45) # radians

## Vectors
s_Dog = vec(r_Dog,0,0) # m
F_Dog = vec(0, (m_Dog*g), 0) # N
t_Dog = cross(s_Dog, F_Dog) # Nm
s_Beam = vec(r_Beam, 0, 0) # m
F_Beam = vec(0, (m_Beam*g), 0) # N
t_Beam = cross(s_Beam, F_Beam) # Nm
s_Hinge = vec(r_Hinge, 0, 0) # m
t_NegBeam = t_Dog + t_Beam # Nm
s_Cable = vec(r_Cable, 0, 0) #m

## Now that we know the net torque caused by the dog and the beam itself we can find the torque caused by the tension cable and from that the force in the cable itself.

F_CableMag = (mag(t_NegBeam))/(r_Cable*sin(theta_Cable)) # N
F_Cable = vec((-(F_CableMag*cos(theta_Cable))), (F_CableMag*sin(theta_Cable)), 0) # N
t_Cable = cross(s_Cable, F_Cable)
F_CablYaxis = vec(0,(F_CableMag*sin(theta_Cable)), 0) # N
F_CableXaxis = vec((-(F_CableMag*cos(theta_Cable))), 0, 0) # N

## Now that know the force vector the cable is exerting on the pivot point we can resolve the force of the hinge on the pivot point
F_HingeYaxis = -1*(F_Beam + F_Dog + F_CablYaxis) # N
F_HingeXaxis = -1*(F_CableXaxis) # N
F_Hinge = vec(mag(F_HingeXaxis), mag(F_HingeYaxis), 0) # N

print("Torque of dog on beam = ", t_Dog, " Nm")
```

```
print("Torque of beam on itself = ", t_Beam, " Nm")
print("Negative torque on beam = ", t_NegBeam, " Nm")
print("Magnitude of tension force on cable = ", F_CableMag, " N")
print("Tension on cable = ", F_Cable, " N")
print("Torque of cable on beam = ", t_Cable, " Nm")
print("Force at hinge on beam = ", F_Hinge, " N")
```

Torque of dog on beam = < 0, 0, -1104.75 > Nm
Torque of beam on itself = < 0, 0, -1.33296e+4 > Nm
Negative torque on beam = < 0, 0, -1.44344e+4 > Nm
Magnitude of tension force on cable = 1.23813e+4 N
Tension on cable = < -1.04999e+4, 6561.08, 0 > N
Torque of cable on beam = < 0, 0, 1.44344e+4 > Nm
Forces at hinge on beam = < 1.04999e+4, 6293.27, 0 > N

Lecture Time: 11 am Name:Christopher Hunt

GORY	PLARY (1.5)	MPLISHED (1)	LOPING (0.5)	GENT (0)
Statement and tion	arning tool for our class is written	blem is clearly presented for reader in n words.	blem is directly copied or is hard .	p into some calculation
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s Tools	iate physics tools are correlated ercise in textbook quality and	iate physics tools are correlated to the . Appropriate tools include: pictures, onservational laws utilized, etc…	hysics tools are correlated to the .	e a few equations written.
n Solution tation	is very clearly presented with g asides or annotations	is complete and clearly presented no significant intuitive demands on the	solution I have to read between	s version of solution with only nts present
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Graded			e	ut your self-assessment is from mine by at least two steps.