**20-R-WE-DK-1**

You ask your little cousin to move a *1 kg* box up a hill with a coefficient of kinetic friction ***mu\_k = 0.2***.

Rather than carrying the box, he overthinks things and drags the box up the hill with a rope. Determine the work done by your little cousin and the work done by friction if he applies a constant force ***F = 10N*** and he drags the box up the hill ***d = 3 m***with an incline of *t****heta = 30 degrees***. How long will it take him to do so?

**20-R-WE-DK-2**

A crane lifts up a crate with mass ***m = 30 kg*** by a cable. If the crane applies a force ***F = 400 N*** and lifts it up to a height ***h = 5 m***, determine the work done by both the crane and gravity, and the crate's final velocity if it started from rest.

**20-R-WE-DK-3**

If a couple moment ***M = (theta^2 + 2theta + 2)Nm*** is applied to a disk, determine the work of the couple moment after the disk has rotated ***4 times***. What would be the sign of the work if the moment was applied in the opposite direction?

**20-R-WE-DK-4**

A frisbee is thrown such that its final angular velocity is ***omega = 9 rad/s*** after being in flight for ***t = 3s***. As it flies, the wind applies a constant moment, causing the frisbee to rotate faster. If the frisbee was initially at rest, determine the moment of the wind and the work done by said moment. Assume the frisbee can be modelled as a disk with mass ***m = 0.175 kg*** and that it rotates about its center of gravity G. The frisbee has a radius ***r = 0.14 m***.

**20-R-WE-DK-5**

Students are testing a platform mechanism consisting of 3 linkages. If each linkage can be treated as a slender rod, determine the total kinetic energy of the mechanism. Each rod has a mass ***m = 5 kg*** and the lengths are given as ***l\_AB = 0.4 m***, ***l\_BC = 0.5 m***, and ***l\_CD = 0.2m***. Rod AB forms an angle ***theta = 30 degrees*** with the horizontal. Rod AB rotates at an angular velocity of ***omega\_AB = 5 rad/s***.

**20-R-WE-DK-6**

If a rectangular plate has dimensions ***a = 4 m, b = 3 m*** what is the difference in kinetic energy if it is rotating about its center of gravity G, comparatively to rotating about the point P which is a distance ***d = 6.5 m*** away. In both cases, the plate has an angular velocity of ***omega = 3 rad/s*** and has a mass ***m = 14 kg***.

**20-R-WE-DK-7**

If a couple moment ***M = (theta^2 + 2theta + 2) Nm*** is applied to a disk, determine the angular velocity of the disk after it has rotated ***4 times***. The disk has a mass ***m = 10 kg*** and radius ***r = 10 cm***.

**20-R-WE-DK-8**

Students are working on a self-righting balance system consisting of a disk and two springs with spring

constants ***k\_1 = 10 N/m*** and ***k\_2 = 5 N/m***. If the disk with mass ***m = 15 kg*** and radius ***r = 0.4 m*** is subjected to a constant couple moment ***M = 5 Nm***, determine the angle through which the disk must rotate to achieve an angular velocity of ***omega = 1 rad/s***. Both springs are initially unstretched.

**20-R-WE-DK-9**

Montana James is shooting a scene in which he is running away from a foam cylinder (it will be replaced by a boulder in post-production). If the cylinder has mass ***m = 35 kg*** and a radius ***r = 1.8 m***, calculate the cylinders total kinetic energy. Assume the cylinder rolls without slipping at an angular velocity of ***omega = 4 rad/s***.

**20-R-WE-DK-10**

Recently your cat has become too fat and senile to descend from his cat tower so you have made him a little cat "elevator". There is no brake - the maximum speed of descent is controlled by the moment of inertia of the reel. If the safest maximum velocity for the platform is considered to be ***v = 1 m/s***, what should be the mass of the reel if the platform descends from a height ***h = 1.8 m***. The reel has a radius of gyration about its center of mass ***k\_G = 1.1 m***. Assume the total mass of your cat and the platform is ***m = 10 kg***, and the reel has a radius ***r = 0.25 m***.

**20-R-WE-DK-11**

A ***30 kg*** sheet of ice with length ***l = 1.5 m*** at an angle ***theta = 30 degrees*** has a force ***F = 650 N*** applied at B. Determine the magnitude of the angular velocity of the plank when it reaches a vertical position. Assume the sheet acts like a thin plate and that contact between the sheet and all surfaces is frictionless.

**20-R-WE-DK-12**

You are prototyping a new type of garbage disposal, in which a conveyor belt transports waste to be flattened by a roller. In your test run, you want to study how the machine will work without any garbage. The roller is adjusted so it is in contact with the conveyor belt. If the roller can be treated as a cylinder with mass ***m = 300 kg*** and the coefficient of kinetic friction between the roller and the conveyor belt is ***mu\_k = 0.25***, determine the distance the roller must travel in order to reach the same speed ***v = 8 m/s*** as the conveyor belt. The roller has a radius ***r = 0.6 m***.

**20-R-WE-DK-13**

Highschool students are designing an experiment to test the concept of potential energy. They come up with several scenarios and would like to measure values to compare later. They decide they will use the same weight and spring for each one of their scenarios, but have not decided their exact dimensions. In their proposed Scenario 1, the weight hangs from the ceiling attached to the spring, a distance ***h/2*** off the ground. In Scenario 2, the weight is attached to the ceiling by a taut string and attached to the top of the spring such that it rests at a height **h/2** off the ground. Assume the spring is large enough that it does not buckle under the weight. Scenario 3 is similar to Scenario 1 except a force is exerted on the weight to extend the spring at an angle ***theta***, such that the weight is held at a height ***h/2*** off the ground.

At a glance, determine if each scenario is feasible and, if they are, compare the energy level of each scenario.

What would happen if all scenarios were adjusted such that the weight was resting at a height ***3/4h*** off the ground?

**20-R-WE-DK-14**

A modern art sculpture consists of a collar, a spring, and a circular track. The collar has a mass ***m = 5 kg*** and the radius of the track is ***r = 0.6 m.*** If the spring is attached to a point P which is a vertical distance ***d = 0.4 m*** away from the perimeter of the circular track, determine the change in potential energy between state 1 and state 2, and between state 1 and state 3. The unstretched length of the spring is ***0.15 m*** and the spring constant is ***k = 50 N/m***.

**20-R-WE-DK-15**

A lazy engineer is designing a robot to move things for him. He places a hub motor inside a ***2.5 kg*** disk such that a couple moment of ***M = 2.943 Nm*** is applied. If the attached package has a mass ***m = 5 kg*** and the coefficients of kinetic friction and static friction for between all objects are ***mu\_k = 0.2*** and ***mu\_s = 0.4*** respectively, determine the angular velocity of the disk after its center of mass has travelled a distance ***d = 0.5 m***. Assume the disk rolls without slipping and the package does not tip.

The disk has a radius ***r = 0.3 m***, the spring constant is ***k = 100 N/m*** and the spring is unstretched originally.

**20-R-WE-DK-16**

A hardworking engineering student is designing a lever system that will slowly lower the lever and its load. The ***10 kg*** slender rod BC has a mass ***m = 5 kg*** attached at the rod's center of gravity G, and a length ***l = 0.6 m***. If the rod is released from rest when the spring is unstretched at ***theta = 30 degrees***, determine the spring constant k needed to obtain an angular velocity of ***omega = 0.5 rad/s*** at the instant ***theta = 60 degrees***. As the rod rotates, the spring always remains horizontal because of the roller support at A.

**20-R-WE-DK-17**

Find the potential energy at point A and at point C. Determine which location has greater potential energy. The collar has a mass ***m = 0.8 kg*** and the spring has a constant ***k = 600 N/m***. Point A is located a horizontal distance of ***d\_A = 0.6 m*** away from the wall while point C is located a vertical distance of ***d\_C = 1.3 m*** below point O on the diagram. Point B is located a vertical distance ***d\_B = 0.9 m*** below point A and the track has a radius ***r = 0.2 m***. The unstretched length of the spring is ***l\_0* = *0.12 m***.

**20-R-WE-DK-18**

You ask your little cousin to move a ***1 kg*** box up a hill with a coefficient of kinetic friction ***mu\_k = 0.2***. Rather than carrying the box, he overthinks things and drags the box up the hill with a rope. Determine the average power exerted by your little cousin if he applies a force ***F = 10 N*** and he drags the box up the hill ***d = 3m*** with an incline of ***theta = 30 degrees***.

**20-R-WE-DK-19**

**20-R-WE-DK-20**

A gardening company is testing a wheel barrow prototype for seniors. The wheel has a hub motor which can apply a moment ***M = 15 Nm***. If the wheel has a radius ***r = 0.3 m*** and the wheel rolls without slipping, determine the power of the hub motor if it moves at a velocity ***v = 1.5 m/s*** when a force of ***F = 15 N*** is applied at an angle of ***theta = 30 degrees.*** Determine the efficiency of the motor if a total of ***250 W*** is put into it.

**20-R-WE-DK-21**

A thin plate with dimensions ***a = 1 m***, ***b = 0.8 m***, has a mass ***m = 2 kg***. If the plate is at rest when ***theta = 0 degrees***, determine the angle ***theta*** at which it begins to slip. The point of contact O between the plate and the ledge is located a length ***l = 0.3 m*** from one side of the plate. Take the coefficient of static friction to be ***mu\_s = 0.3***.

**20-R-WE-DK-22**

What is the work done by all forces to drag a box up an incline of ***20 degrees***? What is the work done by all forces to roll a similar-sized cylinder up the same incline? Take the height of the box and the diameter of the cylinder to be equivalent at ***0.5 m***. Both have a mass of ***5 kg***. The cylinder rolls without slipping and the box does not tip. Take the coefficients of friction to be ***mu\_s = 0.3*** and ***mu\_k = 0.2*** respectively. In both scenarios, a force of ***30 N*** is applied at the object's center of gravity and the objects travel a distance of ***2 m*** up the incline.

**20-R-WE-DK-23**

If collar B moves along the bar CD towards D at a constant rate of ***1 m/s***, find the kinetic energy of the entire mechanical system. Assume the collar has negligible mass and each bar can be treated as a slender rod. The links have lengths ***l\_AB = 1 m, l\_CD = 3 m***, and the angles are given as *theta = 45 degrees* and ***phi = 30 degrees*** at this instant. Each link has a mass of ***1 kg***.

**20-R-WE-DK-24**

For an experiment, your professor assembles a system as shown, consisting of a ***30 kg*** disk, a ***12 kg*** slender rod, and a ***5 kg*** smooth collar. The goal of the experiment is to find information on the collar at given intervals. If the disk rolls without slipping, determine the velocity of the collar at the instant where ***theta = 30 degrees***. Assume the system is released from rest at ***theta = 45 degrees***. The hill has an incline of ***phi = 30 degrees***, the rod has length ***l = 2 m***, and the radius of the disk is ***r = 0.5 m***. Assume the system is frictionless.

**20-R-WE-DK-25**

For a summer, you've taken a job at your uncle's auto shop. You pull on the left side of a chain wrapped around a pulley with a force of ***F = 50 N***. The pulley has a mass ***m = 20 kg*** and a radius ***r = 0.2 m***. If the chain has a mass of ***3.4 kg per metre***, determine the angular velocity of the pulley after it has rotated ***theta = 90 degrees***. There is ***l\_A = 3 m***  of chain hanging off the left side and ***l\_B = 2 m*** hanging off the right side of the pulley. Assume the chain does not slip and that the system was released from rest just before you pulled on it. Assume the pulley can be modelled as a disk.