**20-R-IM-DK-1**

A ***10 kg*** disk with radius ***r = 0.3 m*** is subjected to a moment of ***5 Nm*** and a force of ***10 N*** which is applied by a cord wrapped around the disk. Determine the angular velocity of the disk after ***3 seconds*** if the disk starts at rest. Find the reaction forces at A.

**20-R-IM-DK-2**

A ***200 g*** yo-yo is being pulled along the ground where it rolls without slipping. The string is wrapped around the central hub of the yo-yo and is subjected to a force ***F = (t^2 + 2) N***, where t is in seconds. If the yo-yo can be treated as two outer disks with a radius of ***r\_2 = 4 cm*** and an inner disk (central hub) with a radius of ***r\_1 = 3 cm***, each with the same mass, determine the yo-yo's angular velocity after ***5 seconds*** if it initially starts at rest. Assume the string has negligible mass.

**20-R-IM-DK-3**

A salmon hatchery has a gate to release water whenever water levels get too high. The gate is normally locked into place, but when the water reaches the top of the gate, the lock is instantly removed. While the water would flow out of the gate by itself, there is a pump located upstream from the gate to push water forward. The pump is old so its power slowly ramps up with time. The gate consists of a slender rod in which a **20 kg** thin plate is attached. The plate has dimensions ***a = 1.5 m***, ***b = 2m*** and rotates about the slender rod as if it were a pin. Although there is a seal such that water may not get out, assume the contact between the plate and other surfaces is frictionless. If the gate is subjected to water from the pump that applies a force distribution with a magnitude that is related to both the y-coordinate and time ***dF = (-t(y-2)^2 + 8t) dy N,*** determine the angular velocity of the gate after ***t = 2 seconds*** if the gate initially starts at rest.

**20-R-IM-DK-4**

An engineering student sets up an experiment to record data such that she may apply her findings to a prototype. Specifically, she is curious about the velocity of a load on a pulley that is attached to a motor.

The pulley consists of two wheels rigidly attached to another, with a total radius of gyration of ***k\_O = 0.110 m*** and a total mass of ***m = 15 kg***. The load, in this case a ***40 kg*** cylinder, is attached to a wire wrapped around the wheel with radius ***r\_2 = 0.2 m***, and the motor is attached to a wire wrapped around the wheel with radius ***r\_1 = 0.075 m*** of the pulley. The ends of the wire are rigidly attached to the pulley and do not slip as the pulley rotates. Determine the velocity of the cylinder if the motor applies a constant tensional force ***F = 2000 N*** after ***t = 3 seconds***. The cylinder is initially at rest.

**20-R-IM-DK-5**

N/A

**20-R-IM-DK-6**

Your team is prototyping a simple braking system for your model car. The ***2 kg*** wheel with a radius of ***r = 0.1 m*** is rotating at ***omega = 10 rad/s***. A servo motor can apply a variable force F, which in its first two seconds of operation is equal to F = 10t N and afterwards is equivalent to a constant force of F = 20 N. If the coefficient of kinetic friction between the braking arm and the wheel is ***mu\_k = 0.2***, determine the time needed for the wheel to come to a full stop. The point of contact P between the wheel and the arm is a distance ***r\_P/A = (-0.3 i + 0.12 j) m*** from point A. The force of the servo motor is applied at exactly half of the horizontal distance to A from the point of contact. Assume the wheel can be treated as a disk and that the braking arm is massless.

**20-R-IM-DK-7**

A city engineer is working on a cargo transport system utilizing gears and racks. She is considering a ***30 kg*** gear with a radius of gyration of k\_G = 125 mm and a radius of ***r = 0.15 m***. The gear is in contact with a ***20 kg*** rack. If it takes the gear ***0.6125s*** to reach an angular velocity of ***omega = 20 rad/s***, starting from rest, determine the moment that the gear is subjected to. Assume there is no friction between the rack and the ground.

**20-R-IM-DK-8**

You were able to obtain a roll of toilet paper during quarantine and put it to good use. If the roll rests against a wall where its coefficient of friction is ***mu\_k = 0.2*** and you apply a vertical force ***F = 10 N*** downwards, determine the magnitude of the angular velocity of the roll after ***t = 5 seconds***. Point B and point C are located a vertical distance ***l = 0.15 m*** under point A. Assume the roll can be treated as a cylinder with a mass of ***m = 0.25 kg***, a width of w = 0. 115 m, and a radius of ***r = 0.065 m***. Neglect the mass of the unraveled toilet paper and make sure to wash your hands after.

**20-R-IM-DK-9**

A windchime consists of several slender rods, each suspended on one end by a rope and each with mass ***m***. Consider a singular rod for this problem. As the wind blows, the rod is subjected to an impulse ***I*** at its bottom. Determine the vertical location of point O in which the rod appears to rotate.

**20-R-IM-DK-10**

A punch buggy has a total mass of ***m\_tot = 840 kg***, including the mass of its passengers and its four wheels. Each wheel has a mass ***m\_wheel = 7 kg*** and a radius of gyration about its axle of ***k = 0.4 m***. You are just learning to drive the punch buggy and accidentally step on the accelerometer. If this causes the motor to apply a moment of ***M = 200 Nm*** to the two rear wheels, determine the speed of your car and your panicked instructor after ***t = 3 seconds***. Each wheel has a radius ***r = 0.3 m*** and can be treated as if it were pinned on the axle. Assume the car rolls without slipping and starts from rest. Neglect the screams of your instructor while you do this calculation.

**20-R-IM-DK-11**

You are helping your mom with the groceries when you accidentally drop a can of beans. The ***500 g*** can begins to roll on the ground and has a radius ***r = 4.25 cm***. Assuming the can does not slip nor rebound, determine the minimum initial velocity needed for it to roll over a pebble with height ***h = 0.7 cm***. The pebble does not move after the impact.

**20-R-IM-DK-12**

A ***1 m x 1 m*** thin plate is used as target practice at a firing range where participants are shooting for sport. If the plate has a mass of ***m = 20 kg*** and pinned at point O, determine the angular velocity of the plate just after a ***5 g*** bullet, shot at a velocity of ***v = 400 m/s***, is embedded in it. The bullet hits a vertical distance ***h = 0.75 m*** away from point O.

**20-R-IM-DK-13**

Consider a mechanism in the horizontal plane which consists of a ***5 kg*** rod and two disks. Disk A has a mass of ***m\_A = 6 kg*** and has a radius ***r\_A = 0.2 m***, while disk B has a mass of ***m\_B = 5 kg*** and a radius ***r\_B = 0.15 m***. Both are located at an equal distance ***d = 0.5 m*** away from the pin O. If disk A is given a clockwise angular velocity ***omega\_A = 6 rad/s*** and disk B is given a counter clockwise angular velocity ***omega\_B = 4 rad/s***, determine the angular velocity of the rod after both disks have stopped spinning relative to the rod. The pins at A and B have friction, but pin O is frictionless. Motion is in the horizontal plane.

**20-R-IM-DK-14**

Montana James is now too old for the movie industry and has instead been replaced by his daughter, Mississippi Jane. In her new movie, Mississippi Jane makes a daring escape by jumping off a ledge. In an incredible feat of athletics, she grabs a hook and swings in a perfect circular arc to safety. If Jane has a mass ***m = 60 kg*** and a radius of gyration ***k\_G = 0.25 m***, determine her angular velocity after she has swung 90 degrees. Jane had an original velocity of ***v\_1 = 3 m/s*** at a vertical height ***h = 1.5 m*** away from the hook, and her center of gravity was a horizontal distance ***r\_G = 0.9 m***. Assume her weight during impact does not act as an impulsive force. Assume that her arms stay in the same position as she swings, such that her center of gravity and radius of gyration do not change.

**20-R-IM-DK-15**

A Rube Goldberg machine utilizes a pool ball and a slender ***2 m*** long rod. If the pool ball has a mass m\_ball = 0.16 kg while the rod has mass ***m\_rod = 1 kg***, determine the angular velocity of the rod when the pool ball strikes it at ***v = 3m/s***. The pool ball has radius r = 0.025m and the coefficient of restitution is ***e = 0.8.*** The rod hits the pool ball at the same height as the ball's center of gravity.

**20-R-IM-DK-16**

A ***1 m x 1 m*** plate is used as target practice at a firing range. This time a bean bag cannon is being used. If a bean bag has a mass of ***m\_bag = 2 kg*** and a radius of gyration ***k\_G = 0.1 m***, determine the angular velocity of the plate right after the bean bag strikes it in the center with a velocity of ***v = 20 m/s***. The plate has a mass ***m\_plate = 20 kg*** and the coefficient of restitution is ***e = 0.4.***

**20-R-IM-DK-17**

There is a popular party game which involves throwing a frisbee to knock off cups resting on a stick. For simplicity, assume the frisbee can be modelled as a disk, the stick can be modelled as a rod connected to a pin joint which is held stationary until impact, and neglect any frictional effects. If the frisbee, with mass m\_frisbee = 0.2 kg and radius r = 0.135 m, strikes the very top of the stick with length ***l = 1.3 m*** at a velocity ***v = 6 m/s***, determine the velocity of the frisbee immediately after collision. The stick has mass ***m\_stick = 0.5 kg*** and the coefficient of restitution is ***e = 0.8***.

**20-R-IM-DK-18**

The siege on the castle of Santa Ono continues. The battering ram has been moved to the front and prepares to strike the door. If the ***200 kg*** log is released from rest at an angle of ***theta = 30 degrees***, determine the smallest angle the log will rebound to. The coefficient of restitution is between the log and the door is ***e = 0.4***. Assume the log strikes the door when the linkages are perpendicular to the ground. The linkages have length ***l = 1.2 m.***

**20-R-IM-DK-19**

N/A

**20-R-IM-DK-20**

You are helping your friend move into their new place. While sliding a box full of fragile things on a frictionless floor, the box gets caught on a small bar in the doorway and tips over on its side. Oops. If the box has a mass ***m = 20 kg***, a height of ***h = 0.4 m***, and a width of ***w = 0.4 m***, determine how fast the box had to be moving in order for this to happen. Assume the weight of the box during the impact was non-impulsive and that the size of the bar is negligible.

**20-R-IM-DK-21**

You and your friends are having a great time at mini golf. You are about to take a very light shot at a golf ball with a putter, so you let the putter fall under its own weight. If the putter consists of a head with mass ***m\_H = 0.3 kg*** and a radius of gyration ***k\_G = 0.05***, and a slender rod that extends from point P to G with a length ***l = 0.9 m*** and mass ***m\_r = 0.1 kg***, determine the velocity of the golf ball and the angular velocity of the putter right after impact. The center of gravity of the putter is located in its head. The coefficient of restitution is ***e = 0.9*** and the golf ball has mass ***m\_b = 0.05 kg***. The putter is released from rest when ***theta = 45 degrees***.

**20-R-IM-DK-22**

**20-R-IM-DK-23**