**20-R-KIN-DK-1**

What is the moment of inertia about an axis passing through point P of the plate? The plate has constant density ***8950*** kg/m^3 and a radius of ***rP = 50 mm***. The hole has a diameter ***dH = 10 mm***. The thickness of the plate is given as ***t = 1 cm***.

**20-R-KIN-DK-2**

A kid excitedly swings his foam cutout hammer. If point P acts like a pin and the hammer rotates about that point, what is the moment of inertia of the hammer? The foam has a density of ***100*** kg/m^3 and a uniform thickness of ***0.5***cm. Assume each cutout is a rectangular plate and the foam acts as a rigid body.

Plate A has a length ***l\_A = 30 cm*** and width ***w\_A = 5 cm***.

Plate B has a length ***l\_B = 10 cm*** and width ***w\_B = 20 cm***.

Plate C is identical to plate D, and has a length ***l\_C = 14 cm*** and a width ***w\_C = 7 cm***.

Plate C and D are attached to plate D such that their centers line up.

**20-R-KIN-DK-3**

A circular weight is being spun on a rope in a planar motion about the point P. What is the moment of inertia of the weight? The weight has a density of ***rho = 8000 kg/m^3*** and the radius of the disk is ***r = 0.2 m***. The rope has a length ***l = 50 cm*** and the plate is ***t = 10 cm*** thick.

**20-R-KIN-DK-4**

Your friend attempts to do tricks with an Asian coin. He is able to flip it in such a way that it can rotate about its x-axis or spin about its z-axis. What would the moment of inertia be for these two cases? The coin has a thickness of ***t = 2mm*** and a diameter ***d = 30 mm***. The density of the coin is ***rho = 7700 kg/m^3***. The coin has a cutout that is a ***3x5 mm*** rectangular hole.

**20-R-KIN-DK-5**

A film reel consists of two circular plates connected by a cylindrical core. The core has a radius of ***r = 4.5 cm*** and a height of ***h = 8 cm***, while the plates have a radius of ***r\_P = 20 cm***. Each plate has 6 holes punched into it, each with a radius of ***r\_H*** ***= 4cm*** placed d = 12 cm away from the center of the plate. Calculate the moment of inertia of the film reel if it rotates about the z axis from its center. Take the density of the material to be ***rho = 3000 kg/m^3*** and the thickness of each plate as ***t = 3 cm***.

**20-R-KIN-DK-6**

Determine the radius of gyration about the y-axis of the cone with a constant density of ***rho = 650 kg/m^3***. The cone has a radius ***r = 30 cm*** and a height ***h = 85 cm***. The center of gravity is found a distance h/4 away from the circular base of the cone.

**20-R-KIN-DK-7**

Another kid constructs his own foam hammer to overthrow the previous foam hammer tyrant. The head of the hammer consists of a rectangular plate and four circular disks. The handle is a lone rectangular plate. If point P acts as a pin in which the hammer rotates, what is the hammer’s radius of gyration about point P? The density of the foam is ***rho = 120 kg/m^3***. Assume that the foam acts as a rigid body and the hammer is undergoing planar motion.

Plate A has a length ***l\_A = 40 cm*** and a width ***w\_A =*** ***6 cm***. Point P is located on plate A, a distance of d\_y = 1/4 l\_A from the bottom and d\_x = ½ w\_A from the side.

Plate B has a length ***l\_B = 22 cm*** and a width ***w\_B = 25 cm***.

Plate C is identical to plates D, E, and F, and have a diameter equivalent to l\_B.

Plate A, C, D, E, and F have a thickness of ***t = 4mm*** while plate B has a thickness of ***t = 5mm***.

**20-R-KIN-DK-8**

If a disk has radius ***r = ?*** and rotates about an axis perpendicular to the plate going through P, how many times bigger would its radius have to be to obtain the same mass moment of inertia if it were spinning about its center of mass? Point P is ***d = ?*** away from the center of mass. Assume thickness is constant and that density is uniform.

**20-R-KIN-DK-9 (Picture is complex and shouldn’t be considered a priority for the graphic artist as this question will be used for a video solution)**

For her design competition, a student attempts to use a thin sheet of metal to form a chassis. She drills two cylindrical holes and cuts out two rectangular plates before realizing she messed up. As she tosses it into the recycling bin, the sheet rotates about its original center of mass G. If the sheet has a mass moment of inertia of 0.00236 kgm^2, what is the density? The sheet has a thickness of 3mm. Assume the cylindrical holes have a diameter equivalent to the thickness of the plate.

**20-R-KIN-DK-10**

A student on UBC Formula creates a prototype wheel cover, consisting of a thin ring, five rectangular plates, and a central circular plate. Each plate has a mass of ***m\_plate = 0.5 kg*** while the ring has a mass of ***m\_ring = 1 kg****.* What is the mass moment of inertia if the wheel cover rotates about point P? Assume the thickness of the ring is negligible.

The ring has a radius ***r\_ring = 25 cm*** while the central plate has a radius **r\_central = 7.5 cm**. Each plate has a length ***l = 17.5 cm*** and width ***w = 6 cm.*** Each plate is spaced 72 degrees apart from one another.

*(coding note: l = r\_ring - r\_central)*

**20-R-KIN-DK-11**

A preschooler has constructed a toy arrow from an arrangement of blocks. The blocks consist of plates in the shape of a triangle, a rectangle, and a trapezoid. Locate the centre of mass of the arrow if the blocks have constant density.

The rectangle has a width of ***w = 10mm*** and length ***l = 35 mm***.

The triangle has a base ***b = 25 mm*** and height ***h\_tri = 25 mm***.

The trapezoid has a height ***h\_trap = 12.5***, top length ***l\_top = 20 mm***, and base length ***l\_base = 30 mm***.

**20-R-KIN-DK-12**

An engineer puts together a form study prototype of a robotic arm to show a group of stakeholders. Specifically they want to know about its radius of gyration. Unfortunately, he forgot what material he used. If the mass moment of inertia of the arm is ***I = 15.2 kgm^2*** about point O, calculate the radius of gyration. Each component is a plate with thickness ***t = 5mm***. Assume the plates are rigidly attached to one another.

Plate A is identical to plate B, and has a radius ***r = 2w***.

Plates C, D, and E have the same width ***w = 15 cm***.

Plate C has a length ***l\_C = 1.1 m***, and is angled at phi = 30 degrees with the horizontal.

Plate D is attached perpendicular to plate C at a distance ***r\_D/A = 0.55 m*** from plate A, and has a length ***l\_D = 0.3 m***

Plate E has a length ***l\_E = 0.21 m***, and is angled theta = 105 degrees away from plate D.

**20-R-KIN-DK-13**

A group of engineering peasants have constructed a stationary battering ram in attempts to siege the castle of Santa Ono. Determine the tension developed in the linkages AB and CD as well as the angular acceleration if the ***400 kg*** log is subject to a horizontal force of ***300 N*** and both linkages have an angular velocity of ***omega = 6 rad/s***. Assume the mass of the linkages are negligible.

Links AB and CD have a length ***l = 1.2 m*** and are an equal distance ***d = 1.5 m*** away from the center of gravity of the log.

**20-R-KIN-DK-14**

An engineering student gets a co-op job at a door factory. They transport a door by pushing one on its side with a horizontal force of ***F = 200 N***. If the door has a mass of ***m = 16 kg*** and initial velocity ***v\_o = 0.05 m/s***, how far would it travel in ***t = 5 seconds***? What are the reaction forces at A and B?

The center of gravity is an equal distance ***d = 0.4 m*** away from rollers A and B.

The door has a height ***h = 2.3 m***and the center of gravity is found at h/2.

The student applies the force at a height ***y = 0.8 m*** from the bottom of the door.

**20-R-KIN-DK-15**

In his new movie, Montana James makes a daring escape by cutting wire CD on a platform. The wire is actually a prop cable that instantly snaps when triggered, and the footage is to be edited such that it looks as if Montana James cuts the wire in one swift motion. Before they film the scene, they do a test run without Montana James to ensure everything works properly. If the platform has a mass of ***m = 12 kg*** and has a center of gravity at G, what would be the angular acceleration of the platform and the tension in the cable AB immediately after the wire is snapped? Assume the platform can be considered a slender rod.

The platform has a length of ***l = 16 m*** and wire AB is connected at exactly half of its length.

The center of gravity G is found a horizontal distance ***r\_G/C = 6 m*** from C.

The angle is given as ***theta = 50 degrees***.

**20-R-KIN-DK-16**

You are forced to pull a group of kindergarteners in a cart. If you apply a horizontal force of ***F = 600 N***, determine the normal force on its wheels. The cart has a total mass of ***m = 160 kg*** and has a center of mass at G. Assume the wheels have negligible mass.

Wheel A is located ***0.25 m*** from one end of the cart and is a horizontal distance of ***d\_A = 0.89 m*** from G.

Wheel B is located ***0.25 m*** from one end of the cart is a horizontal distance of ***d\_B = 0.39 m***.

You apply the horizontal force at a height ***y = 0.5 m*** from the bottom of the cart.

The center of gravity G is located at a height ***h = 1.1 m*** from the ground.

*(NOTE: total length of cart is 1.7m, side lengths should be same, code to be difference)*

**20-R-KIN-DK-17**

A punch buggy is challenged to race. As it starts from rest, slamming on the accelerometer causes the rear wheels to slip. If the punch buggy has a mass of ***m = 1400kg*** with a centre of gravity at G, determine the distance it would travel in ***t = 5 seconds*** and the normal force on each of its four wheels. Assume the mass of the wheels are negligible and the coefficients of static and kinetic friction are mu\_s = 0.45 and ***mu\_k = 0.3***, respectively.

The radius of both wheels is ***r = 0.25 m***. G is a height of ***h = 0.5 m*** from the bottom of the frame, and ***d\_A*** *=* ***2 m*** and ***d\_B = 1.5 m***

**20-R-KIN-DK-18**

You are hauling a heavy cart up a ***theta = 30 degree*** incline. Luckily, you have been working out so you can apply a force of ***F = 250 N*** to the cart. If you apply this force at an angle ***phi = 42 degrees*** and the cart has a mass of ***m = 30 kg***, what is the acceleration of the cart and the normal force on each of the cart’s wheels? The cart has a center of gravity at G.

The force is applied at a height ***y = 0.4 m*** from the ground and G is located at a height ***h = 0.5 m***.

Wheel A is located ***x\_A = 0.1 m*** from one side of the cart while wheel B is located ***x\_B = 0.05 m*** from the other end.

Wheel A is a distance ***d\_A = 0.3 m*** from G while wheel B is a distance ***d\_b = 0.25 m***.

**20-R-KIN-DK-19**

Your friend is trying to carefully move his mom’s modern-art sculpture by dragging a rug underneath it. What is the maximum acceleration of the rug without causing the sculpture to move relative to the rug? Determine the normal reaction on the sculpture’s legs if the sculpture has a mass of ***m = 80 kg*** with a centre of gravity at G. Assume the coefficient of static and kinetic friction to be ***mu\_s = 0.3*** and mu\_k = 0.15 respectively.

The center of gravity is located at a height ***h = 0.6 m***from the ground. G is a horizontal distance ***d\_A = 0.4 m*** from A while it is a horizontal distance ***d\_B = 0.5 m*** from B.

**20-R-KIN-DK-20**

Kronk is asked to pull the lever. He applies a force of ***40 N***, causing the ***10 kg*** lever to have an angular velocity of ***3 rad/s***. Determine the angular acceleration of the lever and the reaction forces at O. Assume the lever is a slender rod and that the lever was originally propped up to be level horizontally. The prop was removed at the instant Kronk applied the force.

Kronk applies the force at a length 5/6l and the lever has length ***l = 0.3 m***.

**20-R-KIN-DK-21**

Three slender rods with equal mass are welded together. If the assembly is released from rest, what are the reaction forces at A and the angular acceleration of the rods? The rods have a mass of ***m = 2 kg*** each.

Rod AB has a length ***l\_AB = 1.5 m***, rod BC has a length ***l\_BC = 1 m***, and rod CD has a length ***l\_CD = 0.5 m***. Initially, Rod AB and rod CD are perfectly horizontal. Rod BC forms an angle of ***theta = 45 degrees*** with rod AB.

**20-R-KIN-DK-22**

An advertisement can be modelled as a thin plate with density distribution ***rho = 50x***. If the supporting wire at B suddenly snaps, what is the angular acceleration of the advertisement and the reaction forces at A at that instant? The sign has a width of ***w = 3 m*** and a height ***h = 1.5 m***.

**20-R-KIN-DK-23**

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 = 0.18*** and you apply a force of ***1 N*** at an angle of ***45 degrees*** tangent to the roll, determine the angular acceleration of the precious toilet paper.

Assume the roll can be treated as a cylinder with a mass of ***0.25 kg***, a width of 11.5 cm, and a radius of ***6.5 cm.*** Point B is a vertical distance ***d = 15 cm*** from point A.

**20-R-KIN-DK-24**

At the instant the wire at B snaps, determine the reaction forces at A and the angular acceleration of the ***200 kg*** beam if a force of ***600 N*** is applied at point C. Assume the beam is a slender rod.

Point B is located 1/4l away from point A, and the beam has a length ***l = 4 m***.

**20-R-KIN-DK-25**

A hardworking engineer is developing a playground ride for her kid. If she determines that the maximum angular acceleration of an empty ride in the instant shown should not exceed ***5 rad/s^2*** due to safety reasons, what should be the length of the rod in which a ***1 kg*** seat is attached? The seat can be modelled as a thin disk with radius ***r = 0.3 m*** and the rod, no matter the length, has a mass of ***m = 0.6 kg***. The angle in the instant shown is ***theta = 45 degrees***. Choose the most realistic value for your final answer.

**20-R-KIN-DK-26**

Students are creating a miniature all-terrain vehicle for a competition. An idea was proposed for an additional wheel which could be lowered and raised to dislodge the vehicle if it ever got stuck on jagged rocks. They decide to apply minimum constraint design to their prototype, resulting in a singular linkage arm attached to a wheel with radius ***r = 0.15 m*** at an angle of ***theta = 30 degrees***. The wheel has a mass of ***m = 5 kg*** and a radius of gyration ***k\_B = 0.2 m***. If the students rev the wheel such that it initially spins with ***omega = 30 rad/s***, determine the reaction force exerted on the link AB. What is the time required for the wheel to stop rotating? The coefficient of kinetic friction is given as ***mu\_k = 0.4***. Assume the linkage arm is securely locked in once it is lowered, and neglect the mass of the linkage arm.

**20-R-KIN-DK-27**

Movers are trying to set up an art gallery. They attempt to drag a human-size statue of a soda can with mass ***m = 120 kg*** by tying a rope around it. Determine the force required for the statue to tip and the force for the statue to slip if the coefficient of static friction and kinetic friction is found to be ***mu\_s = 0.4*** and mu\_k = 0.3, respectively. The can has a height of ***h = 1.8 m*** and the rope is tied ***1 m*** off the ground. Assume the statue to be a solid cylinder with radius ***r = 0.3 m*** and constant density.

If the movers can apply the force required for the statue to slip, where is the minimum height they should tie the rope to safely drag the statue?

**20-R-KIN-DK-28**

Your friend is once again trying to move their mom's modern art sculpture by dragging a rug underneath it. Will the statue tip or slip first? Determine the magnitude of the acceleration needed for both tipping and slipping. The statue has a mass of ***m = 80 kg*** and has a radius of gyration ***k\_G = 0.8 m***. The coefficient of static and kinetic friction is determined to be ***mu\_s = 0.25*** and ***mu\_k = 0.2*** respectively. Assume there is no friction between the rug and the ground.

The center of gravity G is found at a height ***h = 1.5 m*** and is a horizontal distance ***d\_A = 0.1 m*** from point A. Point B is a horizontal distance ***d\_B = 0.35 m*** away from the center of gravity.

**20-R-KIN-DK-29**

Montana James is at it again! He jumps into a pipe to escape from monkeys, rolling the pipe at an angular velocity of ***omega = 1 rad/s***. At this instant, the center of gravity of Montana and the pipe is at G, and their radius of gyration is ***k\_G = 1.05 m***. Determine the angular acceleration of the pipe if the combined mass of Montana James and the pipe is ***220 kg***. Assume Montana does not move within the pipe and that the pipe rolls without slipping. The radius of the pipe is ***1.2 m*** and G is a horizontal distance of ***0.15 m*** away from O.

**20-R-KIN-DK-30**

An engineering student is testing out the maximum settings on her punching machine. If the punching bag has a mass of ***m = 45 kg*** and an angular acceleration with magnitude ***omega = 4rad/s^2*** when the machine makes contact, determine the force applied by the machine in this moment. What is the tension and the angular acceleration of the supporting cable AB. The length of cable AB is ***l = 1 m***. Assume the punching bag can be modelled as a cylinder of uniform density with a radius of ***r = 21 cm.***

The punching bag has a height ***h = 1.5 m*** and the machine makes contact a distance ***y = 0.3 m*** from the bottom of the bag.

**20-R-KIN-DK-31**

A mechanical engineering student has been practicing his yoyo tricks because he has too much free time. For one trick, he spins the yoyo such that it contacts the ground and moves forward, emulating someone walking their dog. If the yoyo has a radius of gyration ***k\_G = 0.02 m*** and a mass of ***m = 0.2 kg***, determine the acceleration and angular acceleration of the yoyo when the tension in the string is found to be ***T = 0.4 N***. Assume the string is at its full extent and does not roll up as the yoyo rolls. Assume there is also no friction where the string slips around the yoyo's inner axle.

The coefficient of static and kinetic friction is found to be ***mu\_s = 0.3*** and ***mu\_k = 0.2*** respectively. The angle is ***theta = 60 degrees*** and the radius of the yoyo is ***r = 0.03 m***.

**20-R-KIN-DK-32**

N/A

**20-R-KIN-DK-33**

An engineering student is testing a component of her vehicle for a design competition. The ***5 kg*** rectangular plate is pinned to a carriage at P. If the track is given an acceleration of ***2 m/s^2***, determine the reaction forces at P and the angular acceleration of the plate.

The height of the plate is ***h = 2y*** and G is located a vertical distance ***y = 0.8 m*** away from P.

The plate has a length ***l = 2 m*** and point P is a horizontal distance ***x = 0.6 m*** from the edge.

**20-R-KIN-DK-34**

Mississippi Jane is at it again! She has found herself stuck on a conveyor belt with a rolling pipe - or so it seems. The pipe is actually not there and instead to be added in during post production for the actress' safety. It is up to you to calculate the proper physics of the pipe so that the CGI pipe may look as realistic as possible. If the pipe is meant to have a mass of ***500 kg*** and a mean radius of ***0.5 m***, determine the pipe's angular acceleration if the conveyor belt has an acceleration of ***3 m/s^2.*** Assume the pipe does not slip on the conveyor belt, and neglect its thickness. Which way should the conveyor be rotating for the pipe to roll towards Mississippi if she is on the right of the pipe?

**20-R-KIN-DK-35**

Students are working on a prototype of a switch for their design team. The switch consists of 3 slender rods, each with a mass of ***5 kg***, welded to a linkage system. The rods are assembled in such a shape to resemble that of the letter H, with the shortest rod with length ***l\_1 = 0.1 m*** acting as the bridge. The rod on the left has a length ***l\_2 = 0.3 m*** and the rod on the right has a length ***l\_3 = 0.4 m***. The linkage arms each have a length ***l\_4 = 0.6 m***. Determine the internal forces and the moment that the linkage system exerts on the rods at the instant ***theta = 30 degrees***. The two pinned linkage arms have an angular velocity of ***omega = 5 rad/s*** and an angular acceleration of ***alpha = 3 rad/s^2*** at this instant.

**20-R-KIN-DK-36**

Determine the centroid of the object if the centroid of each individual object is aligned.

The rectangular plate has a length ***l = 5 cm*** and height ***h = 1 cm***.

The smaller triangular plate has a base ***b\_s = 3 cm*** and height ***h\_s = 2 cm***.

The larger triangular plate has a base ***b\_l = 5 cm*** and height ***h\_l = 4.5 cm.***

**20-R-KIN-DK-37**

Two rowdy kids are having a strength competition. Anastasia pulls with a force of ***F\_A = 20 N*** and Brian, who has been hitting the gym recently, pulls with a force of ***F\_B = 45 N***. If the pulley can be modelled as a disk of mass ***m = 5 kg*** with a radius ***r = 15 cm***, determine the acceleration of Anastasia's hand at A and the tension in the cable PG at that instant. Assume the mass of the cable is negligible and no slipping occurs.

**20-R-KIN-DK-38**

An engineering student is working on an experimental drive system that utilizes two wheels to shift between drive and neutral. Wheel A rotates with a constant angular velocity of ***omega\_A = 15 rad/s*** and has a mass of ***m\_A = 1.1 kg***. Wheel B has a mass of ***m\_B = 1.6 kg***. and is initially at rest when it is put into contact with wheel A. If the coefficient of kinetic friction between the two wheels is ***mu\_k = 0.3***, determine the time required for wheel B to reach the same angular speed as wheel A. Assume the two wheels can be modelled as disks with radius ***r = 0.1 m*** and that the mass of bar CD is negligible. The length of bar CD is given as ***l = 0.8 m*** and the angle is ***theta = 30*** degrees.

**20-R-KIN-DK-39**

**20-R-KIN-DK-40**

The disk B has a mass of ***m = 5*** and is initially at rest when it is placed into contact with rotor A and roller C. If disk B has a radius ***r\_disk = 1 m*** and rotor A spins at a constant ***omega = 3 rad/s***, determine the angular acceleration of disk B at the instant contact is made. The point of tangency between A and B is at an angle of ***theta = 30 degrees*** with the vertical. The coefficients of kinetic and static friction are given as ***mu\_k = 0.25*** and ***mu\_s = 0.3*** between all contacting surfaces respectively. Roller C starts from rest and rotor A was spinning before contact. Both the rotor and the roller have a radius ***r = 0.2 m***.

**20-R-KIN-DK-41**

Your wonderful parents have returned from their vacation from Hawaii while you were studying for midterms. At the airport, you stack their luggage, which can be modelled as box A. Box A has a width ***w\_A = 0.5 m*** and height ***h\_A = 0.8 m***. If box A has a mass of ***m\_A = 50 kg***, determine the maximum force F you can apply on the ***12 kg*** car before tipping their luggage over. Assume slipping does not occur and that box A has uniform density even though clothing is probably stuffed in all sorts of places to save space for the souvenirs.

**20-R-KIN-DK-42**

Your friend has just moved into a new apartment and needs help moving some furniture in. You push on a desk at an angle ***theta = 30 degrees*** as shown, and, by chance, apply exactly enough force to overcome static friction. Determine the initial acceleration of the desk at this state and the normal forces at A and B. The desk has a center of gravity at G, with a mass of ***15 kg***. The coefficients of static and kinetic friction are given as ***mu\_s = 0.5*** and ***mu\_k = 0.3*** respectively.

The desk has a length of ***1.1 m*** and a height of ***1 m***. The center of gravity is located ***0.2 m*** below the top of the desk, and the desk has 4 legs in total.

**20-R-KIN-DK-43**

An engineering student has modelled a truncated cone in CAD software by rotating the coloured area about the x-axis. If the y-coordinate can be described by the equation ***g(x) = 1/3x + 1*** and the cup has constant density ***rho = 600 kg/m^3***, determine its radius of gyration about the x-axis. The cone has dimensions ***h = 1m*** and ***l = 3m***.

**20-R-KIN-DK-44**

Determine the applied force F required on wedge A in order to cause block B to either slip or tip first if the coefficient of static and kinetic friction are given as ***mu\_s = 0.3*** and ***mu\_k = 0.2*** respectively. Wedge A contacts block B at a height ***h\_A = 0.1 m*** and block B has a width ***w\_B = 0.05 m*** and height ***h\_B = 0.45 m***. Both A and B have a mass of ***m = 0.5 kg***.