How much wood would a woodchuck chuck if a woodchuck would chuck wood? \[ \sum \text{wood} \cdot m_{\text{wood}} \cdot r_{\text{wood}}^2 \]
**Question 1. (30 points)**

A 100g solid ball of radius 2 cm on a string is raised to an angle of 50° and then released. The distance from the point at which the string is attached to the center of the ball is 1m. The ball swings down and hits an identical ball.

(a) (5 points) How much kinetic energy does the ball on the string have just before it hits the second ball?

(b) (5 points) The collision is elastic. How much kinetic energy does the second ball have just after the collision?

(c) (5 points) The second ball then rolls up a 15° incline to a height of 10 cm. What is the magnitude of the velocity at the top of the slope.

(d) (5 points) What is the angular momentum of the ball at this point? Give magnitude and direction (ie. left, right, up, down, in to page, out of page).

(e) (10 points) The ball then flies off the ramp. At what distance $x$ from the bottom of the ramp does it strike the ground?
Question 2. (35 points)

A robot iceskater is initially at rest and then fires rockets on the end of it’s arms, each of which exerts a force of 100N for 0.5s. Once the rockets have turned off and the robot has reached a constant angular velocity, the robot raises its arms, leading to a change in its angular velocity.

(a) (5 points) Find the moment of inertia of the robot when it’s arms are extended considering that the rockets weigh 2 kg each, each arm weighs 3 kg, the body of the robot is a 50 kg cylinder with radius 10cm. The arms have length 1.1m and are attached to the edge of the cylinder. The rockets may be considered as point masses. You may neglect the moment of inertia of the robot’s head.

(b) (5 points) What is the angular acceleration of the robot during the 0.5s that the rockets are on?

(c) (5 points) What is the angular velocity achieved when the rockets have been turned off but the robot has not yet raised it’s arms? Give your answer in both s⁻¹ and rpm.

(d) (5 points) What is the angular momentum when the rockets have been turned off but the robot has not yet raised it’s arms? Give magnitude and direction (ie. left, right, up, down, in to page, out of page)?

(e) (5 points) What is the moment of inertia of the robot after it has raised it’s arms?

(f) (5 points) What is the angular velocity of the robot once it has raised it’s arms? Give your answer in both s⁻¹ and rpm.

(g) (5 points) What is the magnitude of the linear velocity of one of the rockets once the robot has raised it’s arms?
Question 3. (35 points)

A hinged arm is held on one end by a fixed post, and on the other end by a rope which is run over a pulley of mass 2kg and radius 15cm and then tied to a weight of mass $m$. A second identical weight of mass $m$ is tied to the bottom of the first weight. The system is in equilibrium. The length of the piece of the arm that is free to rotate is 50cm long and weighs 8kg. It can be considered to be a uniform rod. The tensions in the ropes $T_1$ and $T_2$ are labelled on the diagram.

(a) (5 points) What is the mass of each weight, $m$?

(b) (5 points) What is the vertical component of the force exerted on the freely rotating arm segment by the hinge? If appropriate, specify a direction.

(c) (5 points) What is the horizontal component of the force exerted on the freely rotating arm segment by the hinge? If appropriate, specify a direction.

(d) (5 points) What is the moment of inertia for rotation of the freely rotating arm segment around the hinge?

(e) (10 points) The rope is now cut at the position of the dotted line, so that the bottom mass now falls to the ground. When the rope is cut, what is the initial acceleration of the weight that is still attached to the arm? Give magnitude and direction.

(f) (5 points) What are the values of the tensions $T_1$ and $T_2$ just after the rope has been cut.