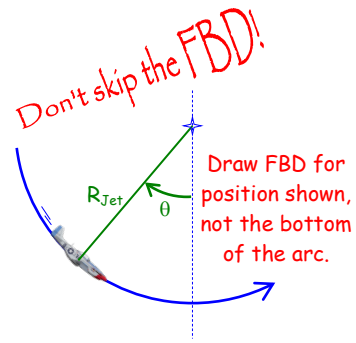
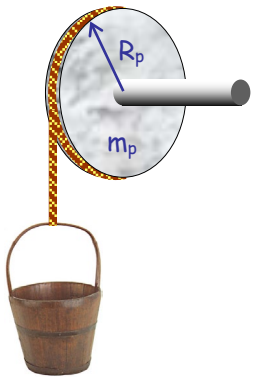
Homework Set 5: Rotational Dynamics
Due Friday, September 18, 2024



1) A jet fighter pilot knows he is able to withstand a force of $9m_{pilot}g$ before blacking out. The pilot points his plane vertically down while traveling at Mach 3 speed and intends to pull up in a circular maneuver before crashing into the ground (WHAT FORCE CAN ONLY BE 9mg? Use v_{sound} = 343 m/s, TM5 use 330 m/s).

a) Where does the pilot sense the maximum acceleration occur in maneuver?

b) What is the minimum circle the pilot can take? Answer: R_{min} = 13.5 km



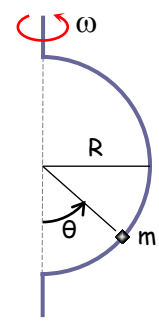
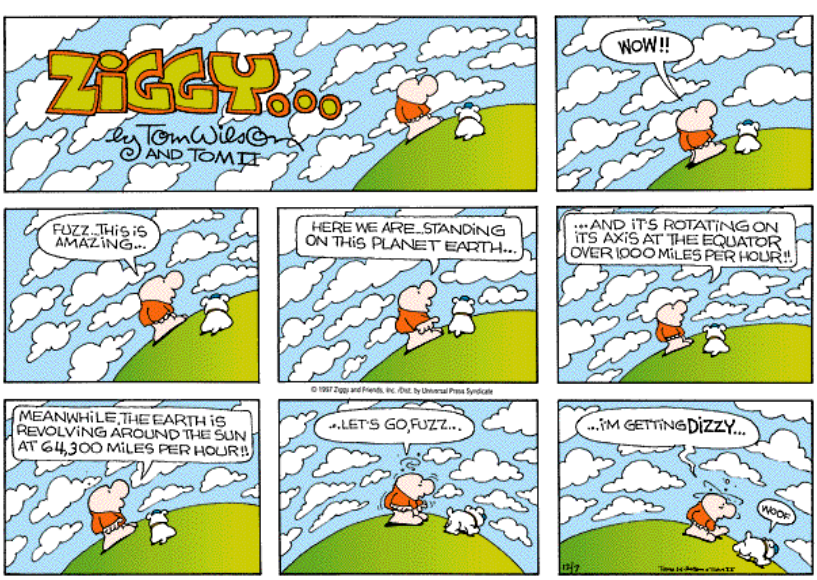
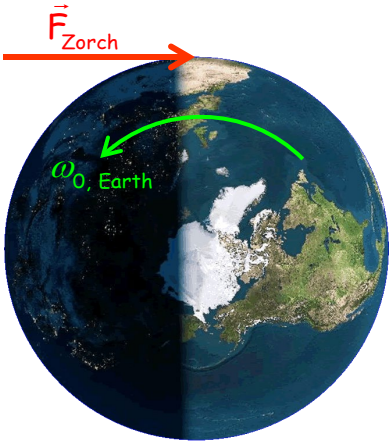
2) A cylindrical pulley of mass m_P with a radius of R_P is used to lower a bucket of mass m_B into a well. The bucket starts from rest.

a) Using Newton's second law in both linear and rotational forms, the relations between the rotational and linear physical quantities, and the equations of rotational kinematics,show that the linear acceleration of the falling bucket is given by

$$a_B = g\left(\frac{m_B}{m_B + \frac{1}{2}m_P}\right)$$

b) If the bucket has a mass of 3 kg, the pulley has a mass of 5 kg, and falls for 4 seconds, show that it falls 42.8 m and find the rotational acceleration of the pulley, α, in rad/s^2 for R_P = 0.6m Answer: α = 8.9 rad/s

3) A small bead with a mass of 100 g slides along a semicircular wire with a radius of 10 cm that rotates about a vertical axis at a rate of 2 revolutions per second. Find the values of θ for which the bead will remain stationary relative to the rotating wire. (WHAT CIRCLE DOES THE BEAD TRAVEL AROUND?) Answer: θ = 51.6°



4) Zorch, an archenemy of Superman, decides to slow the Earth's rotation to once per 28 h by exerting an opposing force at the equator and parallel to it. Superman is not immediately concerned, because he knows Zorch can only exert a force of 4 x 10^7 N (a little greater than a Saturn V rocket's thrust). How long must Zorch push with this force to accomplish his goal? (This gives Superman time to devote to other villains!) Answer: t = 126 Gyr