Final Exam Review in Class for Calculus-Based Physics

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1 Review Questions

1.1 Kinematics and Angular Kinematics

1. A marathon runner runs at a steady 15 km/hr. When the runner is 7.5 km from the finish, a bird begins flying from the runner to the finish at 30 km/hr. When the bird reaches the finish line, it turns around and flies back to the runner, and then turns around again, repeating the back-and-forth trips until the runner reaches the finish line. How many kilometers does the bird travel?
2. You are standing at the top of a building that is 100 meters tall. If you drop a marble from the top, when will it land, and how fast will it be going? If you throw the marble directly upwards, how fast will it be going, and how does this compare to the original speed?
3. We are in an elevator that is moving upwards at constant speed. We accidentally drop our keys, and they land at the same height they had when we dropped them. Draw an accurate graph of the keys' height above the ground (not just the elevator floor) versus time.

1.2 Forces and Torque

1. If there is a cup attached to a spring with $k = 5$ N/m waiting for the marble from the previous question, and the marble weighs 5 grams, by how much is the spring compressed?
2. A 1000 kg car travels at 90 km/hr. What force is required to bring it to a stop in 100 meters?
3. How much torque, in Newton meters, is required to wrench loose a lug nut from a tire, if we require a wrench that is 10 cm long, and we have to put our whole weight into turning it (≈ 50 kg)?

1.3 Work and Energy

1. How much energy is required to lift a 5000 kg mill van from a ship (75 meters above sea level) to the dock (5 meters above sea leve). Is the work done by the crane that lifs the mill vane positive or negative? Is the work done by gravity on the mill van positive or negative?
2. A bow is like a spring, with $k = 10$ N/m. If we draw an arrow (20 grams of mass) back at a 45 degree angle, where will the shot land?

1.4 Momentum, Angular Momentum and Collisions

1. Two objects of equal mass 0.1 kg are moving in the *same direction*, one with 10 m/s and the other with 8 m/s. If they interact elastically, what are the final velocities?
2. A stationary ring with moment of inertia $I = MR^2$, and $M = 0.1$ kg, and $R = 0.1$ m experiences a torque of 10 N m. How long before the ring reaches an angular speed of 10 radians per second?