Final Exam for Calculus-Based Physics-1: Mechanics (PHYS150-01)

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1 Conceptual Questions

1.1 Kinematics and Angular Kinematics

1. If an object is dropped, it accelerates downward at g m/s^2 (no air resistance). If it is *thrown* downward, the acceleration downward
   - is less than g
   - is more than g
   - remains g
2. An object accelerates with constant acceleration. The displacement versus time curve is quadratic. The velocity versus time plot should be ______ and the acceleration versus time plot should be ______.
   - quadratic, linear
   - linear, flat
   - flat, linear
   - linear, quadratic
3. An object experiences constant *angular* acceleration. The angular velocity is a ______ function of time, and the net external torque is ______.
   - linear, constant
   - linear, zero
   - quadratic, constant
   - quadratic, zero
4. A battleship fires simultaneously two shells at enemy ships (Fig. 1). If the shells follow the parabolic trajectories shown, which ship gets hit first?
   - A
   - Both at the same time
   - B

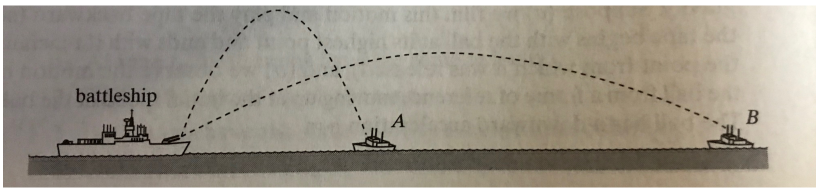

Figure 1: Which ship is hit first?

1.2 Forces and Torque

1. An elevator contains a person standing on a scale. The elevator accelerates upward, then moves at constant velocity, then decelerates to a stop. The scale reads a weight that is ______, then ______, and then ______ the person's actual weight.
   - More than, equal to, less than
   - Less than, equal to, more than

- equal to, equal to, equal to
- More than, equal to, equal to

2. A crate is pushed across a floor at constant velocity against friction. If the crate is flipped so that a side with less surface area is on the bottom, and pushed again at constant velocity, the required force is
   - More than the first side
   - Less than the first side
   - Equal to the first side
3. A man needs to pull a rusty lever to release a mechanism, but he can't. Which of the following will increase torque on the lever?
   - Tying a rope to the end of the lever, and pulling on the rope perpendicular to the lever.
   - Bolting a metal rod to the lever, and pulling the rod perpendicular to the lever.
   - Tying a rope to the end of the lever, pulling the rope parallel to the lever.
   - Bolting a metal rod to the lever, and pulling the rod parallel to the lever.
4. A racecar makes a turn at constant velocity, and the road is flat. There is friction between the road and tires. Which of the following is true?
   - The car experiences centripetal acceleration, provided by friction.
   - The car experiences centripetal acceleration, provided by the normal force.
   - Moving at constant velocity, the car experiences no acceleration.

1.3 Work and Energy

1. In which of the follow situations would energy *not* be conserved?
   - An object is dropped from some height and experiences free-fall, neglecting air-resistance.
   - An external force compresses a mass against an oscillator for a given displacement and then the mass is released.
   - A pendelum is pulled away from equilibrium and then released.
   - A rock slowly skids to a stop on top of a frozen pond.
2. A ball rolls down a hill that has a height h, attaining a speed v at the bottom. In order to attain a speed of $2v$ at the bottom, how tall would the hill have to be?
   - $2h$
   - $3h$
   - $4h$

1.4 Linear and Angular Momentum

1. A star undergoes a supernova, in which significant matter is blown away by a fusion reaction. The remaining also shrinks in size. Suppose the radius decreases by a factor of 10^3. By what factor does the angular velocity increase, if angular momentum is conserved? (Assume the mass doesn't change significantly).
   - 10^4
   - 10^5
   - 10^6
2. A mine cart is moving along a track at constant speed, and passes under a vertical waterfall. Because the cart is filled with water, the speed of the cart
   - increases
   - decreases
   - remains constant (no net forces)
3. If ball 1 in the arrangement shown in Fig. 2 is pulled back and then let go, ball 5 bounces forward. If balls 1 and 2 are pulled back and released, balls 4 and 5 bounce forward, and so on. The number of balls bouncing on each side is equal because
   - of conservation of momentum.
   - the collisions are elastic.
   - the collisions are inelastic.
   - neither of the above.

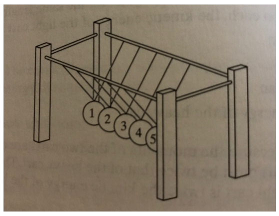

Figure 2: This object is known as a Newton's cradle.

2 Technical Questions

2.1 Kinematics and Angular Kinematics

1. A ball is kicked with an initial velocity of $\vec{v} = 4\hat{i} + 3\hat{j}$ m/s. (a) For how long does the ball remain in the air? (b) Where does the ball land? ($g = 10$ m/s^2).

2.2 Forces and Torque

1. A 900 kg lunar probe hovers above the surface of the Moon. On the Moon, $g \approx 5/3$ m/s^2. An engine is pointed at a 45 degree angle from straight down, spraying propellant. What force does the engine produce to keep the probe from decreasing in height?

2.3 Work and Energy

1. A snowboarder descends a hill with a height of 50 meters (neglect friction). (a) What is her final speed? (b) After descending, she travels along a flat stretch of snow. She turns the board sideways, the coefficient of friction becomes relevant: $\mu = 0.8$. How far does she travel before stopping?

2.4 Linear and Angular Momentum

1. Two objects each of mass $m = 0.1$ kg rotate around the origin of a coordinate system, both at radius $r = 0.1$ m. If the tangential velocity of each is $v = 1$ m/s ($p = mv$), (a) what is $L = L_1 + L_2 = r_1 p_1 \sin\theta_1 + r_2 p_2 \sin\theta_2$, the total angular momentum? (b) What are the values of the *moment of inertia*, $I = mr^2$, and the *angular speed* $\omega = v/r$? (c) Show numerically that $I\omega = rp$.