Final Exam for Algebra-Based Physics-1: Mechanics (PHYS135A-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

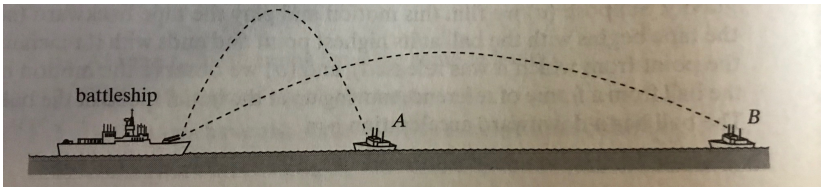

Figure 1: Which ship is hit first?

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 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)
2. 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.
3. 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

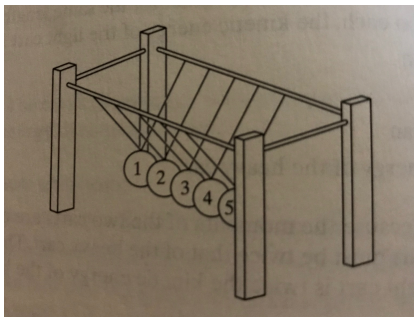

Figure 2: This object is known as a Newton's cradle.

2 Technical Questions

2.1 Kinematics and Angular Kinematics

1. A ball is kicked with an initial velocity of $\vec{v} = 10\hat{i} + 10\hat{j}$ m/s. (a) For how long does the ball remain in the air? (b) What is the velocity vector when the ball lands?

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 straight down, spraying propellant. (a) What force does the engine produce to keep the probe from decreasing in height? (b) If the probe tilts by 45 degrees, by what factor must the force increase to keep the probe from decreasing in height?

2.3 Work and Energy

1. A snowboarder descends a hill with a height of 100 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: $\mu = 0.5$. How far does she travel before stopping?

2.4 Linear and Angular Momentum

1. An object of mass $m = 0.1$ kg rotates around the origin of a coordinate system at radius $r = 0.1$ m. If the tangential velocity is $v = 1$ m/s ($p = mv$), (a) what is $L = rp\sin\theta$, the angular momentum? (b) What are the values of the *moment of inertia*, $I = mr^2$, and the *angular speed* $\omega = v/r$? (c) Show that $I\omega = rp$, either numerically or using algebra.