1)(5) If the sum of forces and the sum of torques on an object are both zero, the object:
   A) cannot be translating.  
   B) cannot be translating and cannot be rotating. 
   C) cannot be rotating.  
   D) can be moving at constant velocity.

2)(5) A man jumps off of a rotating platform (for example, a merry-go-round). The angular momentum of the man-platform system is approximately the same just before and just after the jump because:
   A) the moment arm of the reaction force of the axle is very small.  
   B) the man has zero linear momentum. 
   C) the platform has zero linear momentum.  
   D) no external force acts on the system when the man jumps.

3)(5) A object is attached to a spring and undergoing simple harmonic motion with frequency \( f \). If the object is initially located where its potential energy is a minimum and is moving in the negative \( x \) direction, it will achieve its maximum speed after a time \( t \) equal to
   A) \( 2f/3 \)  
   B) \( 1/(2f) \)  
   C) \( 3/(4f) \)  
   D) \( 1/(4f) \)

4-5)(10) Our Sun rotates every 10 days. One could place 100 Earths across the current diameter of the Sun. At the end of its life (in about 5 billion years), it will shrink to approximately the size of Earth and become a white-dwarf star. Assuming that the sun will not lose appreciable mass or interact with anything at the end of its life, what will be our star’s period of rotation when it becomes a white dwarf (in days)?
   A) 1000  
   B) \( 10^{-1} \)  
   C) \( 10^{-3} \)  
   D) \( 10^{-4} \)

6)(5) You have three and only three apples. How many apples do you have?
   A) five  
   B) four  
   C) three  
   D) I don’t know
7. A uniform solid ball of mass $M$ and radius $R$, released from rest, rolls without slipping down a circular ramp of radius $4R$, as shown. The center of the ball is level with the center of curvature of the ramp when it is released. A constant horizontal blowing force of magnitude $B$ aimed to the right acts on the ball throughout its motion.

a)(5) Complete the diagram at the right with information required to answer part b) below.

b)(45) **OSE:** What is the speed of the ball when it reaches the level surface?
8. A motorized winch is used to pull a block of mass $M$ up a frictionless ramp that makes an angle $\theta$ with the horizontal, as shown in the figure. A rope is wound on the winch, which maintains a constant pulling force on the rope of magnitude $2Mg$. A uniform cylindrical pulley of radius $R$ and mass $2M$ is used to change the direction of the rope down to the block. The pulley’s axle is frictionless and the rope does not slip on the pulley’s surface.

a)(10) Complete the diagram at the right with the information necessary to do task b) below.

b)(40) OSE: Use torque-force methods to derive an expression for the acceleration of the block in terms of relevant system parameters.
9. One end of a uniform rod of length $4L$ is attached perpendicularly to the midpoint of one edge of a uniform square of side-length $2L$, as shown. The rod and the square have the same mass. The other end of the rod is on a frictionless pivot $P$.

a)(40) **OSE:** Derive an expression for the period $T$ for small oscillations of this system about the pivot $P$, in terms of relevant system parameters.

b)(10) **OSE:** Assume that the angle $\Phi$ is the maximum angle that the rod makes with the vertical during its swings. Using the period $T$ now as a system parameter, what is the maximum angular speed of the rod, in terms of relevant system parameters. [Remember, the period $T$ is now a system parameter.]