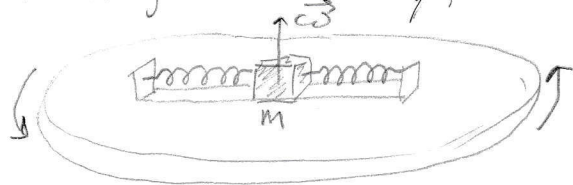


Problem Set #6

Q1 [10 marks]

A block of mass M is attached to 2 springs of spring constant k and allowed to slide without friction along a rigid rod (see figure). The entire system sits on a turntable that is allowed to rotate with a constant angular velocity, $\vec{\omega}$. Assume the mass is oscillating.



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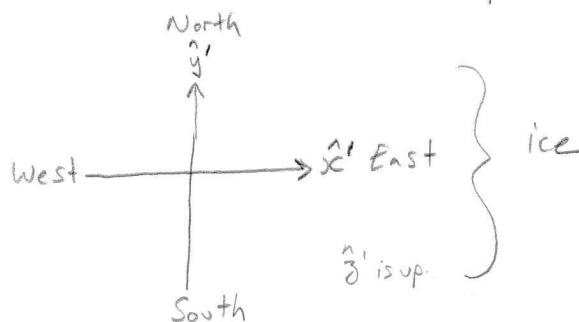
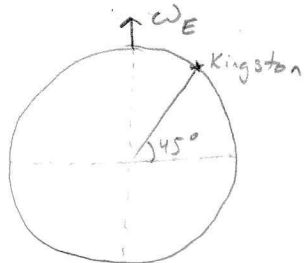
Consider the rotating frame only. Assume mass is displaced from equilibrium and set into simple harmonic motion.

- Show and define your coordinate system in the rotating frame. Hint, set up your coordinate system with the rod along one axis.
- Which fictitious forces act on M in the rotating frame? Justify your answer. Note, you do not need to give equations for these forces here.
- Give the equations for the fictitious forces in terms of the parameters given and a small displacement from equilibrium. Be sure to include the vector directions.
- If the force acting on the mass in the inertial frame is $\vec{F}_I$, use your equation for acceleration in the rotating frame to solve for $\vec{F}_I$. Hint, $\vec{F}_I$ will have two components, so you want to solve each one separately.
- What is the differential equation of motion for the system and what is the period of oscillations?
- At what angular velocity for the turntable will the block stop oscillating? What happens to the block?

Question 2 [10 marks]

One winter, Lake Ontario freezes into a giant sheet of ice. A group of hockey players decide to play a game on this giant rink. One player hits the puck down the ice at a speed of $\vec{v}'$. For this problem, consider the Coriolis force from the Earth's rotation. Assume no friction acts on the puck. The latitude of Kingston can be considered $\theta = 45^\circ$.

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Use the above figures to define your coordinate system.

- 2a) What is the angular velocity $\vec{\omega}_E$ in the non-inertial frame? Show how you get the components along $\hat{x}$, $\hat{y}$, and $\hat{z}$. Express your answer in $\omega_E = |\vec{\omega}_E|$ and θ .
- 2b) Assume the ice is entirely in the $\hat{x}$ & $\hat{y}$ plane and the puck's velocity is on the surface. What is the Coriolis force acting on the puck? Set $\vec{v}' = v'_x \hat{x}' + v'_y \hat{y}'$.
- 2c) Show that the magnitude of the horizontal component of the Coriolis force does not depend on the direction the puck is shot. Hint: The horizontal component acts in the plane of the ice.
- 2d) Compare the directions of deflection from the horizontal component of the Coriolis if the puck is shot straight East versus straight North.
- 2e) Show that the horizontal component of the Coriolis force is always perpendicular to the direction of motion.
- 2f) A player shoots the puck south to a hockey net that is 100 m away. If the puck's speed is $v' = 30$ m/s, what is the horizontal deflection? Comment on your answer. Hint: the acceleration magnitude will be small, so you can approximate the travel time.
- You can assume that $|\vec{\omega}_E| = 7.27 \times 10^{-5}$ rad s $^{-1}$ for 2f.