1. Consider two hunters, one in Escanaba, MI (north latitude ≈ 46°), another near Alice Springs, Australia (south latitude ≈ 25°). Both hunters fire a bullet horizontally due south relative to their respective locations.

Taking into account the rotation of the Earth, will each bullet land at a point *due south* from where it was fired, *west of due south,* or *east of due south?* For each case, explain your reasoning in words and diagrams.

2. A turntable spins clockwise at a constant rate. Relative to a reference frame that remains fixed to the turntable, a bug walks in a radial direction at a constant speed. It is *not* known, however, whether the bug is walking directly *toward* or *away from* the center of the turntable.

Shown at right is the start of a free-body diagram for the bug, drawn in the *turntable frame.* (Note that the force already shown is not yet labeled.)



A. Complete the free-body diagram by including and labeling all horizontal forces, both real and “fictitious.” (*Hint:*  Do not assume that the turntable is frictionless.)

B. Is the bug walking directly *toward* the center of the turntable, directly *away from* it, or could the bug be walking *in either direction?* Explain how you can tell.

C. At the instant shown above, the bug is a distance *D* from the center of the turntable and walks with speed *V* relative to the turntable. In terms of *D, V,* the mass *m* of the bug, and the angular velocity ** of the turntable, determine the **magnitude** of the friction force exerted on the bug at the instant shown. Clearly show all work.

3. An ant, a bee, a cricket, and a dung beetle are on a rotating turntable. *In the frame of the turntable,* each insect walks with the same constant speed toward the center of the turntable. However, the directions of the angular velocity and angular acceleration (if any) of the turntable are *unknown.*

A correct free-body diagram for one of the four insects—drawn in the turntable frame—is shown below.



A. Determine the insect to which the free-body diagram corresponds. Explain how you can tell.

B. Determine the direction of the *angular velocity* of the turntable. Explain how you can tell.

C. Determine whether the turntable is spinning with *increasing, decreasing,* or *constant* angular speed.   
Explain how you can tell.

D. For the insect you identified in part A above, draw a vector representing the (linear) velocity of that insect with respect to the *lab frame.* (Make your vector qualitatively correct; do not worry about exact direction or magnitude.) Explain your reasoning.



4. The rotation of the Earth causes an object that is dropped from rest high above the Earth’s surface to land at a point slightly *east* of its release point. In light of this result, consider the following statement:

“In order for the ball to hit the ground directly beneath the release point, we just need to give the ball just the right amount of initial velocity to the west. That way, the eastward deflection would be exactly canceled out, and the ball would hit the ground directly beneath where it was dropped.”

Do you *agree* or *disagree* with the above statement? If you disagree, how would the resultant motion of the ball (as observed in the frame of the Earth) be different from what is asserted in the statement? Explain. Include one or more diagrams in your explanation.

5. (*Note: This problem may also serve as a post-test for* Accelerating reference frames: The Foucault pendulum.)  
  
The diagrams below show a coordinate system fixed to the surface of the Earth at a northern latitude *.*



A particle at this latitude ** moves with *horizontal* velocity *.*

Show that the *horizontal component* of the Coriolis “force” has a magnitude that is *independent* of the value *.* Clearly show all work.