**Answers for Homework 9**

**By SJ**

1. KK 8.1

Answer: (a) Acceleration A generates a fictitious force that is equivalently act at the C.M. of rod. By including the Ffic=-mA, it is just like inertial. Pick pivot as origin:





 i.e. 

(b) It is not going to be an equilibrium, since if the rod is away from, say becomes smaller, mg torque will dominate, pulling the rod further down.

The motion can be solved using

, 









, 

No oscillation.

1. KK8.2

Answer: (a) 

MA

θ

You can solve for  by



It is more easy to use work-energy theorem. The work done from  is:









(b) Trent motion of C.M. to get FHorizontal.





1. KK8.5

Answer: Using the Gyro Approximation so that the total angular momentum of the Gyro 

Neglect gravity (the gyro could be placed on the top of frictionless table), take P as origin  (pointing down).

Ls will go down for this torque 







1. KK8.9

Answer: Only  contribute to horizontal force, and  contribute to vertical force. Fc will point to west direction. For v along South,







1. KK8.11

Answer:

Here I shall first work with approximation in the earth frame in which the hydrofoil is moving. But I shall assume the motion is in a plane(neglecting the earth curvature), in this case the calculation is easier:

1. Approximate method:

The earth bound gravity is g (this is already the apparent gravity which includes the centrifugal part).

At equator, if travel North or South,, so that coriolis-force is zero. So for (c) and (d), .

For (a), travel east,  is pointing up. So the apparent gravity would be less:



(b) west, c-force points down, .

(2) More accurate method

Essentially I assume the hydrofoil is moving with the speed not too large so that the curvature of the earth is neglected, of course this is best an approximation and I did not justify the approximation, since who knows the 200mile/hour may be fast. So I should show you the accurate method:

Now I shall choose the hydrofoil as my frame, i.e. I am a person in it and weighting my weight. The frame this way is more complicated than the earth frame. The hydrofoil is rotating around earth with angular velocity (HE means hydrofoil to earth):

The coordinate is chosen so that east is +x, north is +y and up is positive z. We are looking for force along z direction (weight). The motion of hydrofoil along North, South, East and West, the angular velocities in these 4 cases are:

North: , direction is along west (-x)

South: 

East: 

West: 

The total angular velocity of the hydrofoil with respect to inertial frame have to take the spin of earth into consideration too (the above is only the motion relative to earth):





at equator

Since is in x-y plane, perpendicular to z, then:





This is comparing the difference to the true gravity (g0). However what we want to compare is with the effective gravity on the ground which is the weight you measure on the ground, so the above need to be modified as:



Throw in all above to calculate centrifugal (which can be a beast)

North: , 



South would be exactly same.

For the low velocity case as in our approximation before, basically  is very small, this can be neglected, of course when v is big, this term cannot be neglected (you certainly feel weightless if the hydrofoil moves so fast that becoming a satellite)

East: 



The first term is the Coriolis force in the approximation and the second is due to extra centrifugal due to the motion of the hydrofoil.

West case would be similar with 

This rigorous calculation justifies my initial approximation.

With the known, the effective gravity can be computed from centrifugal force(there will be no Coriolis force here since there is no motion in our hydrofoil frame)

1. KK8.12

Answer: Here we consider a simple case when the  is not big so that the lowest point is still the stable equilibrium point. The problem is not very clear on this, it just states amplitude small so I interpret it as small angular velocity. (If the , the lowest point will not be the equilibrium point, I hope most of you can prove this.)

This problem could be solved in two ways.

1. The method discussed in Chap7. Considering  (L comes from 2 angular velocity,  and rotation around points AB).





Ω

,,

x

y



θ





small θ, , .

1. The method by taking rotating coordinate of this chap, in such frame, besides gravity, there will be forces from centrifugal and Coriolis force.

Coriolis force will be perpendicular to the paper (pointing either into or out of paper depends on travel direction). But this Coriolis force will be balanced by the force at pivots since the bob is restricted to the motion in plane perpendicular to the pivots axis. So only need to consider the gravity and centrifugal force.

The torques are: 



 ,

，.

1. Answer: The tidal force due to Sun, 

The tidal force due to Moon, 









1. Answer: The velocity along the land is 

If no spin of earth, .

Consider the spin of earth.

Initially, ac toward the west 







So the cannon ball will miss the target but to the west of it (not the east as stated in the problem)

1. Answer: There are actually many ways to tell whether the frame is inertial or not. A marble stone on ice initially hold still, after release it is going to slide with centrifugal force; a pendulum will behave as Foucault pendulum; you push the marble travel in straight line but it will bend with Coriolis force; A bucket water hold still but the water surface will not be a plane but curved as Newton’s example (also in KK book example calculating the curve of the water)…… (I cannot list all)

The easiest way to find the center of rotation may be using centrifugal force because it points away from the center. Release the marble and observe its initial velocity due to centrifugal force (when the velocity small, the Coriolis effect can be neglected at beginning), this velocity will be pointing away from center. And you repeat such experiment at another location and find velocity direction. The two velocities’ interception point should be the center of rotation.

As to the measurement of rotation speed of the non-inertial, you may use Foucault pendulum. Or the gyro compass we had in chapter 7 (as in the KK’s 8.12)…