

PHYSICS 105 FIRST MIDTERM EXAM

October 26, 2006

This exam consists of **four** problems. When we begin, check to see that this copy of the exam has all four. Use the same exam booklet for all problems, continuing to another booklet if necessary. **Print** your name on **each** booklet as you start it. On the cover of your first booklet, **COPY** and **SIGN** the following pledge:

I pledge my honor that I have not violated the Honor Code during this examination.

At the end of the exam, indicate clearly on the cover of your first exam booklet how many booklets you used.

Some useful test-taking hints:

- You may not be able to complete every problem. Keep moving – do what you know first.
- Make it clear what your answer is by circling it.
- Use symbols rather than numbers wherever possible and check units.
- Whenever possible, check whether an answer or intermediate result makes sense before moving on.
- If you get stuck on an early part of a problem, check the later parts — some may be independent and doable.
- If you get stuck on an early part of a problem, and a later part depends on it, **clearly** define a symbol for the unknown answer and use it in later parts. However, keep in mind that we often give multiple parts to guide you through a problem.

- **To get full credit you need to show your work!**

The exam will last 1.5 hours: 7:30-9:00 PM

Good luck!

Problem 1. [10 points] When an airplane is driven forward by its engines, the air flowing over its wings generates an upward force called *lift*. When this lift balances the weight of the plane, it can fly horizontally. A plane *banks*, that is, tilts its wings to the side, to turn, thus using the lift force another way. Note that it must then increase speed to generate more lift if it wants to stay at the same altitude while turning.

A jet airliner remains at constant altitude at a constant speed of v_0 while banking at θ_b with respect to the horizon to turn in a circle. What is the radius of the circle?

Problem 2. [10 points] A spacecraft wants to hover in fixed position near the surface of the moon ($g_m \approx g/6$). The spacecraft has mass M_0 , including fuel. The engine expels its exhaust fuel with a speed u with respect to the spacecraft.

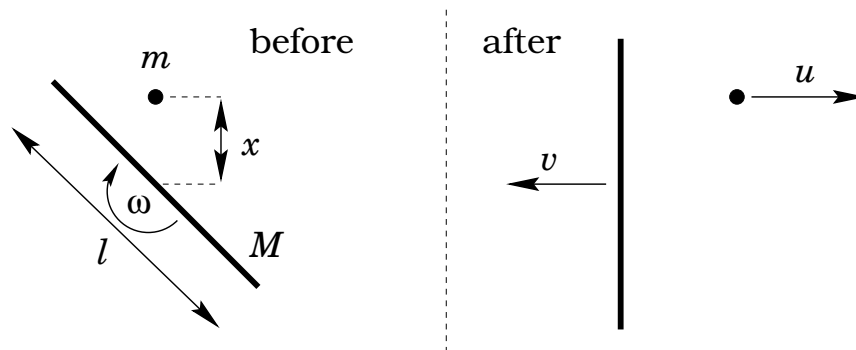
- As it begins to hover, what is the initial rate $-dM/dt$ at which the spacecraft must expel exhaust fuel in order to maintain its altitude?
- If $1/3$ of the mass M_0 is fuel, how long can it hover?

Problem 3. [15 points] A long thin rod of length ℓ and mass M (and $I_{center} = \frac{1}{12}M\ell^2$) is rotating clockwise on a frictionless horizontal table with angular velocity ω about its center of mass, **which is stationary**. A small ball of mass m is placed on the table a distance x from the center of mass of the rod.

The rod collides **elastically** with the ball. After the collision, the rod is translating to the left with speed v **without rotating**, and the ball moves to the right with speed u .

Give your answers in terms of ℓ , M , m , and ω .

- What is the initial kinetic energy K of the spinning rod?
- What are v and u ?
- What is the distance x .



Problem 4. [15 points] A thin rod of length ℓ and mass m is suspended horizontally by two vertical strings, A & B, one attached at each end of the rod. The density of the rod is given by $\rho(x) = \rho_0(x/\ell)^3$ where $x = 0$ corresponds to the position of string A. Give your answers in terms of m , ℓ , and g .

a) Where is the center of mass, x_{cm} ?

b) What is the tension in string B?

At some time, string B breaks.

c) What is the angular acceleration of the center of mass of the rod about $x = 0$ immediately after the string breaks?

d) What is the tension in string A immediately after the first string breaks?