

Physics 106a: Classical Mechanics  
Homework 1: Newton's Laws

**Due: Thursday, 5 October 1999**

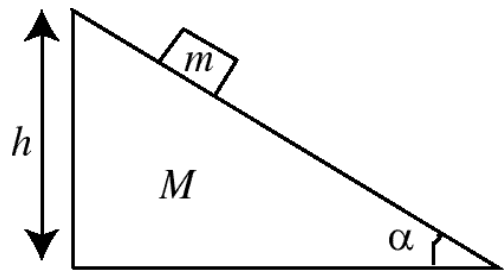
Remember: Late homework (turned in after 5:00 p.m.) will be graded for 50% credit UNLESS PRIOR ARRANGEMENT IS MADE WITH ME OR WITH A TA.

Reading: Review your favorite treatment of Newton's laws

1. According to a New York Times editorial on Jan 13 1920 discussing the feasibility of space flight, "It is when one considers the multiple-charge rocket as a traveler to the moon that one begins to doubt...for after the rocket quits our air and really starts on its longer journey, its flight would be neither accelerated nor maintained by the explosion of the charges it has left...That Professor Goddard, with his "chair" in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action to reaction, and of the need to have something better than a vacuum against which to react – to say which would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools.

Explain in no more than two paragraphs, using language that a journalist can understand, why Professor Goddard has turned out to be right.

2. A block of mass  $m$  slides on a frictionless inclined plane of mass  $M$ . The plane has height  $h$ , makes an angle  $\alpha$  with the horizontal (see sketch), and rests on a flat, frictionless surface. The small block can slide down the plane, and the plane can slide along the surface. If the small block starts at the top of the plane, how long will it take to reach the bottom? (You will no doubt notice the solution to this problem in your textbook. Attempt to solve it yourself using Newton's laws – refer to the solution if you get stuck).



3. Prove that a bead that is placed anywhere on a vertical frictionless wire in the form of a cycloid satisfying

$$x = h(\theta + \sin\theta), \quad z = h(1 - \cos\theta); \quad -\pi < \theta < \pi$$

(where  $x$  is a coordinate advancing in the horizontal direction and  $z$  advances in the vertical direction), will reach the bottom in the same time regardless of the starting point and find this time.

4. a) A spherical satellite of mass  $m$ , radius  $a$ , moves with speed  $v$  through a tenuous atmosphere of density  $\rho$ . Find the frictional force on it, assuming that the speed of the air molecules can be neglected in comparison with  $v$ , and that each molecule which is struck becomes embedded in the skin of the satellite. Do you think these assumptions are valid? b) If the orbit is a circle 400 km above the earth (radius 6360 km), where  $\rho = 10^{-11} \text{ kg/m}^3$ , and if  $a = 1\text{m}$ ,  $m = 100 \text{ kg}$ , find the change in altitude and the change in period of revolution in one week.

**OVER**

Extra Credit: Isaac Newton demonstrated (rather unsatisfactorily) that if the Earth behaved as a fluid and had constant density, then its equatorial radius would exceed its polar radius by about 28 km. Working from first principles, not textbooks, can you do the same?