PRINCETON UNIVERSITY PHYSICS COMPETITION

Onsite Test 2014 Directions: Short Version

The test consists of **two** questions which you will be given **40** minutes to complete. Calculators are allowed. **No collaboration** is allowed and partial credit will be given for incomplete solutions.

Some useful test-taking hints:

1. You may not be able to complete every problem. Keep moving; do what you know first.
2. Make your answer clear by circling it.
3. Use symbols rather than numbers wherever possible and check units.
4. When possible, check whether an answer or intermediate result makes sense before moving on.
5. If you get stuck on an early part of a problem, check the later parts – some may be independent and doable.
6. 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! Partial credit will also be awarded at the judges' discretion. The total number of points one can receive on the Onsite Test (regular version) is 100. Each question will be weighed equally and is worth 30 points, but it does *not* necessarily mean that the problems are of comparable level of difficulty. Everyone starts with 10 free points.

PUMaC Finalists will be given more bonus points as compensation for ineligibility for medals due to the shorter part. You *will* be eligible for customized Diplomas if you do well on these two problems.

Good luck!

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Jane Street

USG Undergraduate Student Government

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Question 1. **Disk in a gas.**

Imagine a disk of radius r moving with constant velocity v (perpendicular to the plane of the disk) in a certain contained volume of gas of density n that is in thermal equilibrium at temperature T. What is the drag force on the disk? *The answer does not have to be rigorous.* Assume that:

a. the gas molecules collide with the disk elastically,

b. the speed of the disk is slow compared with the average molecular speed, and

c. the disk is large compared to a molecule but small compared to the molecules' mean free path.

Hint: Finding the leading term in the force to within a numerical factor is sufficient.

Question 2. **Minimum energies.**

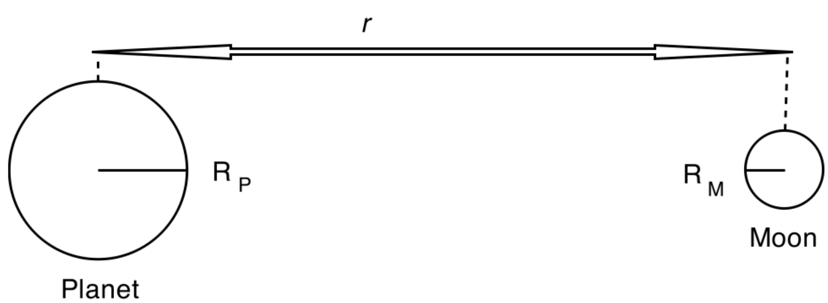

Figure 1: A planetary system - see question 2

If we colonize other planets we will want to move easily between planets and their moons. Assume that you have a planet of mass M_P and at a distance r there is a moon of mass M_M, and you want to send a package of mass δ, from the planet to the moon. Assume that both the planet and the moon have their mass perfectly spherically distributed and that the radius of the planet is R_P and that of the moon is R_M. What is the minimum energy required so that you can transport the package between the planet and the moon?

Ignore any form of friction, any gravitational effects caused by any other body around the planet, and any corrections due to general relativity.