Midterm Exam 02 (2020 Fall)

PHYS 203A-002: College Physics

Department of Physics, Southern Illinois University–Carbondale

Date: 2020 Oct 1

Instructions

- There are 11 questions in this exam.
- To be considered for partial credit present your work in detail and organize it clearly.
- This is a timed exam, from 12:35 PM to 01:50 PM. This time includes the time required for downloading the exam and uploading the solutions.
- Submit a single PDF file on D2L. Note that D2L will not allow submissions few minutes after 01:50 PM.
- In case of technical issues contact me by email at the earliest. Accommodations will be made after fairness to other students is taken into consideration.
- This is an open book and open resource examination, and use of Internet is allowed. However, consultation is prohibited.

1 Conceptual questions

1. (**5 points.**) Compute the value for

$$\frac{GM}{R^2} \tag{1}$$

to two significant digits. Given Newton's gravitational constant $G = 6.7 \times 10^{-11}\,\text{Nm}^2/\text{kg}^2$, mass of earth $M = 6.0 \times 10^{24}\,\text{kg}$, and radius of earth $R = 6.4 \times 10^6\,\text{m}$. Also, deduce the units for the value you computed.

2. (**5 points.**) A mass of 75 kg (735 Newtons) is placed on a bathroom scale that is lying on an incline that makes an angle of 30° with respect to the horizontal. How much is the reading on the weighing scale expected to be (in Newtons)?

3. (**5 points.**) Consider a hollow planet of mass M whose mass is uniformly distributed on a spherical shell of radius R. A small mass is placed inside the hollow planet such that it is away from the center of the planet and closer to the shell. What is the magnitude and direction of the gravitational force on the small mass from the hollow plant.

4. (**5 points.**) The Atwood machine consists of two masses m_1 and m_2 connected by a massless, inextensible, string going over a frictionless, massless, pulley. Under these ideal circumstances both the masses have the same acceleration (in magnitude). Under what circumstances will the masses constituting the Atwood machine have different accelerations in magnitude? That is, which particular idealization leads to same accelerations.

2 Problems

5. (**10 points.**) The acceleration due to gravity g on Earth is $9.8\,\mathrm{m/s^2}$. Determine the acceleration due to gravity on a planet whose mass is one-fourth the mass of Earth and whose radius is half the radius of Earth.

6. (**10 points.**) Three particles have their positions on a straight line, far away from any other objects. See Fig. 1. The masses of these particles are $m_1 = 300\,\mathrm{kg}$, $m_2 = 500\,\mathrm{kg}$, and $m_3 = 200\,\mathrm{kg}$. The distances are $r_{12} = 50\,\mathrm{m}$ and $r_{23} = 25\,\mathrm{m}$. Find the magnitude and direction of the net gravitational force acting on mass m_3.

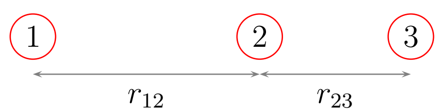

Figure 1: Problem 6

7. (**10 points.**) A $20\,\mathrm{kg}$ mass is hanging from the ceiling of an elevator. Determine the tension in the string that holds the mass to the ceiling when the elevator is speeding up at $2.0\,\mathrm{m/s^2}$ while moving upward?

8. (**10 points.**) A $10\,\mathrm{kg}$ mass is held stationary on a frictionless incline plane by exerting a horizontal force F on the mass. See Fig. 2. Determine the force F if the plane is inclined at 30° with respect to the horizontal.

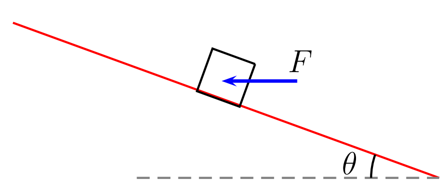

Figure 2: Problem 8.

9. (**10 points.**) A car is traveling at 30.0 m/s on a horizontal highway. It is brought to a stop by slamming on the brakes, which amounts to the tires skidding (without rolling) on the road. What is the stopping distance when the surface is dry? The coefficient of static friction μ_s between road and tires is 0.60 and the coefficient of kinetic friction μ_k between road and tires is 0.20?

10. (**10 points.**) A stuntman whose mass is 75 kg drives a car at a uniform speed of 30.0 m/s through the bottom of a valley, the cross section of which can be approximated by a circle of radius $R = 150$ m. What is the normal force acting on the stuntman while crossing the deepest part of the valley?

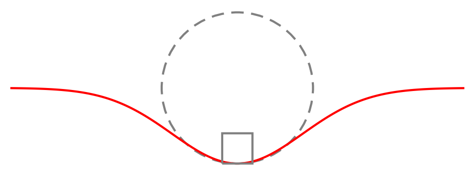

Figure 3: Problem 10

11. (**10 points.**) Determine the orbital time period (in hours) of a satellite orbiting Earth at a height of 310 km above the Earth's surface. Use values of gravitational constant, mass of Earth, and radius of Earth, given in Problem 1 to two significant digits.