Final Exam (2020 Fall)

PHYS 203A-002: College Physics

Department of Physics, Southern Illinois University–Carbondale

Date: 2020 Dec 10

Instructions

- There are 8 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 12:30 PM to 2:30 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 2:30 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.

Problems

1. (**10 points.**) Convert $4.3\,\mathrm{g/cm^3}$ into $\mathrm{kg/m^3}$.

2. (**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_2.

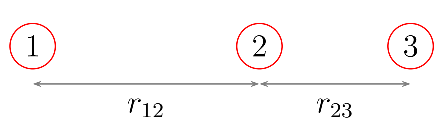

Figure 1: Problem 2

3. (**10 points.**) Acceleration due to gravity on the surface of Earth (assuming it to be a perfect sphere in shape) is given by

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

Given Newton's gravitational constant $G = 6.7 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$, mass of earth $M = 6.0 \times 10^{24}\,\mathrm{kg}$, and radius of earth $R = 6.4 \times 10^6\,\mathrm{m}$. Compute the value of the acceleration due on gravity (to two significant digits) in an aeroplane that is flying 3.000 km above the surface of Earth. That is, what is the change in the acceleration due to gravity due to the change in height.

4. (**10 points.**) A mass $m = 10.0\,\mathrm{kg}$ slides down a frictionless incline, starting from rest at point A at height $h = 1.0\,\mathrm{m}$. After sliding down the incline it moves horizontally on a frictionless surface before coming to rest by compressing a spring of spring constant $k = 2.0 \times 10^4\,\mathrm{N/m}$ by a length x. See Figure 2.

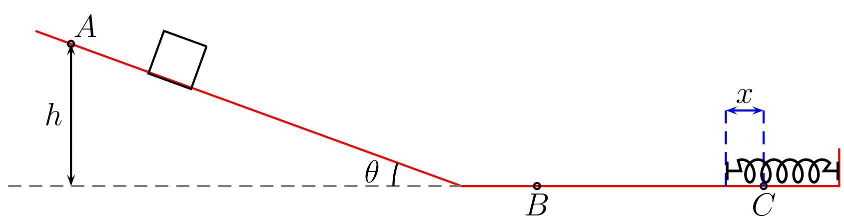

Figure 2: Problem 4.

   (a) Determine the change in kinetic energy of the mass between points B and C.

   (b) Determine the change in gravitational potential energy of the mass between points B and C.

   (c) Determine the change in potential energy stored in the spring while the mass moves between points B and C.

5. (**10 points.**) Two masses $m_1 = 1.0\,\mathrm{kg}$ and $m_2 = 2.0\,\mathrm{kg}$ are placed on a horizontal massless plank at distances x_1 and x_2 from the axis $\mathcal{O}$, as illustrated in Figure 3. Given that the plank is under rotational equilibrium determine the ratio x_1/x_2.

6. (**10 points.**) Five balls of masses $m_1 = m$, $m_2 = 2m$, $m_3 = 3m$, $m_4 = 4m$, and $m_0 = 5m$, are connected by massless rods of length a and b, as shown in Figure 4. This configuration is rotated about an axis coming out of the plane containing the five masses and passing through the mass m_0. The inertia associated with this rotational motion is quantified by the moment of inertia. Show that the moment of inertia for this configuration can be expressed in the form

$$I = \alpha\, ma^2 + \beta\, mb^2, \tag{2}$$

where α and β are numbers. Determine α and β.

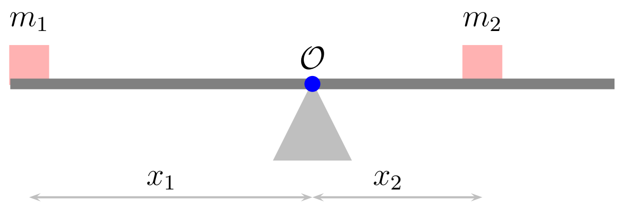

Figure 3: Problem 5.

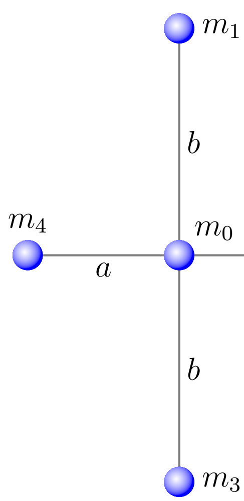

Figure 4: Problem 6.

7. (**10 points.**) A spring ($k = 1500\,\mathrm{N/m}$) is hanging from the ceiling of an elevator, and a $10.0\,\mathrm{kg}$ object is attached to the lower end of the spring. By how much does the spring stretch (relative to its unstrained length) when the elevator is slowing while moving downwards at $1.00\,\mathrm{m/s^2}$.

8. (**10 points.**) Astronauts on a distant planet set up a simple pendulum of length $1.0\,\mathrm{m}$. The pendulum executes simple harmonic motion. What is the time period of the pendulum on the distant planet if the acceleration due to gravity on the planet is 4 times larger than on Earth.