Midterm Exam No. 02 (2022 Spring)

PHYS 205A-001: UNIVERSITY PHYSICS

Department of Physics, Southern Illinois University–Carbondale

Date: 2022 Mar 4

(Name) (Signature)

Instructions

- Seating direction: Please be seated on seats with seat numbers divisible by 2.
- Total time = 50 minutes.
- There are 7 questions in this exam.
- Equation sheet is provided separately.
- To be considered for partial credit present your work in detail and organize it clearly.
- A simple calculator (with trigonometric functions) is allowed.
- Use of mobile phones is strictly prohibited. It should stay out of reach during the exam.

1. (**5 points.**) The gravitational force exerted by Earth, (mass $M = 6.0 \times 10^{24}\,\text{kg}$,) on a mass $m = 10.0\,\text{kg}$ is

$$mg = 98\,\text{N} \tag{1}$$

and points towards the center of Earth. What is the magnitude of the gravitational force exerted by the mass m on Earth?

2. (**5 points.**) A cup of coffee is on a table in an airplane flying at a constant altitude and a constant velocity. The coefficient of static friction between the cup and the table is 0.50 and the coefficient of kinetic friction between the cup and the table is 0.30. Suddenly, the plane accelerates forward, its altitude remaining constant. What is the direction of the friction force with respect to the velocity of the airplane?

3. (**5 points.**) You are driving a car on an icy (frictionless) flat (unbanked) road. How will you maneuver a right turn without sliding while perfectly rolling?

4. (**10 points.**) Your mass is 75 kg. How much will you weigh on a bathroom scale (designed to measure the normal force in Newtons) inside an elevator that is slowing down at $2.0\,\mathrm{m/s^2}$ while moving upward?

5. (**10 points.**) Two masses $m_1 = 10.0\,\mathrm{kg}$ and $m_2 = 20.0\,\mathrm{kg}$ are stacked together on a frictionless plane. A force $\mathbf{F}$ is exerted on m_2. See Figure 1. Given $F = 33\,\mathrm{N}$. Determine the contact force exerted by mass m_1 on mass m_2.

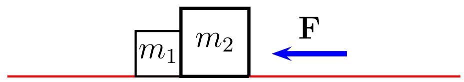

Figure 1: Problem 5.

6. (**10 points.**) A mass m_2 is connected to another mass $m_1 = 1.0\,\text{kg}$ by a massless (inextensible) string passing over a massless pulley as described in Figure 2. The coefficient of static friction between mass m_1 and the surface is 0.50 and the coefficient of kinetic friction between the block and plane is 0.25. Determine the minimum mass m_2 for which the mass m_1 starts moving.

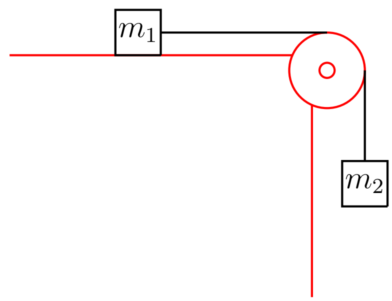

Figure 2: Problem 6

7. (**10 points.**) Consider the case of drag force that is linearly proportional to velocity. For a mass m falling under gravity and experiencing such a drag force after starting from rest we have the equation of motion

$$m\frac{dv}{dt} = mg - bv, \tag{2}$$

which leads to the solution

$$v(t) = v_T\left(1 - e^{-\frac{t}{\tau}}\right), \tag{3}$$

where the terminal velocity v_T is defined by requiring $dv/dt = 0$, that is

$$v_T = \frac{mg}{b} \tag{4}$$

and $\tau = v_T/g$ is the time constant and sets the scale for time. Given $v_T = 9.8\,\mathrm{mm/s}$, determine the time it takes for the mass to attain $95\,\%$ of the terminal velocity.