• You have 60 minutes to complete the exam.
• Formulae are provided on a separate colored sheet. You may NOT use any other formula sheet.
• You may use a calculator.
• When calculating numerical values, be sure to keep track of units. Results must include proper units.
• Be alert to the number of significant figures in the information given. Results must have the correct number of significant figures.
• If you are unable to solve a problem whose solution is needed in another problem, then assign a symbol for the solution of the first problem and use that symbol in solving the second problem.
• If you need additional space to answer a problem, use the back of the sheet it is written on.
• Mark your answers clearly by drawing boxes around them.
• Please write clearly. You may gain marks for a partially correct calculation if your work can be deciphered.
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Problem 1. 20 points.

A block of mass $M$ slides with friction along a surface inclined at an angle $\theta$ above the horizontal. The coefficient of kinetic friction is $\mu$. A light strong rope connects the block via a pulley to another block, also of mass $M$ which hangs in the air as shown.

The angle and coefficient of friction have values such that the hanging block moves down, and the sliding block moves up the plane.

Calculate the acceleration of the hanging block.
Physics 218: Mechanics, Exam 2

Problem 2. 20 points.

A block of mass $M$ is pressed against a vertical wall by a constant applied force $P$. The coefficient of static friction between the wall and the block is $\mu$. What is the minimum value of $P$ such that the block does not slide down the wall?
Problem 3. 20 points.

The starship *Enterprise* is holding position near a binary star system. The system consists of two identical spherical stars which both have mass $M$ and are separated by a distance $2b$ as shown.

Suppose the engines fail and the spaceship is subjected only to the gravitational pull of the stars. Calculate the acceleration of the spaceship for the following two cases:

(a) The spaceship is on a line which is perpendicular to a line connecting the stars, and a distance $b$ from the center of mass of the stars.

(b) The spaceship is on the line connecting the stars, and a distance $b$ from one of them.
A block of mass $M$ is released from rest on a frictionless ramp a height $h$ above the base. The ramp makes an angle $\theta$ with the horizontal. The block slides down the ramp, and then continues across the floor. The floor is also frictionless, except for a small region of length $s$ that is rough. The coefficient of kinetic friction between the block and the rough part of the floor is $\mu$. After the block traverses this rough part, it encounters a spring of force constant $k$. The block compresses the spring some amount before coming to rest (and then rebounding off). Calculate the maximum displacement (compression) of the spring from equilibrium.

*Hint:* This is easy. Pay attention to the initial and final velocity. Don’t bother with intermediate steps, just solve the whole thing.

Some useful formulas from Ch. 7:

Work done by a spring is

$$W = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2.$$  

Work done by a gravity is

$$W = -mg(y_f - y_i).$$  

Work done by friction is

$$W = -fs.$$
Problem 5. 20 points.

A trash-compactor at a construction site consists of a movable piston that compresses debris in a confined space. Suppose that the hydraulic system that moves the piston applies a constant force $P$ to the piston, and that the trash pushes back on the piston by an amount proportional to the square of the distance that the trash has been compressed. If we denote the distance that the trash has been compressed by $x$ and the proportionality constant by $k$, then the total force on the piston is

$$F(x) = P - kx^2.$$  

(a) (10 points) Calculate the maximum distance that the trash is compressed.

(b) (10 points) Assuming the mass of the piston is $m$, calculate the maximum speed at which the piston moves.