Name: ____________________________

Recitation section (circle one)

R01 Mon. 12:50 **R02 Wed. 12:50** **R03 Mon. 3:50**

Final Exam

Closed book. No notes allowed. **Any** calculators are permitted. There are no trick questions here. There are five questions, one per page, each worth **20 points**, for a maximum score of **100**. In general, you need to show the reasoning behind your answer. A correct number alone will not get much credit.

Do the exam on these pages. It would be smart to write your name on all pages, in case of staple failure. If a question seems too easy, perhaps it is just easy. Relax and good luck! Two significant figures will be accepted as sufficient on this test. Do not forget to give units in your final answer. If your calculator fails, you should get **numerical** answers to 10% by simple arithmetics for almost full credit. **The exams will be graded by Tuesday, May 16 and can be looked at in Sasha Abanov's office (B-102).**

Turn cell phones off. Have your University ID out for checking, please.

Problem 1	
Problem 2	
Problem 3	
Problem 4	
Problem 5	
Total Score	

Total score for the course (out of 100)

Grade

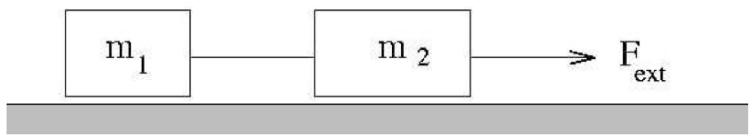
Problem 1

Two masses $m_1 = 10.0$ kg and $m_2 = 14.0$ kg, are coupled by a massless cord. They slide on a horizontal surface. An external force $F_{ext} = 25.0$ N is applied to mass m_2 as shown.

a) Suppose there is no friction. Find the acceleration.

b) Find the tension in the cord.

c) Now suppose that there is friction, determined by a coefficient μ_k of kinetic friction which is the same for each mass. The system slides to the right at constant speed $v = 1.2$ m/s. What is the coefficient of friction μ_k?



Solution

Problem 2

A discus thrower can throw a discus (on the Earth, of course) over 70 m distance (close to the world record). Will the athlete be able to throw a discus with an escape speed on the surface of an asteroid of density 2500 kg/m^3 and diameter of 200 km? Assume that the space suite is very light and does not hinder athlete's movements. To solve this problem:

a) Find the initial speed of the discus from the given range.

b) Find the escape velocity from the asteroid.

c) Compare those velocities and come to a conclusion.

Hint: the range of the projectile's motion is given by $R = \frac{v_0^2 \sin 2\alpha_0}{g}$. The constant $G = 6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$.

Solution

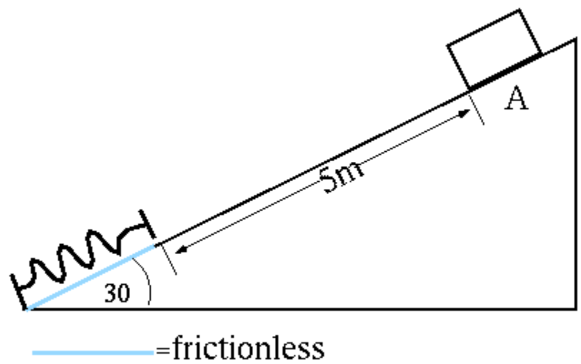
Problem 3

A mass $m = 5.0$kg is released from the point A and it slides down the incline ($\theta = 30^o$), where coefficient of kinetic friction is 0.3. It goes distance $L = 5.0$ m and hits an ideal spring with a spring constant $k = 3000$N/m. While it is being acted upon by the spring, assume it is on a frictionless surface.

a) What is the maximal compression x of the spring?

b) How far does the block go up the plane on the rebound from the spring?

Hint: In calculations you can assume that the maximal compression of the spring is small $x \ll L$.



Solution

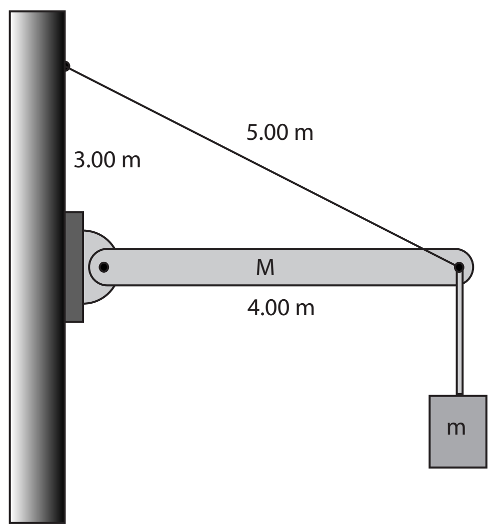
Problem 4

The horizontal beam shown in the figure has a mass of $M = 20$kg, and its center of gravity is at its center. The mass of the load $m = 10$kg. The load is connected to the beam by a very light rod. Find

a) the tension T in the 5.00 m cable,

b) the horizontal and vertical components of the force exerted on the beam at the wall,

c) the change of the length of the 5.00 m cable due to tension. The cross-sectional area of the cable is $A = 1.0$ mm^2 and it is made of copper (Y=11×10^{11} Pa).



Solution

Problem 5

Consider again the system described in the previous problem. Assume that the 5.00 m cable breaks and the beam pivots around the pin with no friction.

a) What is its initial angular acceleration α of the beam, just after the cable breaks?

b) What is its initial linear acceleration a of the load, just after the cable breaks?

c) At the same moment, what is the tension of the very light rod F_T connecting the load m with the beam?

Assume that the rod stays vertical as it is freely connected to the beam (on a hinge).

Hint: The moment of inertia of a uniform bar about an axis through its center is $I = \frac{1}{12}ML^2$ and about an axis through one end is $I = \frac{1}{3}ML^2$.

Solution