

3 best out of 4 problems count, each 5% to final grade. If you score at B+ level I will count the 4th problem at 50% as bonus (in other words attempt the 4th problem ONLY after you are pretty sure to have done your three problems). You can use a cheat(better memory)-sheet from first test with add-on of 1/2 page, to be returned with test.

What is out (aside of simple calculator and pen) you will hand in. I prefer if you sign ONLY with your personal 4-digit code. This makes grading more anonymous and thus increases grading fairness, personal code must be stated. If you use scratch paper, it must be handed in, and sign-coded. Responses not to the point of the test are not graded. Define all symbols other than what is consistently used in class (like $t, x, v, a, I, \alpha, \omega, F$, etc need no definition). Remember: a figure speaks 100 words, focus on what is asked in problem. Formulas which are not argued do not count, There are fundamental and frequently used laws and relations, these you need NOT to derive but you must state that you are using e.g. "using angular momentum conservation, $d\vec{L}/dt = 0$ "

PROBLEM I: You are skiing down a snowball of radius R . (of course you ignore wind, friction, elasticity of skis, etc). a) At what (i) angle and (ii) at what velocity will you loose contact?

b) Evaluate your result for a skier of mass $M = 80\text{kg}$ and snowball $R = 40\text{m}$. Does this make sense to you?

c) Set-up and solve the dynamical equation for the motion of the skier AFTER she loses contact with the snow bowl.

PROBLEM II: Apply law of energy conservation to study the dynamics of a mass M_B falling subject to gravity, and being kept back by a non-stretching string attached to a table-gliding mass M_A , with coefficient of kinetic friction μ_k , string turning over a uniform pulley of radius R with frictionless axle, and mass M_C .

a) Explain why, and evaluate for what range of values M_B, M_A even if you try to set M_B in motion, there can be no motion?

b) What is the speed v of both, M_A and M_B , as function of distance d that the body M_B has fallen?

c) Evaluate the magnitude of the acceleration a_B which M_B experiences – hint: compare to free fall i.e. when the string is not present.

d) What is the angular acceleration α , angular velocity ω and the rotation angle ϕ of the pulley as function of the distance fallen. Hint: there are very simple answers, DO NOT start anew, think!

PROBLEM III: A uniform rod of length L oscillates through small angles ϕ about a point a distance x from rod center. Recall that $I_{\text{CM}} = ML^2/12$.

a) Set up the governing dynamical equation.

b) Solve the equation and obtain angular oscillation frequency $\omega_0(x)$.

c) Discuss the shape of $\omega_0(x)$ as a function of x . In particular explain which best value of x would you choose and why when designing a pendulum clock.

PROBLEM IV – this simple problem is testing your general understanding of Newton’s laws

A $m = 45.0$ kg woman stands in a $M = 60.0$ kg canoe of length $L = 5.00$ m. She walks from a point $x_1 = 1.00$ m from the one end to a point $x_2 = 1.00$ m from the other end. If you ignore resistance to motion of the canoe in the water, how far and in which direction does the tip of the canoe move during this walk?