

The exam comprises two parts: 5 short-answer questions, and 4 problems. A formula sheet is attached to the back of the exam. Calculators are allowed.

Answer **all the short-answer questions** with a few words or a phrase, but be concise, please! For the problems, your grade will be calculated with the **best three problems**. Show your work.

The short answer problems are worth two points each, and the problems are worth 10 points each. Put all answers in the **red and white answer booklets** provided; you may keep this exam.

Good luck !

Short answer questions (answer all): you should not need to do any calculations for these questions. Answer in **a few words, a short phrase, or a simple sketch**.

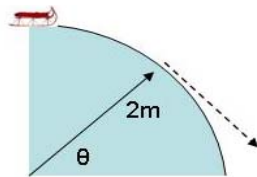
- 1) [2 pts] Can a centripetal force ever do work on an object moving in a circular path at a constant speed?
- 2) [2 pts] Two drivers are on a highway at the same speed, side by side. At the same instant, they each see an obstacle on the highway and start to brake (ignore reaction times). Driver 1 hits the brakes, locks the wheels, and skids to a stop. Driver 2 hits the brakes and applies the brakes to the verge of locking, but so that the wheels never lock up. Which driver stops in the shorter distance?
- 3) [2 pts] Your professor is giving a demonstration by tying a stone to a string and whirling it in a circle at constant speed. He tries it in two different ways: in a horizontal circle, and in a vertical circle. Assuming the speed is constant and the same in both cases, in which case is the string most likely to break? Explain **briefly**.
- 4) [2 pts] A sailboat is moving at constant velocity. Is work being done by a net external force acting on the boat?
- 5) [2 pts] In Superman© comic books, the hero is often seen hovering in mid air and then grabbing a villain and throwing him forward. Superman remains stationary during the throw. Besides the awful clothing choices of our protagonist, what is wrong with this scenario?

### Problems (do 3 out of four):

- 1) [10 pts] A child is sledding on a semi-circular hill as shown, starting from rest at the top of the hill. Assume a frictionless surface. At some point down the hill the sled leaves the surface.

a) Draw a free-body diagram for the sled at an arbitrary angle  $\theta$ .

b) When the sled leaves the surface, the normal force is zero. Calculate where this happens (ie, at what value of the angle  $\theta$ ). (Hint: at that instant consider the motion to be uniform circular motion).



- 2) [10 pts] Sand is being poured into a dump truck that is sitting on a scale. The sand is being poured from a height of 2.50 m above the truck. Because of the impulse that the sand delivers to the truck, the scale shows a larger weight than the weight of the sand and truck together. If sand is being poured at a rate of 100 kg/s and we assume the sand is in freefall until it hits the truck, calculate the difference between what the scale shows and the true weight of the mass and truck.

- 3) [10 pts] A fire hose ejects a stream of water at an angle of  $35^\circ$  from the horizontal and at a speed of 25.0 m/s. Assume the water behaves like a projectile (with no air resistance).

a) What is the highest fire that this hose can be used for?

b) How far from the building should the hose be placed for that fire?

- 4) [10 pts] An extreme skier starts from rest down a slope that has an angle of  $25^\circ$  from the horizontal. The coefficient of static friction between her skis and the snow is 0.22. After a distance of 24.0 m down the slope she goes over a cliff without slowing down. She lands a vertical distance 5.0 m below the cliff edge.

a) Draw a diagram. Indicate  $v_1$  (the velocity at the cliff edge), the slope distance of 24.0 m, the vertical distance of 5.0 m, and the approximate impact point (without doing any calculations). (For extra points, colour the skis a pretty colour).

b) Calculate her velocity just before she lands.