Physics 109 Practice Problems for Final Review

These are adapted from problems I found on previous finals. In the four finals I looked at, on average there were:
2 questions about mirrors/lenses (e.g., sample problem 1)
1 question about ballistics with different start and end heights (e.g., sample problem 2)
2/3 of a question on moment of inertia and Newton's law for torque (e.g., sample problem 4)
1 1/3 questions with drawing a free-body diagram of a system under constant acceleration (e.g., sample problem 3)
2/3 of a question with drawing a free-body diagram of a system with torques (e.g., sample problem 5)
1/3 of a question about conservation of momentum in a collision (e.g., sample problem 6 part c)
2/3 of a question on conservation of energy (e.g., sample problem 3 part c)
2/3 of a question on rotational dynamics (e.g., sample problems 3 and part a of 6)
1/3 of a question on rotational energy/momentum (e.g., sample problem 7)

As well, on average 1 1/3 questions involved only variables with no concrete numbers (e.g., sample problem 7) and one problem involved a pulley.

Problem 1:

A real object is 10.0 cm away from a converging lens with a focal length of 15 cm.
a) Find the location of the image
b) Find the magnification of the image
c) Is the image real or virtual, and is it upright or inverted?

Problem 2:

A catapult flings a rock towards a castle 160 m away. When the catapult arm is extended it's 10 m tall and the rock leaves the catapult with a speed of 40 m/s at an angle of 60º to the horizontal. At what height will the rock strike the castle wall?

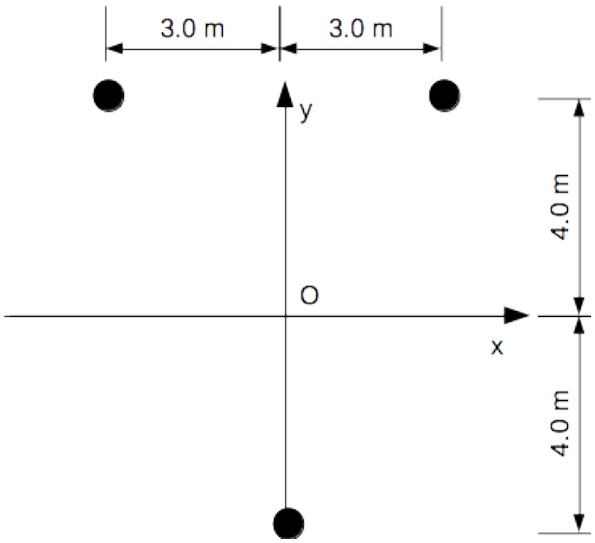
Problem 3:

A 700 kg car is travelling down an icy 10º incline that has a coefficient of friction of 0.20. Suddenly the car slams on the brakes and skids 30 m before coming to a stop.

a) Find the work done on the car by friction.
b) Find the work done on the car by gravity.

c) Using the work-energy theorem, find the initial speed of the car.

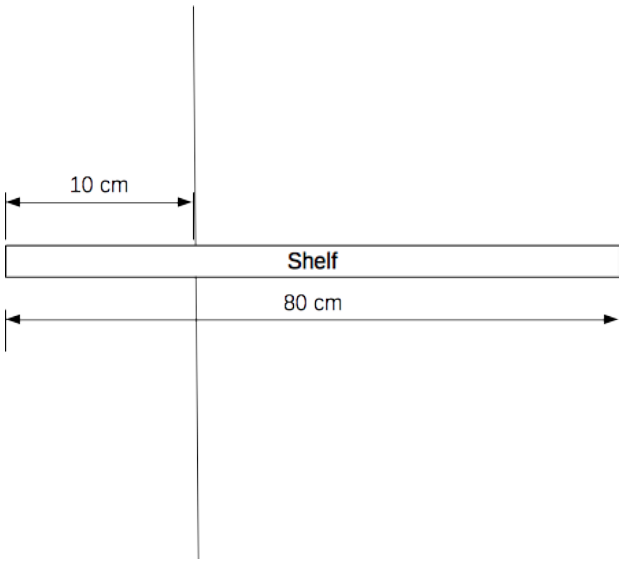
Problem 4:



a) Find the moment of inertia of the system about the x axis, and find the torque necessary to produce an angular acceleration of 2.5 rad/s^2
b) Find the moment of inertia of the system about an axis through O that is perpendicular to the page, and find the angular acceleration resulting from the torque found in part a.

Problem 5:

An 80 cm long wooden shelf of mass 7.0 kg sits in a 10 cm slot in a wall. This causes the wall to exert a torque on the shelf.
a) Draw a free-body diagram of the shelf, which should include <u>two</u> forces from the wall.
b) Calculate the three forces.



Problem 6:

A 42 kg child is on a carousel that is 5.0 m in diameter and has a mass of 110 kg. They are hanging onto a bar that is 2.2 m away from the centre of the carousel. Someone pushes the carousel, tangentially, with a force of 310 N.
a) If the child's maximum grip strength is 250 N, what will be the angular speed of the carousel when the child cannot hang on any more?
b) If the carousel starts from rest and the person pushes with the same force, how long before they push it to the speed found in part a? (Assume the carousel is a uniform disk and the child is a point mass).
c) In an unfortunate coincidence, when the child flies off of the carousel they collide with a dog with a mass of 22 kg who is travelling 4.0 m/s in a direction perpendicular to the child's direction of motion. Will this be an elastic or inelastic collision? What will the final velocity(s) of the child and dog be? Assume the child and dog are unharmed.

Problem 7:

A spherical boulder rolls down a hill that is a uniform hemisphere of radius R. Show that the boulder becomes airborne when it is at a height of $\frac{7}{17}R$ below the top of the hill. *Hint: This is the point when the normal force becomes 0.*
Note: This is a more difficult version of the one of the most difficult problems I could find out of four previous physics 109 finals.