

Høsten 2014

# FYS100 Fysikk

## Obligatorisk indlevering IV

DEADLINE FOR HANDING IN:

**Week 45, At the latest Friday 7/11 kl. 18:00**

**This is a hard deadline!! We must correct it by 14/11, to make the deadline for the exam. Do not hand in late!**

WHERE TO HAND IN:

Scanned, uploaded in a single .pdf file to It's Learning in the folder

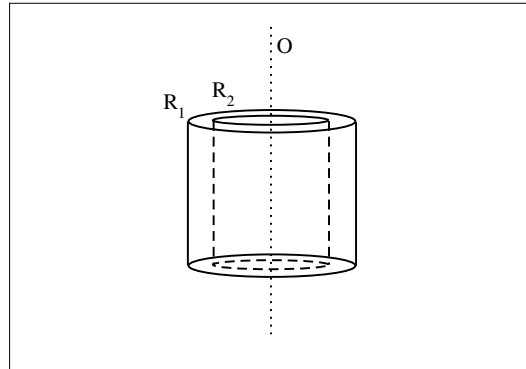
"Indlevering 4".

The set consists of 4 problems, all of which must be solved. The problems are based on chapters 8, 9 and 10 of the textbook.

**For each problem I expect you to draw a relevant sketch, and this time, you need to make it look nice, too! So write nicely, no scratchings over, keep it tidy. For some of you, this means writing it up nicely after you have solved the problems.**

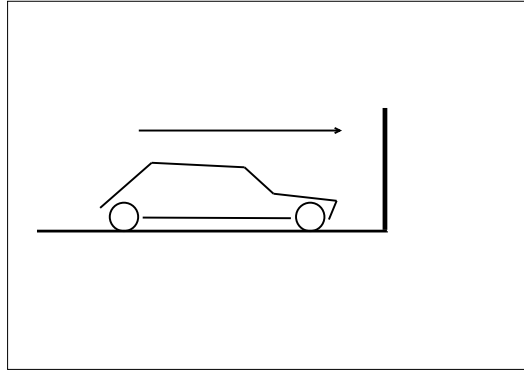
Problems are not weighted equally. Partial credit is awarded. Good luck!

## Problem 1



- a) Compute the moment of inertia of a uniform hollow cylinder of mass  $M$ , outer radius  $R_1$  and inner radius  $R_2$  and height  $h$ , around an axis through the centre of the circular cross-section (see figure). Compare to the result stated in the book, page 304.
- b) Compute the moment of inertia of a uniform hollow cylinder of mass  $M$ , outer radius  $R_1$  and inner radius  $R_2$  and height  $h$  (same thing as in a)), around an axis parallel to the one in a), but now shifted to a radius of  $(R_1 + R_2)/2$  from the middle of the cylinder.
- c) Compute the moment of inertia of a thin uniform rod of mass  $M$  and length  $L$  around a point  $L/3$  from one end;  $L/4$  from one end;  $L/5$  from one end.

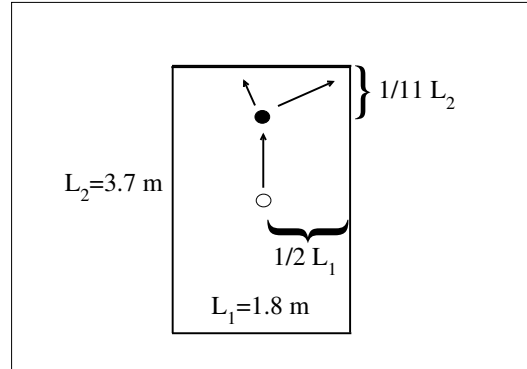
## Problem 2



A Tesla of mass 2100 kg accelerates from rest to 100 km/h in 3.40 seconds, and we will assume that the acceleration is constant. In the following, ignore resistance from the air and the rolling friction of the wheels against the surface. The wheels are rolling without sliding (no wheel-spinning here!), and they have a diameter of 50.0 cm. A wheel weighs 18.0 kg, and has a moment of inertia corresponding to a cylinder. The weight of the wheels is included in the total 2100 kg. A car has 4 wheels (surprise!), and they are taken to be the same and carry the same amount of weight.

- Draw a sketch of the forces on the car, and the forces and torques acting on each wheel.
- What is the required torque that the engine has to provide for each wheel, to have this acceleration?
- What is the required coefficient of static friction between road and wheel, to avoid spinning?
- What is the total kinetic energy of the Tesla as it reaches 100 km/h?
- After reaching a constant speed of 100 km /h, the Tesla now unfortunately crashes against a solid wall. In doing so, the front end of the car is crushed together a length of 2 m, and the car comes to a halt. What is the impulse provided by the wall, how long does it take to stop and what is the average force provided by the wall? [You may use the impulse approximation, and ignore the friction force on the wheels, which ensure rolling without slipping, and hence the wheels will continue spinning as the car crashes, and eventually afterwards come to a halt due to kinetic friction with the surface. This is not important for the calculation.]

### Problem 3

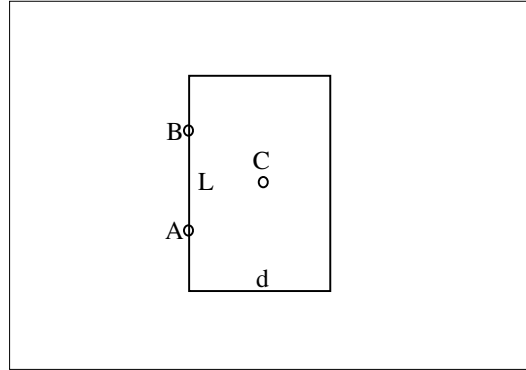


On a snooker table ( $L_2 = 3.70 \text{ m}$  times  $L_1 = 1.80 \text{ m}$ , see figure), the black ball is on its spot,  $1/11 L_2$  from the near cushion, and midway between the two side-cushions. The white cue ball is on the blue ball spot, in the exact centre of the table. The balls have the same mass of  $m = 0.160 \text{ kg}$ , and we take the x-coordinate to be along the short side of the table, the y-coordinate along the long side.

The cue ball hits the black ball with a speed of  $4.00 \text{ m/s}$  on a path along the middle of the table, in the y-direction (and a tiny bit off, so that it hits the black ball at an angle). Assuming that the black ball is putted into the near right-side corner pocket, what are the velocities of the cue ball and black ball immediately after the collision? For the purpose of this exercise, you may ignore the rolling motion of the balls (think of them as sliding), and the collision is taken to be (perfectly) elastic.

Hint: Write down conservation of energy and momentum. What is the angle between the black and white ball after the collision? Remember to do a sketch!

### Problem 4



Consider a door, hanging on two hinges (see figure). The door is  $L$  tall and  $d$  wide, and the hinges are placed at heights  $L/4$  (point A) and  $3L/4$  (point B) from the floor. The door is uniform, and so its centre of mass is in the middle of the door (point C).

- Draw a sketch, identify and mark all the 3 forces in the problem. Explain what you expect to happen if either of the hinges were not there. What does this imply about the direction of  $F_A$  and  $F_B$ , if the door is supposed to hang at rest?
- What is the torque from each of the 3 forces around point A?
- What is the torque from each of the 3 forces around point B?
- For the door not to rotate, the sum of all the torques must be zero, around any point. Write down the corresponding equations.
- For the door to neither fly sideways, upwards or downwards, what other two equations can you write down for the forces?
- We will assume that the upwards components of the two hinge forces,  $F_y^A$  and  $F_y^B$ , are the same. Solve for the complete hinge force vectors.