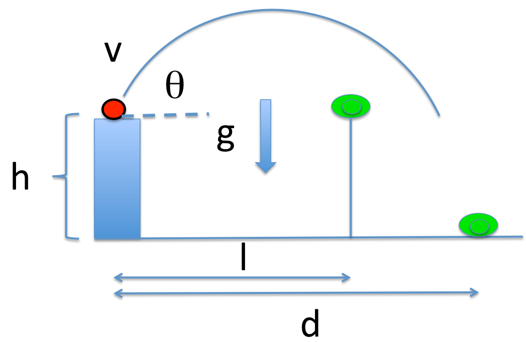
Høsten 2015

FYS100 Fysikk
Obligatorisk Indlevering II

To be handed in at the latest **Friday 25. September, at 18.00**. You must hand it in by scanning your handwritten solution into a single .pdf file, and uploading it to It's learning in "Indlevering 2". If you have written the solution as a electronic document (and not by hand), convert this to .pdf and upload.

Good luck!

Problem 1: Angry Birds to the rescue!

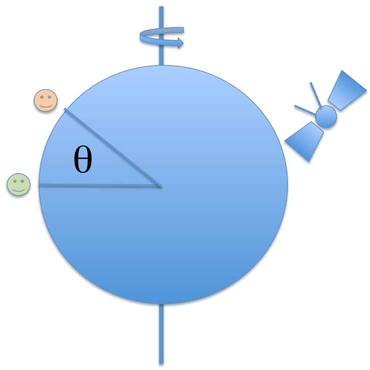


You are the chief of the Angry Birds (Google it, if you don't know the reference...it's not important). You can shoot red birds from a catapult, and they will fly as projectiles under the effect of gravity. Gravity points downwards and has magnitude $g = 9.80\ \mathrm{m/s^2}$. Your goal is to hit some nasty green pigs, who have stolen your Angry Bird Eggs. You are able to adjust the angle θ and speed v of the projectile, as it leaves the catapult. The projectile leaves the catapult at a height h above the ground.

a) First, consider the case when a single green pig is placed on the ground, at a distance d from the foot of the catapult. Find a relation between the angle and speed required to hit it. Remember to draw a sketch of the situation.

b) Next consider the case where there are two green pigs. One on the ground at a distance d as before, the other at a distance $l < d$, and placed on a pole of height h. What should you choose for θ and v in order to hit both pigs with the same red bird? Why must one require $l < d$? Remember to draw a sketch of the situation.

Problem 2: Uniform Circular Motion... in Space!



The Earth turns once around its axis in 24.0 hours. We will assume that it is perfectly spherical, with radius 6400 km. The mass of the Earth is taken to be 6.00×10^{24} kg. The gravitational acceleration on the surface is taken to be $g = 9.80\ \mathrm{m/s^2}$.

a) What is the centripetal acceleration of a person at the equator? How big a fraction of the gravitational acceleration does this correspond to? Remember to draw a sketch of the situation.

b) How fast would the Earth have to turn for the centripetal acceleration to be exactly equal to gravity? Give the answer in revolutions per day. Remember to draw a sketch of the situation.

c) Define θ to be the latitude, so that $\theta = 0$ corresponds to the equator, and $\theta = 90°$ is the North Pole. What is the centripetal acceleration of a person standing on the surface at a given value of θ? Remember to draw a sketch of the situation.

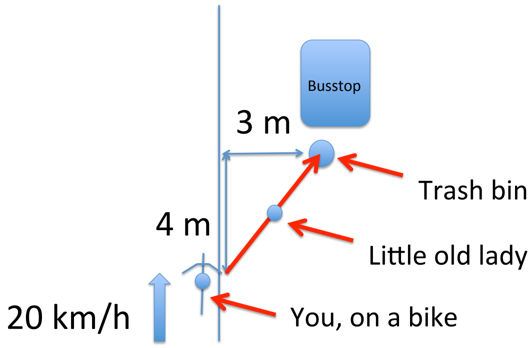
d) Taking into account that the centripetal acceleration is towards the rotation axis, and gravity is towards the centre of the Earth, how fast should the Earth now turn for gravity to be just enough to provide the necessary centripetal acceleration (as function of θ)? Remember to draw a sketch of the situation.

e) Using the force of gravity

$$|F_g| = G\frac{Mm}{r^2}, \tag{1}$$

where M is the mass of the Earth, m the mass of the orbiting object. Find the required speed v_{orbit}, as a function of r, so that the object performs uniform circular motion around the Earth, under the influence of gravity. How long does it take to go round once in an orbit 900 km above ground? Remember to draw a sketch of the situation.

Problem 3: Apple motion.



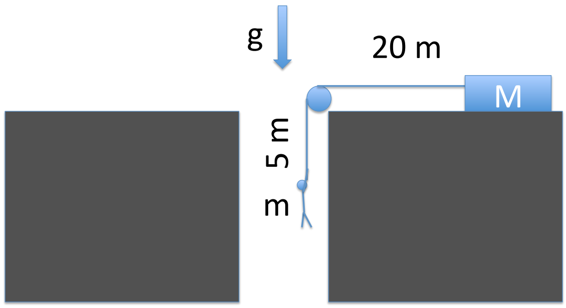
You are travelling on a bike, moving at a constant speed of 20.0 km/h. You just finished eating an apple, and you wish to pop the core into a trash bin located by a busstop (pretty ambitious on a bike at this speed...but ok, it would look pretty cool, if it would work!). The bin is 3.00 m from the edge of the road (where you are biking). You throw it at a point 4.00 m before you pass the trash bin. The apple core behaves as a projectile under the force of gravity $g = 9.80$ m/s^2, and you can ignore friction and wind. The height of the (top of the) bin is the same as the height of your hand as you throw, 1.00 m above the ground.

a) You throw the apple upwards at an angle of $\phi = 20.0°$ with horizontal. With what initial velocity vector relative to the Earth should you throw the apple to hit the bin? Remember to draw a sketch of the situation.

b) With what initial velocity vector relative to you and the bike should you throw the apple to hit the bin? What speed does that correspond to? Remember to draw a sketch of the situation.

c) As it happens, a little old lady is standing exactly halfway between you and the bin. She is 160 cm tall. Do you hit her? Remember to draw a sketch of the situation.

Problem 4: Chuck Norris.



A man (Chuck Norris) of mass $m = 80.0$ kg hangs from a rope down into a hole. The rope goes over a massless pulley and is connected to a block of rock of mass $M = 200$ kg, which is lying on a frictionless horizontal surface. The distance between pulley and man is 5.00 m; between pulley and block 20.0 m.

a) What is the acceleration of the man (and rock)? How long does it take before the block crashes into the pulley, rips it off and everything plunges into the hole? The block and man start from rest. Remember to draw a sketch of the situation.

b) Instead of just hanging there, the man decides to climb up the rope while everything is moving. Is it possible for him to get enough (constant) acceleration to get to the pulley and to safety, before the block hits the pulley? What is the acceleration of him and of the block in the case where he *just* makes it (Chuck Norris does not need to make room for errors; errors need to make room for Chuck Norris). Remember to draw a sketch of the situation.