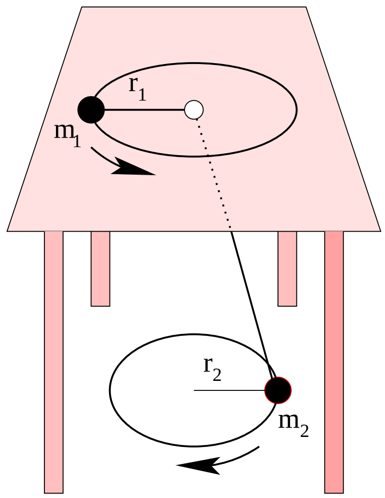
# PH101 ASSESSMENT 2
# DUE 20/11/07

*1) Man with a sack in an elevator*

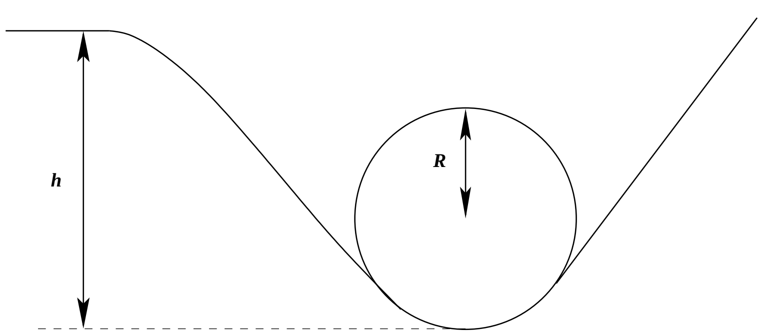
A man carrying a 20 kg sack on his shoulder rides in an elevator. What is the force the sack exerts on his shoulder when the elevator is accelerating upward at 2.0 m/s$^2$. (3 marks)

*2)Two circular motions*




A mass $m_1$ slides on a smooth, frictionless table. The mass is contrained to move in a circle by a string that passes through a hole in the center of the table and is attached to a second mass $m_2$ hanging below the table. The second mass swings in a circle, so the string makes an angle of $\theta$ with the vertical. The two masses move around their circles in unison, so they are always at diametrically opposite points from the hole. If the radius of the circular motion of the first mass is $r_1$, what must be the radius of the circular motion of the second mass? (7 marks)

*3) Roller Coaster*




The roller coaster at an amusement park starts from a height $h$ and rolls down a steep region (starting with zero velocity) before entering the circular vertical loop.

a) If the loop has a radius of 10 m, what is the minimum speed that a car must have at the top of the loop if it is not to fall off? (4 marks)

b) What is the minimum speed with which the car must enter the loop at the bottom? (3 marks)

c) What is the minimum height $h$ such that the cars do not fall at the top of the loop, assuming that the cars have zero initial velocity at the top? (3 marks)

*4) Pushing a Book against the Wall*

You are holding a book against a vertical wall by pushing upwards with your hand. The angle between your force and the vertical is $\alpha$ ($< 90°$). The mass of the book is $m$ and the coefficient of static friction is $\mu$. If you push too hard, the book will start to slide upwards, if you don't push hard enough, the book will slide down.

a) Draw "free body" diagrams for these two cases when the book is just about to slide up and slide down, *i.e.* draw all forces acting on the book in these two cases. (4 marks)

b) Calculate the magnitude of your force (as a function of $\alpha$) to just prevent slipping, in both cases. (4 marks)

c) Calculate the force (as a function of $\alpha$) for which the friction becomes zero. Evaluate your result for $\alpha = 0°$ and $90°$. (4 marks)

d) For what values of $\mu$ (as a function of $\alpha$) is it impossible to make the book slide upwards? (3 marks)

*5) Horizontal spring with friction*

A 3.0 kg block rests on a leveled table. The coefficients of friction between the block and the table are $\mu_s = 0.30$ for static friction and $\mu_k = 0.20$ for kinetic friction. The block is attached to a wall by means of a horizontal spring of spring constant $k = 80\ N/m$. We pull on the block and stretch the spring and then let go with the block initially at rest. Use $g = 10\ m/s^2$).

a) What is the maximum extension of the spring for which the block will remain stationary when released? (4 marks)

b) The block is placed in this position and then given a very gentle push towards the wall. At what position will the block reach its maximum speed? (4 marks)

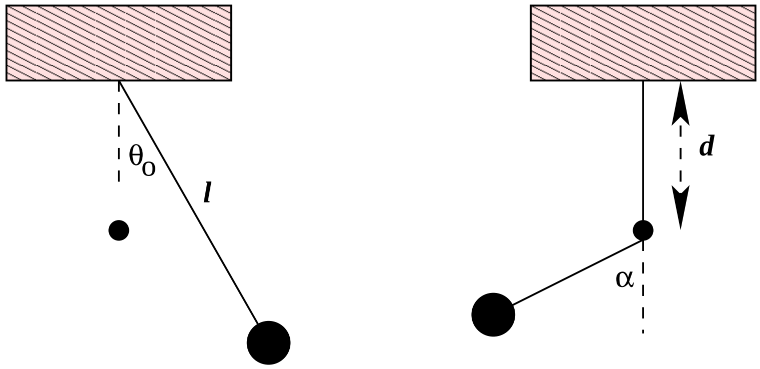
*6) Bungee Jumping*

A bungee jumper jumps from a tall bridge attached to a light elastic cord (bungee cord) of unstretched length $L$. The cord first straightens and then extends as the jumper falls. This prevents her from hitting the water. Suppose that the bungee cord behaves like a spring with spring constant $k = 100 N/m$. The bridge is $h = 100$ m high and the jumper's mass is $m = 50$ kg.

a) What is the maximum allowed length $L$ of the unstretched bungee cord to keep the jumper alive? ( Assume that the spring constant does not depend on $L$). (4 marks)

b) Before jumping, our jumper verified the spring constant of the cord. She lowered herself very slowly from the bridge to the full extent of the cord and measured the distance to the water surface. What was that distance? (4 marks)

*7) Pendulum in action*




A pendulum consists of a massless string of length $l$ and a bob of mass $m$. We release the bob (without speed) when the string is at an angle $\theta_0$ with respect to the vertical. A pin is located a distance $d$ below the top of the string. When the pendulum swings down, the string hits the pin.

a) What is the maximum angle $\alpha$ that the string below the pin makes with the vertical after hitting the pin? (5 marks)

b) If the bob had been released with an initial tangential velocity $v_0$, what would then be the maximum angle $\alpha$. Does the direction of this tangential velocity matter? (5 marks)

*8) From Earth to the Moon*

Neglect the gravity of the Moon and neglect atmospheric friction in this problem. A long time ago, Jules Verne, in his book *From Earth to the Moon* (1865), suggested sending an expedition to the Moon by means of a projectile fired from a gigantic gun.

a) With what muzzle speed must a projectile be fired vertically from a gun on the surface of the Earth if it is to (barely) reach the distance to the moon? Take the earth moon distance to be 384,000 km and the mass of the earth to be $6 \times 10^{24}$ kg and the radius of the earth is 6,400 km. (4 marks)

b) Suppose that the projectile has a mass of 2000 kg. What energy must the gun deliver to the projectile? The explosion of 1 short ton (2000 lb) of TNT releases $4.2 \times 10^9$J. How many tons of TNT are required for firing this gun? (4 marks)

c) If the gun barrel is 500 m long, what must be the average acceleration of the projectile during firing? (4 marks)

*9) Sliding on Ice*

John and his friend, Nancy, sit motionless on sleds on frictionless ice. John slides a 10 kg block across the ice to Nancy at 3 m/s relative to his sled (i.e. after the block is released, the relative velocity of the block relative to his sled is 3 m/s). Nancy catches is and slides it back to John at the same speed of 3 m/s relative to her own sled. John and his sled (without the 10 kg block) together have a mass of 100 kg, and Nancy and her sled together have a mass of 80 kg.

a) What is the speed of John's sled and what is the speed of the block after John releases the block? (4 marks)

b) What is the speed of Nancy's sled immediately after she catches the block? (2 marks)

c) What is the speed of Nancy's sled and what is the speed of the block after she slides the block back to John? (4 marks)

d) What is the speed of John's sled after he catches the block? (2 marks)

e) What is the total kinetic energy of the block and the sled after John releases the block? (2 marks)

f) What is the total kinetic energy of the two sleds and the block just after Nancy catches the block? (2 marks)

g) What is the total kinetic energy of the two sleds and the block just after Nancy releases the block? (2 marks)

h) What is the total kinetic energy of the sleds after John catches the block? (2 marks)

i) The kinetic energy of the system is increasing. Where is that energy coming from? (2 marks)

*10) Colliding Pucks*

Two pucks of mass $m_1$ and $m_2$, moving on a horizontal frictionless surface, undergo an *elastic* collision. Prior to the collision, their speeds were $v_1$ and $v_2$ respectively, as measured in their center-of-mass frame (the frame in which the center of mass is at rest).

a) What are their speeds, as measured in the center-of-mass frame, after the collision? (4 marks)

b) Can you make any statement about their directions of motion after the collision? (2 marks)

c) What was the total kinetic energy before the collision in the center-of-mass reference frame? (3 marks)

d) What was the total kinetic energy after the collision in the center of mass reference frame? (3 marks)