

# Physics 2414, Spring 2008

## Group Exercise 5, Feb 21, 2008

Name 1: \_\_\_\_\_ OUID 1: \_\_\_\_\_

Name 2: \_\_\_\_\_ OUID 2: \_\_\_\_\_

Name 3: \_\_\_\_\_ OUID 3: \_\_\_\_\_

Name 4: \_\_\_\_\_ OUID 4: \_\_\_\_\_

Section Number: \_\_\_\_\_

### Frictional Force

#### Notation

$\vec{F}_f$  - Frictional force (static or kinetic).

$\vec{F}_s$  - Static frictional force.

$\vec{F}_k$  - Kinetic frictional force.

#### Description

A tank (of mass 10 kg with water of mass 90 kg) open to the sunlight (so that the water evaporates) is attached to a mass  $m_0 = 50$  kg using a massless frictionless pulley as shown in Figure 1. The surface on which the tank rests has coefficient of static friction  $\mu_s = 0.8$ , and coefficient of kinetic friction  $\mu_k = 0.5$ . Assume the string is long enough so it can accelerate for many hours.

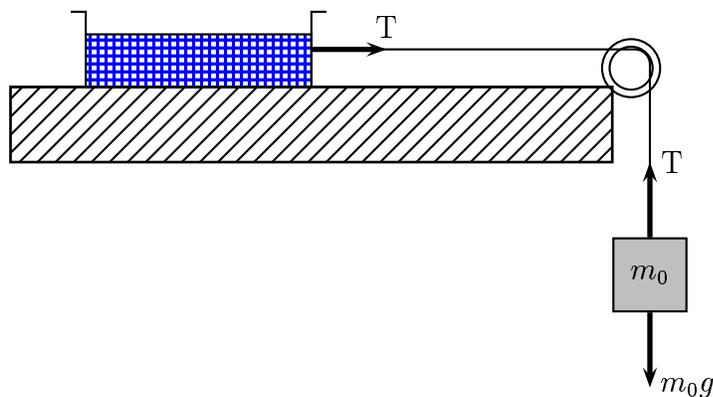
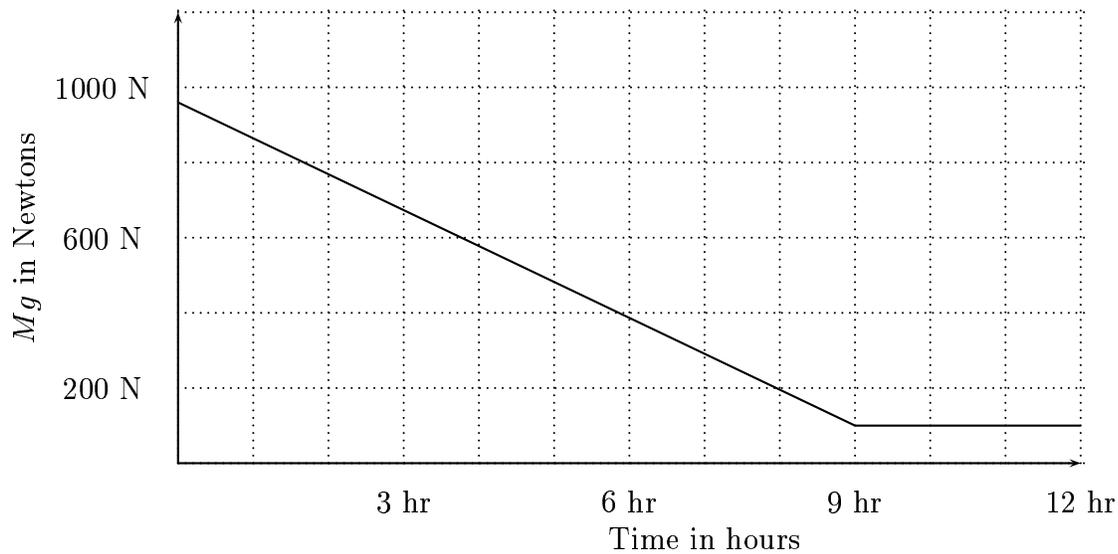


Figure 1: Diagram showing the water+tank being pulled by mass  $m_0$ .

Due to evaporation, the weight ( $= Mg$ ) of the tank+water varies as shown in the plot 1.



Plot 1:  $Mg$  verses time

### Problems

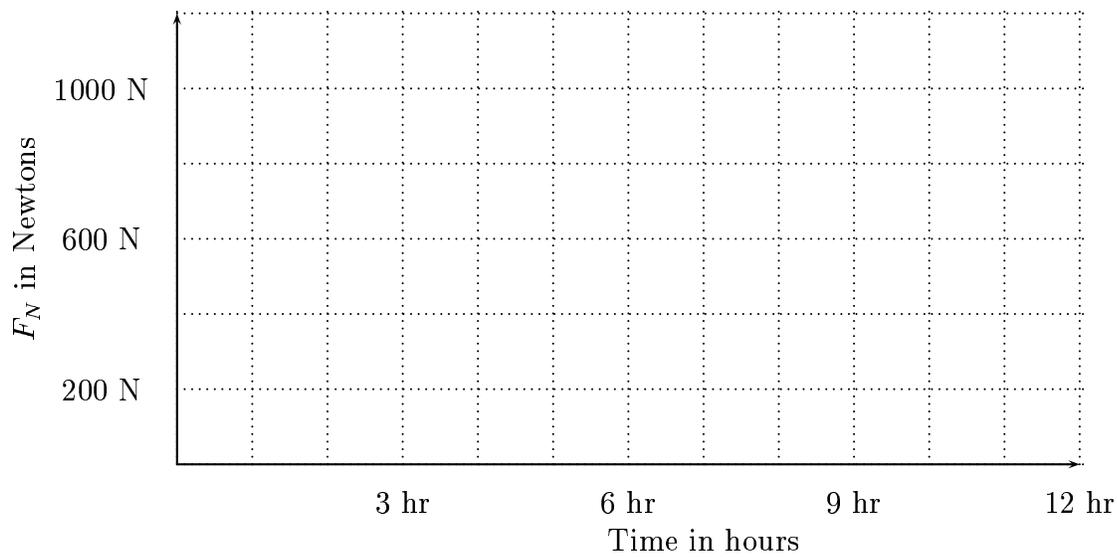
1. *Normal force:*

(a) Draw the free body diagram for the system consisting of the tank+water.



(b) Write the expression for the normal force on the tank+water system.

(c) Plot the normal force as a function of time in Plot 2.



Plot 2: Normal force verses time

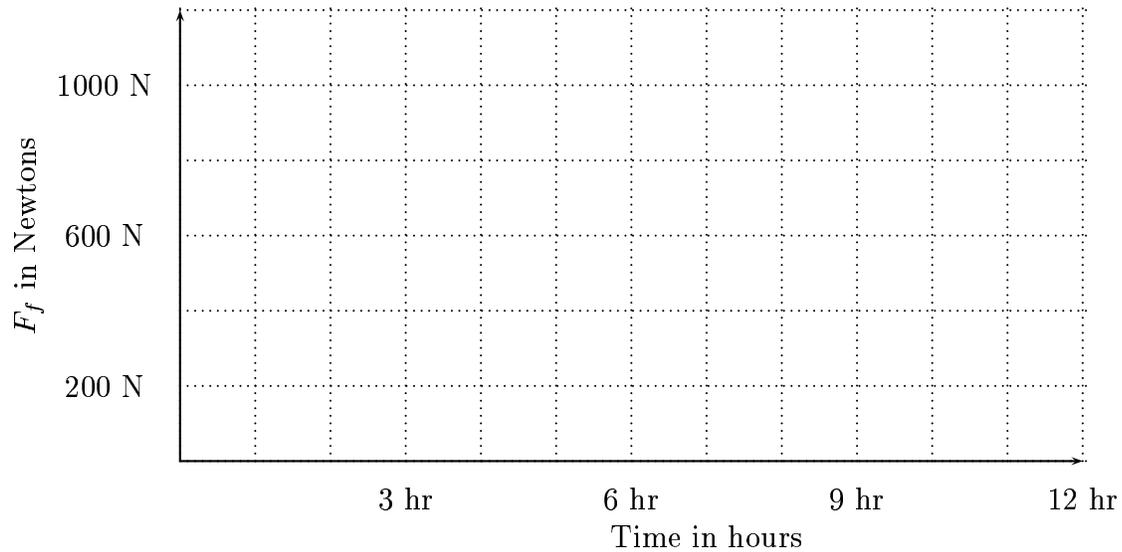
2. *Friction:*

(a) Write the force equation for the tank+water in the horizontal direction.

(b) At what time does the tank start to move?

(Hint:  $T = m_0g = 490$  N before the tank starts moving; the acceleration of the tank is zero before it starts to move; and  $F_f = \mu_s F_N$  instantly before the tank starts to move.)

(c) Plot the frictional force as a function of time in Plot 3.  
(Hint:  $F_s \leq \mu_s F_N$  and  $F_k = \mu_k F_N$ .)



Plot 3:  $F_f$  verses time

(d) What can you tell about the acceleration of the tank after it starts to move? Does the acceleration of the tank attain a constant value after all the water in the tank evaporates? What is the acceleration of the tank after all of the water has evaporated?