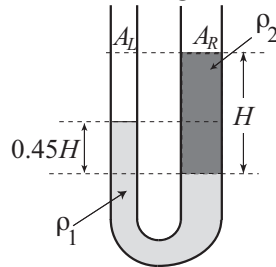
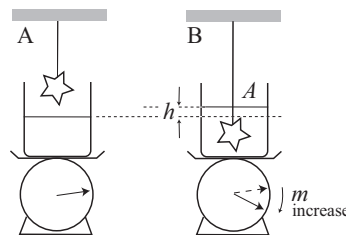


Name: \_\_\_\_\_ Section: \_\_\_\_\_ Score: \_\_\_\_\_/20

1. A vertical U-tube described below contains two distinct liquids with densities  $\rho_1$  and  $\rho_2$ , respectively, which do not mix. The cross sectional area of the left column is  $A_L = A$  and that of the right  $A_R = 3A$ . The ends of the tube are open to the air. The stationary state of these liquids in the tube is illustrated in the figure below. What is the ratio  $\rho_1/\rho_2$ ? [5]

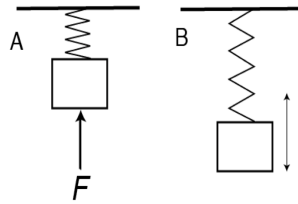


2. When an object of mass  $M$  hanging from above is immersed (without touching the bottom; see the illustration below) into a liquid of density  $\rho$  in a container of cross sectional area  $A$  below, the surface of the liquid rises by  $h$  (See the change from A to B in the figure). What is the change of the reading of the scale on which the container sits? You may answer this as the mass change  $m$  or the weight change  $mg$  in terms of  $h$ ,  $A$ ,  $\rho$ , etc., where  $g$  is the acceleration due to gravity. [5]



(3 and 4 on the next page)

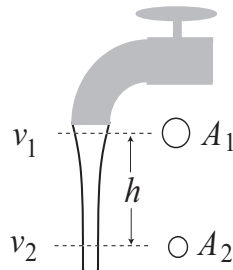
3. A block of mass  $M$  is suspended from the ceiling by a spring with spring constant  $k$ . Initially, the block is applied a force  $\mathbf{F}$  from below as illustrated in A. Then, the force is turned off, and the block starts to oscillate as in B. What is the maximum acceleration  $a_M$  of the block in terms of  $F = |\mathbf{F}|$ ,  $M$  and  $k$ ? (You need not use all the quantities.) [5]



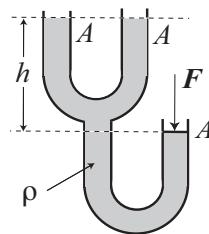
4. A pendulum made from a string and a small weight of mass  $m$  attached to its end has a frequency  $f$  on the earth. Its frequency is  $f'$  on Europa whose acceleration due to gravity on its surface is 13.4 % of the earth's. What is  $f'/f$ ? ([5]

Name: \_\_\_\_\_ Section: \_\_\_\_\_ Score: \_\_\_\_\_/20

1. A water column illustrated below is formed when a faucet is opened.  $A_1$  and  $A_2 = A_1/\sqrt{2}$  denote the cross sectional areas and  $v_1$  and  $v_2$  the speeds of water at the respective heights separated by distance  $h$  vertically in the illustration. Obtain  $v_1$  in terms of  $h$  and  $g$ , the acceleration due to gravity. [5]

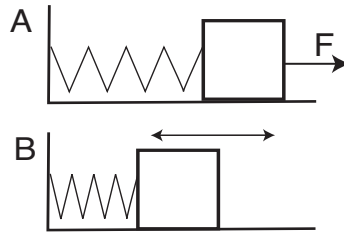


2. A ‘branched U-tube’ illustrated below is filled with a liquid of density  $\rho$ . A force of magnitude  $F$  is pushing the piston in the right column vertically down and the liquid surface on the left columns is pushed up by  $h$ . The cross sectional area of the columns are all  $A$ . Now, the force is increased slightly, and the piston goes down by  $\Delta$ . What is the change of the height of the liquid surfaces in the left columns? (Or, obtain the change in  $h$ , if you can.) [5]



(3 and 4 on the next page)

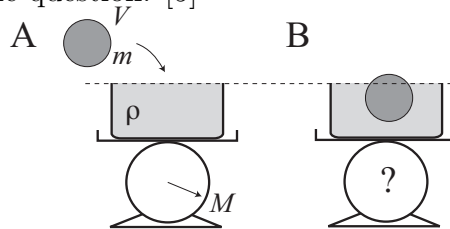
3. A block of mass  $M$  is attached to a wall by a spring with spring constant  $k$ . Initially, a force of magnitude  $F$  pulls the mass to the right as in A. The block is at rest when the force is turned off. What is the maximum kinetic energy  $K_M$  of the block when it oscillates as in B in terms of  $F$  and  $k$ ? Assume that the floor is horizontal and frictionless. [5]



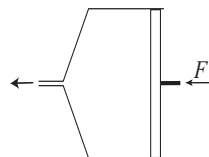
4. A pendulum is made from a string of length 1 m and a small weight of mass  $m = 2$  kg attached to its end. The amplitude of the oscillation is  $A = 0.1$  m. What is the maximum speed of the weight? You may use the small amplitude approximation. [5]

Name: \_\_\_\_\_ Section: \_\_\_\_\_ Score: \_\_\_\_\_/20

1. On a spring scale is a container that contains brimful of a fluid of density  $\rho$  as shown in A. The reading of the scale is  $M$  (kg). Now, a uniform ball of mass  $m$  and volume  $V$  is put in the container as shown in B. The ball floats and the liquid spills over. After removing the spilled fluid, what is the reading of the scale? You may use  $M$ ,  $m$ ,  $V$  and  $g$  (the acceleration due to gravity) to answer the question. [5]



2. A water ejector has a piston of cross sectional area  $100 \text{ cm}^2$  and a small nozzle of cross sectional area  $1 \text{ cm}^2$ . We wish the ejected water to have a speed of  $10 \text{ m/s}$ . What is the magnitude of the required force  $F$ ? The density of water is  $\rho = 1000 \text{ kg/m}^3$ . [5]



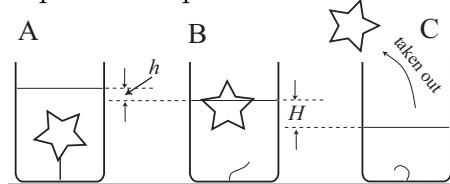
(3 and 4 on the next page)

3. A block of mass  $M = 0.2$  kg on a horizontal and frictionless floor is attached to a wall by a spring with spring constant  $k = 60$  N/m. When its displacement from the equilibrium position is 0.1 m, its speed is 3 m/s. What is the maximum speed of the block?[5]

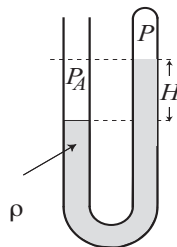
4. A pendulum made of a small mass and a string of length 1 m is gently released from its initial position with a displacement angle of  $5^\circ$ . After how many seconds does the speed of the mass reach its maximum for the first time? [5]

Name: \_\_\_\_\_ Section: \_\_\_\_\_ Score: \_\_\_\_\_/20

1. Totally immersed in a liquid of density  $\rho$  in a cylindrical container is a uniform object tethered to the bottom of the container as illustrated in A. When the tether is cut, the object bobs up to the liquid surface and stays there as shown in B. The liquid surface goes down by a distance  $h$ . When the object is taken out of the container as in C the liquid surface goes down further by a distance  $H$ . What is the density of the object in terms of  $\rho$ ,  $h$  and  $H$ ? (Be sure that the total drop of the liquid surface is  $h + H$  in C from A.) [5]

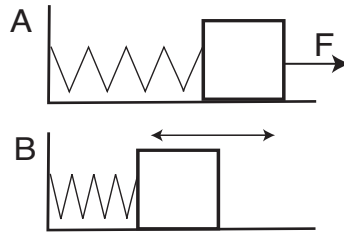


2. One end of a U-tube is closed, and a liquid of density  $\rho$  partially fills it as shown in the figure. The closed end has a vapor pressure  $P$  and the other end is open to the air (the atmospheric pressure is  $P_A$ ). The liquid surface in the closed branch is higher by  $H$  than that in the open branch. Find  $P_A - P$  in terms of  $\rho$ ,  $H$  and  $g$ , the acceleration due to gravity. [5]



(3 and 4 on the next page)

3. A block of mass  $M$  is attached to a wall by a spring with spring constant  $k$ . Initially, a force of magnitude  $F$  pulls the mass to the right as in A. The block is at rest when the force is turned off. What is the maximum magnitude of the acceleration  $a_M$  of the block when it oscillates as in B? Assume that the floor is horizontal and frictionless. [5]



4. A pendulum is made from a string of length 1 m and a small weight of mass  $m$  attached to its end. If we wish to have the same period of the pendulum on Mars as on Earth, what is the required length of the string on Mars? The acceleration due to gravity on Mars is 38% of that on Earth. [5]