PHY 250: Midterm

October 27th, 2020

Name:

Part 1: Test Your Understanding (30 p)

Q1

If the polar ice caps were to completely melt due to global warming, the melted ice would redistribute itself over the earth. This change would cause the length of the day (the time needed for the earth to rotate once on its axis) to

(i) increase;
(ii) decrease;
(iii) remain the same.

Q2

A ball is attached to one end of a piece of string. You hold the other end of the string and whirl the ball in a circle around your hand.

(a) If the ball moves at a constant speed, is its linear momentum constant?

i) Yes,
ii) No.

(b) Is its angular momentum constant?

i) Yes,
ii) No.

Q3

A maintenance crew is working on a section of a three-lane highway, leaving only one lane open to traffic. The result is much slower traffic flow (a traffic jam). Do cars on a highway behave like

(i) the molecules of an incompressible fluid or
(ii) the molecules of a compressible fluid?

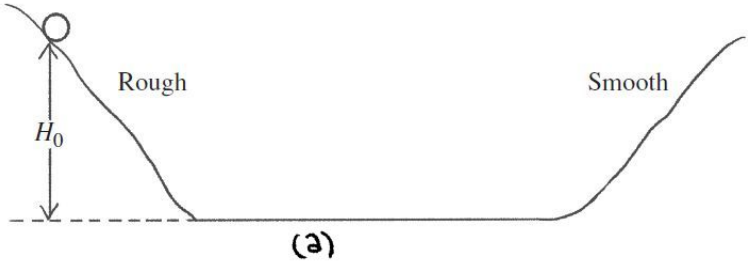
Q4

Mercury is less dense at high temperatures than at low temperatures. Suppose you move a mercury barometer from the cold interior of a tightly sealed refrigerator to outdoors on a hot summer day. You find that the column of mercury remains at the same height in the tube. Compared to the air pressure inside the refrigerator, is the air pressure outdoors

(i) higher,
(ii) lower, or
(iii) the same?

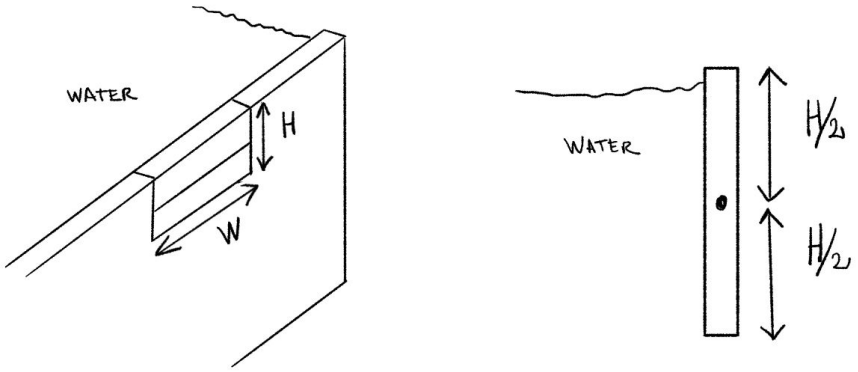
Part 2: Solve exercises (70 p)

Exercise 1



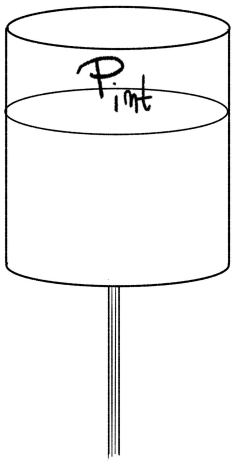
A basketball (which can be closely modeled as a hollow spherical shell) rolls down a mountainside into a valley and then up the opposite side, starting from rest at a height H_0 above the bottom. The rough part of the terrain prevents slipping while the smooth part has no friction. (a) How high, in terms of H_0 will the ball go up the other side? (b) Why doesn't the ball return to height H_0? Has it lost any of its original potential energy?

Exercise 2



The upper edge of a gate in a dam runs along the water surface. The gate is 2.00 m high and 4.00 m wide and is hinged along a horizontal line through its center. Calculate the torque about the hinge arising from the force due to the water. (Hint: calculate the torque on a thin, horizontal strip at a depth h and integrate this over the gate.)

Exercise 3



A closed and elevated vertical cylindrical tank with diameter 2.00 m contains water to a depth of 0.800 m. A worker pokes a circular hole with diameter 0.0200 m in the bottom of the tank. As the water drains from the tank, compressed air above the water in the tank maintains a gauge pressure of 5×10^3 Pa at the surface of the water. Ignore any effects of viscosity. Just after the hole is made, a) Proof that the velocity at the surface is $v_s \simeq 0$ b) What is the speed of the water as it emerges from the hole? c) What is the ratio of this speed to the efflux speed if the top of the tank is open to the air?

Exercise 1

Exercise 2

Exercise 3