CASE WESTERN RESERVE UNIVERSITY
Case School of Engineering

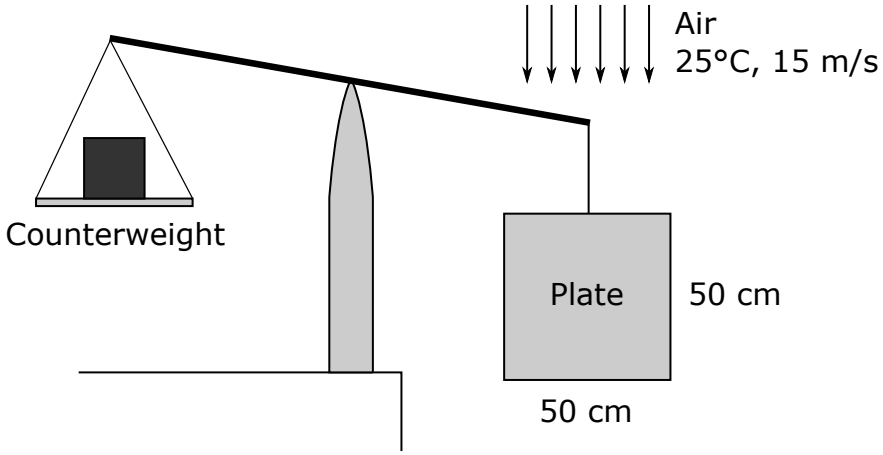
ECHE 225: Fall 2024
Homework #10: External flow
Due: November 13

1. [Chapter 15] An 8-m-diameter hot air ballooon that has a total mass of 400 kg is standing still in air on a windless day. The balloon suddenly is subjected to a 50 km/hr wind. Determine the initial acceleration of the balloon in the horizonal direction.

2. [Chapter 15] To reduce the drag coefficient and thus improve the fuel efficiency of cars, the design of side rearview mirrors has changed dramatically in recent decades from a simple circular plate to a streamlined shape. Determine the amount of fuel and money saved per year as a result of replacing a 15-cm-diameter flat mirror by one with a hemispherical back. Assume the car is driven 25,000 km a year at an average speed of 95 km/hr. Take the density and price of gasoline to be 0.75 kg/L and \$0.90/L, respectively; the heating value of gasoline to be 44,000 kJ/kg and the overall efficiency of the engine to be 30 percent.

3. [Chapter 15] Consider laminar flow of a fluid over a flat plate. Now the freestream velocity is doubled. Determine the change in the drag force on the plate. Assume that the flow remains laminar.

4. [Chapter 15] The weight of a thin flat plate 50 cm x 50 cm in size is balanced by a counterweight that has a mass of 2 kg. Now a fan is turned on and air at 1 atm and 25°C flows downward over both surfaces of the plate (front and back in the sketch) with a freestream velocity of 15 m/s. Determine the mass of the counterweight that needs to be added in order to balance the plate in this case.



5. [Chapter 15] A jumbo jet airplane has a mass of about 400,000 kg when fully loaded with over 400 passengers and takes off at a speed of 280 km/hr. Determine the takeoff speed when the airplane has 100 empty seats assuming that each passenger with luggage is 150 kg and the wing and flap settings are maintained the same.

Answers

1. 2.9 m/s^2
2. 13.1 L/year, \$11.75/year
3. 2.8x increase
4. 13 g
5. 275 km/hr