Seminar 4: Lectures 7-8

Print and answer all questions found below.
Please bring your completed worksheet to the Seminar Class.

Question 1

A seesaw (lever) is 4 meters long and has a pivot point in the center. A child of mass 30 kg sits 1.5 meters from the pivot on one side, and another child of mass 20 kg sits on the opposite side 2m from the pivot.

(a) Calculate the moment of force exerted by each child.

(b) Determine the position where a third child of mass 25 kg should sit on the seesaw to balance it.

(c) If the third child sits 1 meter away from the pivot on the same side as the first child, calculate the net moment and determine if the seesaw is balanced or not.

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Question 2

A cylindrical object with a height of 2 meters and a base area of 0.5 m^2 is floating in water. The density of the object is 600 kg/m^3, and the density of water is 1000 kg/m^3.

(a) Draw a diagram of the object floating in water, indicating the forces acting on it (gravitational force and buoyant force).

(b) Calculate the volume of the object submerged in water.

(c) Determine the buoyant force acting on the object.

(d) If a 100 kg weight is placed on top of the object, calculate the new volume submerged.

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Question 3

A wheelbarrow is used to lift a load of 2000 N with the effort applied at the handles being 500 N. The distance from the wheel (pivot) to the center of the load is 0.5 m, and the distance from the wheel to the handles is 1.5 m.

(a) Calculate the mechanical advantage of the wheelbarrow.

(b) Determine the efficiency of the wheelbarrow if the actual effort required is 600 N.

(c) If the load is increased to 2500 N, what effort is needed to lift it (assume 100% efficiency)?

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Question 4

A hydraulic lift is used to lift a car of mass 1500 kg. The cross-sectional area of the small piston is $0.02\ m^2$ and the large piston is $1\ m^2$.

(a) Calculate the force that must be applied to the small piston to lift the car.
(b) Determine the pressure exerted by the small piston.
(c) If the area of the small piston is reduced to $0.01\ m^2$, what would be the new force required?

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Question 5

Water flows steadily through a horizontal pipe that narrows from a diameter of 10 cm to 5 cm. The speed of the water in the wider section of the pipe is $2\ m/s$. Assume the density of water is $1000 kg/m^3$.

(a) Using the continuity equation, calculate the speed of the water in the narrower section of the pipe.

(b) Apply Bernoulli's equation to find the pressure difference between the two sections (assume that the two sections have no height difference).

(c) If the narrower section of the pipe is 2 m higher than the wider section, how does this affect the pressure difference?

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Question 6

A Venturi meter is used to measure the flow rate of water in a pipe. The diameters of the pipe at the inlet and throat are 10 cm and 5 cm, respectively. The pressure at the inlet is 10^5, and the pressure at the throat is $9 \times 10^4\ Pa$.

(a) Draw a diagram of the Venturi meter, labeling the diameters, pressures, and flow direction.

(b) Calculate the velocity of the water at the inlet and the throat using Bernoulli's equation.

(c) Determine the flow rate through the pipe.

(d) If the pressure difference between the inlet and throat decreases, how will this affect the velocity of the water at the throat? Explain using the Venturi effect.

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Question 7

A ray of light travels from air into a glass slab ($refractive\ index\ n = 1.5$) at an angle of incidence of 30°.

(a) Draw a diagram showing the ray of light incident on the glass slab, the normal line, and the refracted ray. Label the angles of incidence and refraction.
(b) Calculate the angle of refraction inside the glass slab using Snell's law.
(c) Now consider that light goes from the glass to the air. Determine the critical angle for total internal reflection when the light is inside the glass slab and tries to exit into the air.
(d) For the previous case, what happens to the light ray, if the angle of incidence inside the glass slab is greater than the critical angle? Describe the phenomenon and its applications.

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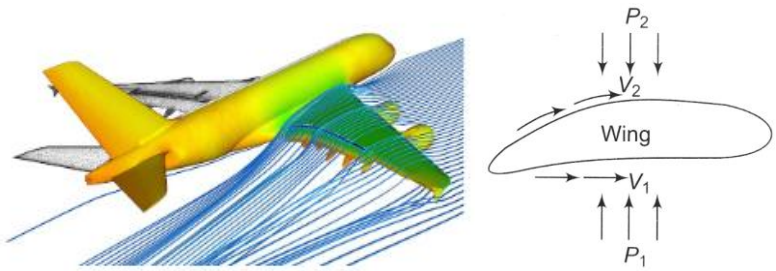
Question 8

Lift on an airplane. Air flows horizontally past a small airplane's wings such that the speed is 70 m/s over the top surface and 60 m/s under the bottom surface. If the plane has a mass of 1340 kg and a wing area of 16.2 m^2, what is the net vertical force (including the effects of gravity) on the airplane? The density of the air is 1.20 kg/m^3.



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Extension Questions

Question 9

A cube of side length 10.0 cm and made of unknown material floats at the surface between water and oil. The oil has a density of 810 kg/m^3. If the cube floats so that it is 72% in the water and 28% in the oil (hence it is completely submerged), what is the mass of the cube and what is the buoyant force on the cube?

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Question 10

A person whose eyes are 1.64 m above the floor stands 2.30 m in front of a vertical plane mirror whose bottom edge is 38 cm above the floor, as shown in the figure below. What is the horizontal distance *x* to the base of the wall supporting the mirror of the nearest point on the floor that can be seen reflected in the mirror?

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Question 11

A fish tank has dimensions 36 cm wide by 1.0 m long by 0.60 m high. If the filter should process all the water in the tank once every 4.0 h, what should the flow speed be in the 3.0 cm diameter input tube for the filter?