

NATIONAL EXAMINATIONS, December 2008, 04-BS-7, Mechanics of Fluids

National Examinations December 2008

04-BS-7, Mechanics of Fluids

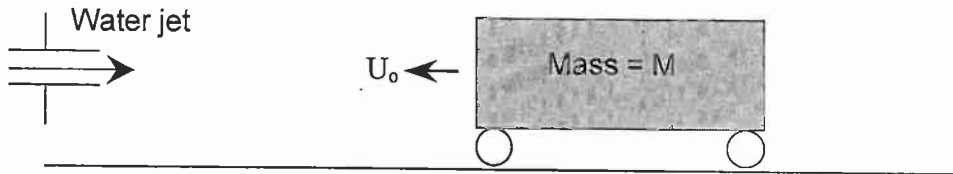
3 hours duration

NOTES:

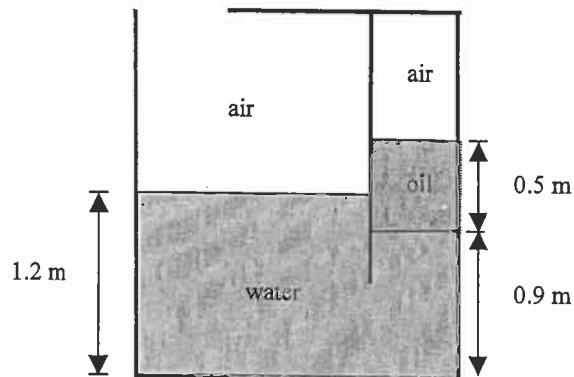
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam. No aids other than a CASIO or a SHARP electronic calculator is permitted.
3. Any data required are given with the questions or are listed in point 7 below.
4. All questions have equal value.
5. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book(s) will be marked. Indicate clearly any questions you do not wish to have marked.
6. Neat sketches, wherever possible, should accompany your solutions. All calculations must be clearly shown.
7. Unless otherwise stated, assume that the density of water ρ is 1000 kg/m^3 and the acceleration due to gravity is 9.81 m/s^2 .
8. One $8 \frac{1}{2}$ inches by 11 inches aid sheet (both sides) is permitted.

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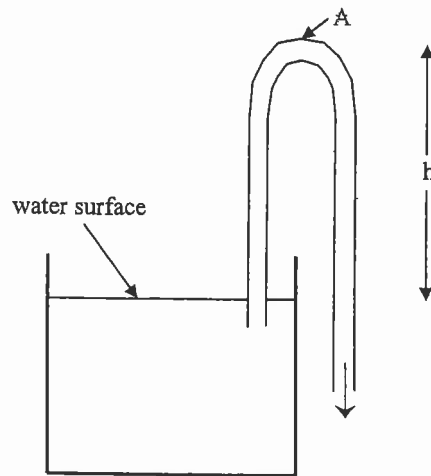
1. As shown in the figure below, a block (mass = M) is rolling without resistance with a velocity U_0 . At time = 0, the block is subjected to a horizontal water jet (density ρ , velocity V_{jet} , and cross-sectional area A_{jet}) which acts to slow the block's motion.
 - a) Develop an algebraic expression for the deceleration of the block as a result of the water jet.
 - b) At what time will the velocity of the block be zero?



2. The partitioned tank shown below contains air, water, and oil ($\rho_{oil} = 827 \text{ kg/m}^3$). The left compartment of air is open to the atmosphere.
 - a) Calculate the pressure of the air in the top right section of the tank.
 - b) What pressure would the air in the top right section need to be increased to in order to have the upper surface of the oil at a height of 1.2 m?



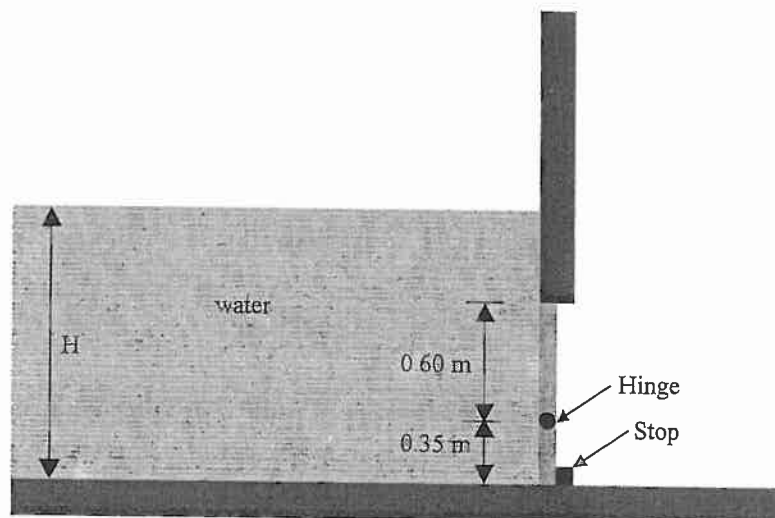
3. Water flows through a smooth siphon at a flow rate $0.002 \text{ m}^3/\text{s}$. The fluid temperature is 20°C (which yields a saturation pressure of 2.34 kPa). The pipe diameter is 15 mm . The viscosity of water is $\mu = 9.0\text{E-}04 \text{ Ns/m}^2$ and atmospheric pressure is 101 kPa .
- Assuming inviscid flow, what is the maximum height, h , that the top of the siphon can be above the fluid surface while ensuring that the pressure at point A is still above the saturation pressure?
 - If major losses (i.e., friction at the wall) are included, what will the value of h be? You may neglect the effect of losses in the section of pipe immersed in the water and the effect of the pipe curvature near the top of the siphon. You may use the attached Moody Diagram to assist in this calculation.



4. Water flows between two large horizontal plates. The upper plate moves to the left at a speed of 0.2 m/s , while the bottom plate is stationary. The fluid is subjected to a pressure gradient dP/dx . The plates are separated by a distance of 4 mm . The viscosity of water is $\mu = 9.0\text{E-}04 \text{ Ns/m}^2$. You may assume that the flow is laminar and one-dimensional.
- Solve for the one-dimensional velocity profile between the plates.
 - Calculate the pressure gradient that is required to ensure that there is zero net flow at a cross-section.

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5. Experiments show that the drag on a sphere depends on the fluid viscosity (μ) and density (ρ), the diameter of the sphere (D), and the velocity of the freestream (U_∞).
- Use Buckingham-Pi theorem to develop the corresponding dimensionless groups for evaluation of fluid drag
 - Suppose that you wish to design a large tethered weather balloon and you need to know what the drag on the balloon will be for an air velocity of 6 m/s. A $\frac{1}{25}$ scale model is developed to be tested in water ($\rho=1000 \text{ kg/m}^3$, $\mu=9.0\text{E-}04 \text{ Ns/m}^2$). The properties of air are: $\rho=1.2 \text{ kg/m}^3$, and $\mu=1.8\text{E-}05 \text{ Ns/m}^2$.
 - What water velocity will be required test the model?
 - If the model drag is found to be 3kN, find the corresponding drag on the actual weather balloon.
6. A high rise building (200 m high) requires water at a rate of 200 litres/min. The water is pumped through a smooth pipe from ground level into a storage tank at the top of the building. The storage tank is at atmospheric pressure. City water is available at ground level at a pressure of 300 kPa (gauge).
- Calculate the minimum pipe diameter to keep the fluid velocity below 3.5 m/s.
 - What pressure rise across the pump is required to meet these flow requirements? You may use the attached Moody diagram to assist with this problem. The viscosity of water is $\mu = 9.0\text{E-}04 \text{ Ns/m}^2$ and the density is 1000 kg/m^3 .
 - For a pump efficiency of 70%, what is the required power to drive the pump?
7. A rectangular gate of width 2.5 m is hinged as shown in the diagram below. Calculate the depth H at which the gate will begin to open.



pipe friction chart

applicable to circular pipes running full

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