ENGINEERING 4020

MARINE FLUID DYNAMICS

HOME WORK #1

A certain submarine has a length L equal to 25m and a diameter D equal to 5m. Its cruising speed is 25 knots. Data from a 1:10 scale model suggests that when the submarine is operating well below the water surface its drag coefficient is 0.1. What would be the drag on the prototype? What should be the speed of the model submarine in this case? Is it realistic? What should be the speed of the model submarine when it is operating close to the water surface? Is it realistic?

A tube shaped streamlined instrumentation pod is observed to free fall through the water. Its diameter is 0.5m. Its drag coefficient is 0.1. The difference between the weight of the pod and its buoyancy is 1000N. What would be the terminal speed of the pod?

A certain oil rig sits in waves with period T. The characteristic dimension of the rig is D. Derive a wave period coefficient for the rig. [Hint: g] Deep water wave theory gives the following connection between wave period T and wavelength λ: $T=\sqrt{[2\pi\lambda/g]}$. What does this suggest about the ratio D/λ?

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HOME WORK #2

In the hydraulic transients lab, a pressure sensor was placed flush with the pipe wall just upstream of the valve. Imagine a setup where the sensor was placed at the end of a small tube attached to the pipe. Using wave reflection concepts, describe what happens in the tube when the valve in the pipe is suddenly shut. What would be the maximum pressure generated inside the tube? Assume that the wave speed for the pipe is 1000m/s and the wave speed for the tube is 500m/s. Also assume that, for the pipe, the initial pressure is 1BAR absolute and the initial flow speed is 0.5m/s. The initial pressure in the tube is also 1BAR.

Using wave reflection concepts, describe what happens when a stable leaky valve is suddenly shut. Using wave reflection concepts, describe what happens when an unstable leaky valve is suddenly shut.

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HOME WORK #3

A steel brace tube on a certain exploration rig has a length L=10.0m and an OD=1.0m and an ID=0.98m. What current speed would cause the tube to undergo 1st mode resonance due to vortex shedding? Assume that the tube has clamped-clamped supports and has air inside. Imagine now that the tube had a square cross section. What current speed would cause galloping? For this, assume that the damping factor for the tube is 0.05.

A certain marine riser tube bundle has steel tubes with an OD=0.15m and an ID=0.14m. The distance between the tube supports is 5.0m. There is oil inside the tubes. The damping factor for the bundle is 0.15 and the bundle factor is 5. What current speed would cause the tubes to vibrate? Assume that the tubes have pivot supports. Repeat the calculation for the case where the tubes have clamped-clamped supports.

What internal oil flow speed would cause a tube in the marine riser to buckle? Assume pivot supports and zero gage pressure and tension. What internal oil flow speed would cause a tube in the riser to undergo whip? Assume the tube is a cantilever beam 5m long.

The certain sail is made from nylon 2mm thick. It has a tension of 500N per meter width. What wind speed on one side of it would cause the sail to flutter?

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HOME WORK #4

A certain supertanker has straight sides which are 250m long. The draft of the tanker is 25m and its beam is 50m. Its cruising speed is 25 knots. Calculate the side wall drag on the tanker. The wake drag coefficient is 0.05. Calculate the wake drag on the tanker. Calculate the power to overcome these drags. What is the wave drag on a typical supertanker?

A certain hydrodynamic lubrication bearing for a ship has 4 pads. The pads are narrow and the outer and inner edges are blocked. Develop an equation for the circumferential variation of pressure in each pad. Develop an equation for the total load supported by the pads. Let the wedge angle of the pads be 60 degrees. Let the outer radius be 1.5m, the inner radius be 1.0m, the front gap be 1.5mm and the back gap be 0.5mm. Let the density of the bearing oil be 880 kg/m^3 and its viscosity be 0.15 Ns/m^2. Let the RPM of the propeller shaft be 100. What is the load?

Imagine that you have a propeller that has 4 wedge shaped flat blades. Let the wedge angle be 60 degrees and let the angle of attack of the blades be 10 degrees. Let the hub radius of each blade be 0.5m and let the tip radius be 1m. The RPM of the propeller is 250. Estimate the total thrust of the propeller.

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HOME WORK #5

A closed loop of copper pipe is used to heat a room in the winter and cool it in the summer. A pump in the loop moves water through the loop. The total length of pipe in the loop is 20m. The diameter of the pipe is 1cm. There are forty 180° bends in the loop. The flow rate is 5 GPM. Sketch the system demand curve. Determine the pump power. What type of pump should be used in the loop? Repeat the calculations for the case where the pipe diameter is doubled to 2cm. Repeat the calculations for the case where the pipe diameter is cut in half to 0.5cm. Comment on the results.

A certain jet propulsion unit for a boat takes in water at the speed of the boat and throws it out at twice the speed of the boat. The volumetric flow rate through the unit is 60 GPM. The outlet pipe diameter is 5cm. Determine the speed of the boat. Determine the thrust generated by the unit.