CE 376 HOMEWORK 7

1) In flow past a flat plate, the boundary layer thickness δ varies with distance *x*,free stream velocity *U*, viscosity μ, and density ρ. Find the dimensionless parameters for this problem.

(Answer: $\Pi_1 = \frac{\delta}{x}; \Pi_2 = \frac{\rho Ux}{\mu}$)

2) The lift force *F* on a missile is a function of its length *L*, velocity *V*, diameter *D*, angle of attack α, density, viscosity μ, and speed of sound *a* of the air. Find the dimensionless parameters for this problem.

(Answer : $\frac{F}{\rho V^2 L^2} = f\left(\alpha, \frac{\rho VL}{\mu}, \frac{L}{D}, \frac{V}{a}\right)$)

3) A one-fifteenth-scale model of a parachute has a drag of 2000 N when tested at 5 m/s in a water tunnel. If Reynolds-number effects are negligible, estimate the terminal fall velocity at 1500 m standard altitude of a parachutist using the prototype if parachute and parachutist together weigh 900 N. Neglect the drag coefficient of the woman. (Take ρ_{air} = 1 kg/m^3)

(Answer = 7.07 m/s)

4) The power *P* generated by a certain windmill design depends upon its diameter *D*, the air density ρ, the wind velocity *V*, the rotation rate Ω, and the number of blades *n*.
(a) Write this relationship in dimensionless form. A model windmill, of diameter 50 cm, develops 2.7 kW at sea level when *V* = 40 m/s and when rotating at 4800 rev/min.
(b) What power will be developed by a geometrically and dynamically similar prototype, of diameter 5 m, in winds of 12 m/s at 2000 m standard altitude?
(c) What is the appropriate rotation rate of the prototype?
(Take; ρ_{air} = 1.0067 kg/m^3 at 2000m altitude and ρ_{air} = 1.2255 kg/m^3 at sea level)

Answer: a) $\frac{P}{\rho D^2 V^3} = f\left(\frac{\Omega D}{V}, n\right)$; b) P_{proto} = 5990 W; c) Ω_{proto} = 144 rev/min

5) A simply supported beam of diameter *D*, length *L*, and modulus of elasticity *E* is subjected to a fluid crossflow of velocity *V*, density ρ , and viscosity μ . Its center deflection δ is assumed to be a function of all these variables. Rewrite this proposed function in dimensionless form.

Answer: $\frac{\delta}{L} = f\left(\frac{L}{D}, \frac{\rho VD}{\mu}, \frac{E}{\rho V^2}\right)$

6) A prototype ocean-platform piling is expected to encounter currents of 150 cm/s and waves of 12-s period and 3-m height. If a one-fifteenth-scale model is tested in a wave channel, what current speed, wave period, and wave height should be encountered by the model?
Answer: 39 cm/s, 3.1 s, 0.20 m

7) A prototype spillway has a characteristic velocity of 3 m/s and a characteristic length of 10 m. A small model is constructed by using Froude scaling. What is the minimum scale ratio of the model which will ensure that its minimum Weber number is 100? Both flows use water at 20°C. [$We = \rho V^2 L / \sigma$, σ : Surface tension, (for water = 0.073 N./m)]
Answer : 1/111

8) A dam spillway is to be tested by using Froude scaling with a one-thirtieth-scale model. The model flow has an average velocity of 0.6 m/s and a volume flow of 0.05 m^3/s. What will the velocity and flow of the prototype be? If the measured force on a certain part of the model is 1.5 N, what will the corresponding force on the prototype be?
Answer: 246 m^3/s ; 40500 N

CE 376 HOMEWORK 8

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Answer: a) $\frac{P}{\rho D^2 V^3} = f\left(\frac{\Omega D}{V}, n\right)$; b) P_{proto} = 5990 W; c) Ω_{proto} = 144 rev/min

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Answer: 39 cm/s, 3.1 s, 0.20 m

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Answer : 1/111

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Answer: 246 m^3/s ; 40500 N