Assignment-11

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I. 2023-AE 53-65

53) Consider a thin-walled cylindrical pressure vessel made of an alloy with yield strength of 300 MPa. The vessel has end caps to contain the pressure. The ratio of radius of the vessel to its wall thickness is 100. As per the von Mises yield criterion, the internal pressure that would cause the failure of the vessel is _____ MPa. (round off to two decimal places)

54) Consider the differential equation

$$x^2\frac{d^2y}{dx^2} + 4x\frac{dy}{dx} + 2y = 0$$

for $x \geq 1$ with initial conditions $y = 0$, $\frac{dy}{dx} = 1$ at $x = 1$. The value of y at $x = 2$ is _____.(round off to two decimal places)

55) The operating characteristics of a pump were measured to be $C_p = a\Phi^2$, where power coefficient $C_p = \frac{P}{\rho\omega^3 D^5}$, Φ is the flow coefficient, a is a constant, D is a length scale, ω is the rotation rate, ρ is fluid density, and P is the power required. The flow coefficient is a dimensionless volume flow rate scaled with ω and D . Assuming that the flow rate remains the same, if the rotation rate is increased to 1.25ω, the power changes to αP. The value of α is _____ . (round off to two decimal places)

56) A thin cambered airfoil has lift coefficient $C_l = 0$ at an angle of attack $\alpha = -1.1°$. Assuming that stall occurs at much larger α, the C_l at $\alpha = 4°$ is _____. (round off to two decimal places)

57) In a potential flow, a uniform stream of strength U directed along the x-axis and four line sources (2-dimensional) of strengths $\frac{\pi}{2}, -\frac{\pi}{3}, \frac{\pi}{4}, -\frac{\pi}{5}$ are placed along the x-axis at $x = 0, 1, 2$ and 3, respectively. The strength of an additional line source to be placed at $x = 4$ such that a closed streamline encircles all five sources is _____. (round off to two decimal places).

58) Enstrophy is defined as the square of the magnitude of vorticity. For the three-dimensional velocity field

$$\mathbf{V} = (4x - 1.5y + 2.5z)\,\hat{i} + (1.5x - 1.5y)\,\hat{j} + (0.7xy)\,\hat{k},$$

the enstrophy at location $(1, 1, 1)$ is _____. (round off to two decimal places).

59) An airplane with wing planform area of 20 m^2 and weight 8 kN is flying straight and level with a speed of 100 m/s. The total drag coefficient is 0.026 and the air density is 0.7 kg/m^3. The total thrust required to introduce a steady climb angle of 0.1 radians is _____ N. (round off to the nearest integer)

60) The maximum permissible load factor and the maximum lift force coefficient for an airplane is 7 and 2, respectively. For a wing loading of 6500 N/m^2 and air density 1.23 kg/m^3, the speed yielding the highest possible turn rate in the vertical plane is _____ m/s. (round off to the nearest integer)

61) A gas turbine combustor is burning methane and air at an equivalence ratio $\phi = 0.5$, where $\phi = \frac{F/A}{[F/A]_{stoich}}$ and $[F/A]_{stoich}$ is the ratio of mass flow rate of fuel to the mass flow rate of air at stoichiometry. If the air flow rate is $\dot{m}_{\text{air}} = 20$ kg/s then the mass flow rate of methane is _____ kg/s. (round off to two decimal places)

62) The universal gravitational constant is 6.67×10^{-11} Nm^2/kg^2. For a planet of mass 6.4169×10^{23} kg and radius 3390 km, the escape velocity is _____ km/s. (round off to one decimal place).

63) A satellite is in a circular orbit around Earth with a time period of 90 minutes. The radius of Earth is 6370 km, mass of Earth is 5.98×10^{24}kg and the universal gravitational constant is 6.67×10^{-11}

Nm^2/kg^2. The altitude of the satellite above mean sea level is _____ km. (round off to the nearest integer)

64) A centrifugal air compressor has inlet root diameter of 0.25 m and the outlet diameter of the impeller is 0.6 m. The pressure ratio is 5.0. The air at the inlet of the rotor is at 1 atm and 25°C. The polytropic efficiency is 0.8 and slip factor is 0.92. Use C_p = 1.004 kJ/kg-K and γ = 1.4. The impeller speed in revolutions per minute (RPM) is _____. (round off to the nearest integer)

65) Consider a cryogenic liquid rocket engine using an expander cycle with liquid hydrogen and liquid oxygen as the two propellants. The mass flow rate of hydrogen $\dot{m}_{H_2}$ into the combustion chamber is 32 kg/s , and the mass flow rate of oxygen $\dot{m}_{O_2}$ into the chamber is such that $\dot{m}_{O_2}/\dot{m}_{H_2}$ = 8. The combustion of hydrogen and oxygen is at stoichiometry. Assuming that the rate of the forward reaction is much larger than that of the reverse reaction, the rate of formation of H_2O is _____ kmol/s. (round off to the nearest integer)