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40) A structural member of rectangular cross-section 10 mm $\times$ 6 mm and length 1 m is made of steel (Young's modulus is 200 GPa) (coefficient of thermal expansion is $12 \times 10^{-6}/°\text{C}$). It is rigidly fixed at both ends and then subjected to a gradual increase in temperature. Ignoring the three-dimensional effects, the structural member will buckle if the temperature is increased by ΔT °C, which is
   a) 19.74
   b) 9.87
   c) 78.96
   d) 39.48
41) A gas cylinder (closed thin-walled cylindrical pressure vessel) of diameter 30 cm and wall thickness 1 mm is subjected to a design maximum internal pressure of 5 bar (0.5 MPa). The material used for manufacturing this cylinder has a failure stress of 260 MPa. Assuming von Mises failure criterion, the factor of safety (with respect to maximum allowable stress) for this cylinder is
   a) 2.8
   b) 2.0
   c) 6.9
   d) 4.0
42) A cantilevered beam is subjected to a parabolic distribution of shear traction at the right edge while the top and bottom surfaces are traction-free. To solve this problem, the following Airy's stress function is proposed: $\phi = C_1xy + C_2xy^3 + C_3x^2y^2 + C_4x^3y$. This is an admissible Airy's function that would satisfy the biharmonic equation as well as the boundary conditions if and only if
   a) $C_1 = 0$, $C_2 = \lambda$, $C_3 = 0$, $C_4 = \frac{\lambda}{3d^2}$
   b) $C_1 = \lambda$, $C_2 = \frac{\lambda}{3d^2}$, $C_3 = 0$, $C_4 = 0$
   c) $C_1 = 0$, $C_2 = 0$, $C_3 = \lambda$, $C_4 = -\frac{\lambda}{3d^2}$
   d) $C_1 = \lambda$, $C_2 = -\frac{\lambda}{3d^2}$, $C_3 = 0$, $C_4 = 0$
43) A 1 kg mass is hanging from a spring with stiffness 500 N/m attached to a massless, symmetric beam of length 0.6 m, moment of inertia about the bending axis $I = 8.33 \times 10^{-10}$ m^4, and Young's modulus $E = 210$ GPa as shown in the figure. The fundamental natural frequency $\left(\frac{rad}{s}\right)$ of the system is
   a) 3.24
   b) 20.36
   c) 22.36
   d) 3.56
44) A single degree of freedom system is vibrating with an initial (first cycle) amplitude of 5 cm. The viscous damping factor associated with the vibrating system is 2%. The vibration amplitude of the fifth cycle (in cm) is
   a) 1.65
   b) 4.41
   c) 2.67
   d) 3.02
45) A cruise missile with an **ideal** ramjet engine is flying at Mach 4.0 at an altitude where the ambient temperature is 100 K. Consider the ratio of specific heats $\gamma = 1.4$ and specific gas constant $R = 287$ J/kg K. If the stagnation temperature in the combustion chamber is equal to 2310 K, the speed of the exhaust gases is $\cdots$
46) A gas turbine engine is operating under the following conditions:
   - Stagnation temperature at turbine inlet: 1350 K
   - Stagnation pressure at turbine inlet: 10 bar
   - Static temperature at turbine exit: 800 K
   - Velocity at turbine exit: $200\frac{m}{s}$
   - Total-to-total efficiency of turbine: 0.96
   - γ (ratio of specific heats): 1.33
   - C_p (specific heat at constant pressure): $1.147\frac{kJ}{kgK}$

   The stagnation pressure (in bar) in the nozzle (considering an isentropic nozzle) is equal to $\ldots$
47) Air at a stagnation temperature of 300 K (ratio of specific heats, $\gamma = 1.4$)and

$\left(\text{specific gas constant} R = 287 \frac{J}{kgK}\right)$ enters the impeller of a centrifugal compressor in axial direction. The stagnation pressure ratio between the diffuser outlet and impeller inlet is 4.0. The impeller blade radius is 0.3 m and it is rotating at 15000 revmin. If the slip factor σ ratio of tangential component of air velocity at the blade tip to the blade tip speed is 0.88, the overall efficiency (total-to-total) of the compressor $(in\%)$ is

48) A stationary two-stage rocket with an initial mass of 16000 kg, carrying a payload of 1000 kg, is fired in a vertical trajectory from the surface of the earth. Both stages of the rocket have the same specific impulse, I_p, of 300 s and the same structural coefficient of 0.14. The acceleration due to gravity is $9.8 \frac{m}{s^2}$. Neglecting drag and gravity effects and considering both stages with the same payload ratio, the terminal velocity attained by the payload in m/s is

49) An aircraft is flying at Mach 3.0 at an altitude where the ambient pressure and temperature are 50 kPa and 200 K, respectively. If the converging-diverging diffuser of the engine (considered isentropic with a ratio of specific heats, $\gamma = 1.4$) and (specific gas constant $R = 287$ J/kg K) has a throat area of 0.05 m^2, the mass flow rate through the engine in $\frac{kg}{s}$ is

a) 197
b) 232
c) 790
d) 157

50) A cryogenic rocket has a specific impulse of 455 s and a characteristic velocity of $2386 \frac{m}{s}$. The value of the thrust coefficient for this rocket is

a) 1.78
b) 1.73
c) 1.87
d) 1.95

51) For a given airplane with a given wing loading executing a turn in the vertical plane, under what conditions will the turn radius be minimum and the turn rate be maximum?

a) Highest possible C_L and lowest possible load factor
b) Lowest possible C_L and lowest possible load factor
c) Lowest possible C_L and highest possible load factor
d) Highest possible C_L and highest possible load factor

52) Lift-off distance for a given aircraft of weight W is S_{LO}. If the take-off weight is reduced by 10%, then the magnitude of percentage change in the lift-off distance (assuming all other parameters to remain constant) is