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1) Let matrix $[A] = \begin{pmatrix} 2 & -6 \\ 0 & 2 \end{pmatrix}$. Then for any non-trivial vector $\{x\} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$, which of the following is true for the value of $K = \{x\}^T [A] \{x\}$:

   a) K is always less thean zero
   b) K is always greater than zero
   c) K is non-negative
   d) K can be anything

2) consider the initial value problem:

$$\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 6y = f(t) ; y(0) = 2, \left(\frac{dy}{dt}\right)_{t=0} = 1$$

   If $Y(s) = \int_0^\infty y(t) e^{-st} dt$ and $F(s) = \int_0^\infty f(t) e^{-st} dt$ are the Laplace transforms of $y(t)$ and $f(t)$ ly, then $Y(s)$ is given by:

   a) $\frac{F(s)}{(s^2+4s+6)}$

   b) $\frac{F(s)+2s+9}{(s^2+4s+6)}$

   c) $\frac{F(s)}{(-s^2+4s+6)}$

   d) $\frac{F(s)-2s+9}{(s^2+4s+6)}$

3) Let u(x, t) denote the displacement of a point on a rod. The displacement satisfies the following w=equation of motion:

$$\frac{\partial^2 u}{\partial t^2} - 25\frac{\partial^2 u}{\partial x^2}, 0 < x < 1$$

   with $u(1,0) = 0.01\sin(10\pi x)$, $\frac{\partial u}{\partial t}(x,0) = 0$; $u(0,t) = 0$, $u(1,t)$. The value of $u(0.25, 1)$ is _____ (in two decimal places).

4) The equation

$$x\frac{d^2y}{dx^2} + 5x\frac{dy}{dx} + 4y = 0$$

   has a soultion $y(x)$ that is :

   a) A polinomial in x
   b) Finite series in terms of non -integer fractional powers of x
   c) Consists of negative integer powers of xx and logarithmic function of x
   d) Consists of exponential functions of x

5) Consider a straight wing with rectangular platform of aspect ratio 10 and with a NACA 0012 airfoil. The span effectiveness factor for this wing is 0.95. Assume the flow to be incompressible and governed by thin airfoil theory. The lift coefficient of this wing, at an angle of attack of 6°, is _____ (in two decimal places).

6) Consider an incompressible flow over a flat plate with the following approximation to the velocity profile:

$$\frac{u(y)}{U} = \begin{cases} \frac{y}{\delta} & \text{for } y \leq \delta \\ 1 & \text{for } y > \delta \end{cases}$$

where δ is the boundary layer thickness and U the free-stream speed. The normalized momentum thickness $\left(\frac{\theta}{\delta}\right)$ for this profile is _____ (in two decimal places).

7) An idealized velocity field is given by $\mathbf{V} = 4tx\hat{i} - 2t^2 y\hat{j} + 4xz\hat{k}$. At point $(-1, 1, 0)$ and at $t = 1$, the magnitude of the material acceleration vector of the fluid element is _____.

8) A trace from the schlieren photograph of the flow around a corner reveals the edges of the expansion fan as shown below. The leading and trailing edges of the expansion fan make the angles as shown. Assuming $\gamma = 1.4$, the angle of the expansion fan (in degrees) is _____ (in two decimal places).

Pradtl Meyer function is given by

$$v(M) = \sqrt{\frac{\gamma+1}{\gamma+1}}\,\tan^{-1}\left(\sqrt{\frac{\gamma-1}{\gamma+1}(M^2-1)}\right) - \tan^{-1}\left(\sqrt{M^2-1}\right)$$
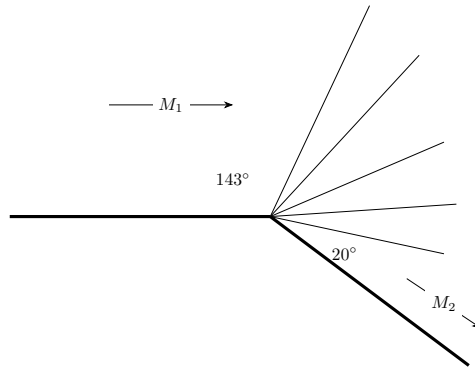

9) A strong normal shock wave, with a pressure ratio of 29 across it, is traveling into stationary air $(\gamma = 1.4)$ at $T = 280K$ in a straight duct (*see figure*). The magnitude of the velocity of the air induced behind the shock wave is _____ m/s. (in two decimal places). (Gas constant = $287 J/kg.K$; Shock wave relations:

Pressure ratio: $\dfrac{p_1}{p_2} = 1 + \dfrac{2\gamma}{\gamma+1}\left(M^2 - 1\right)$; Density ratio: $\dfrac{\rho_2}{\rho_1} = \dfrac{(\gamma+1)M^2}{\gamma - 1M^2 + 2}$

)

Duct   Shock wave
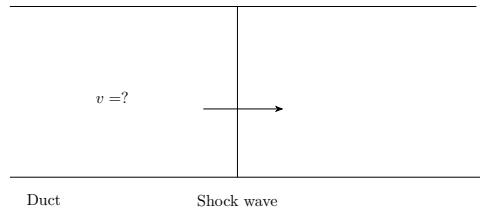
10) In the figure below, water exits from a nozzle into atmospheric pressure of $101kPa$. If the exit velocity id $V_2 = 8m/s$ and friction is neglected, the magnitude of the axial force on the flange at location 1 required to keep the nozzle attached to the pipe is _____N (in two decimal places).
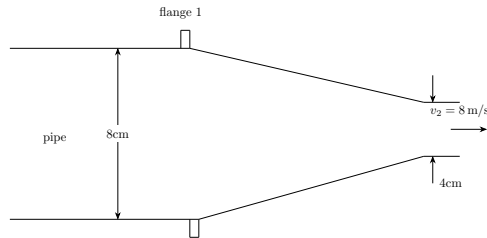
11) A football meant to be thrown at $100km/h$ in sea level air $\left(\rho = 1.22kg/m^3, \mu = 1.78x10^{-5}N - s/m^2\right)$, is to be tested using a one-quarter scale model in a water tunnel $\left(\rho = 1000kg/m^3, \mu = 10^{-3}N - s/m^2\right)$. For dynamic similarity, the ratio of the model force to the prototype force is _____ (in two decimal places).

12) An aircraft model was tested in a low speed wind-tunnel $\left(\text{Reynolds number} = 2x10^6 \text{ based on wing mean chord.}\right)$ The variation of pitching moment coefficient (C_m) with angle of attack (α) for two elevator deflections (δ_e) as recorded during this test is presented below. Based on the result presentes in the
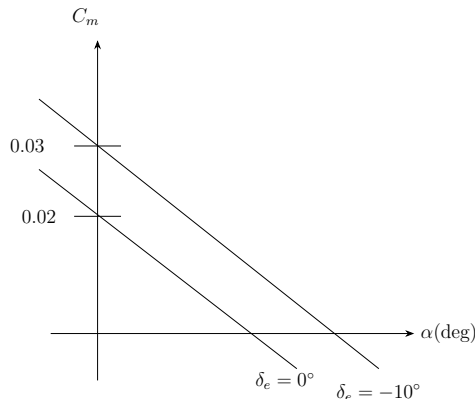

figure above, the value of elevator control power $(C_{m\delta e})$ in per radian will be _____

(in two decimal places).

13) A pilot was flying a single-engine propeller aircraft and maintaining a steady level flight at a lift coefficient, $C_L = 0.5$ at an altitude of $500m$. Due to some emergency, at the same altitude ($500m$), the pilot had to fully deploy the landing gear. If the pilot wants to maintain steady level flight at the same $CF_L = 0.5$ and at the same altitude, which of the following control actions should the pilot undertake:

a) Move the elevator up, and decrease the throttle
b) Move the elevator up, and increase the throttle
c) Move the elevator down, and decrease the throttle
d) Move the elevator down, and increase the throttle