1. Optimization problem for designing the stiffest bar for a given volume can be written as :

$$\underset{A(x)}{Min}\, SE = \int_0^L \frac{1}{2} EAu'^2 dx$$

Subject to

$$\lambda : (EAu')' + p = 0$$

$$\Lambda : \int_0^L A dx \le V^*$$

Select the adjoint equation for the above problem.

a) $(EA\lambda')' = -(EAu')'$

b) $(EA\lambda')' = (EAu')'$

c) $(EA\lambda')' = pu$

d) $(EA\lambda')' = -pu$

2. For constant axial load throughout the length of the bar, the area profile of a stiffest bar for a given volume…

a) varies as the cube of x along the x-axis
b) varies as the square of x along the x-axis
c) varies linearly along the x-axis
d) is uniform along the x-axis

3. Which of the following statements about area profile of a stiffest bar for a given volume is false?

a) Lagrange multiplier function corresponding to the equilibrium equation is equal to axial deformation.
b) Optimal area profile is independent of the load.
c) Axial strain in the bar is a constant throughout the bar.
d) The bar is uniformly stressed.

4. Solve the problem with $J = \int_0^L pudx$ minimized instead of $SE = \int_0^L \frac{1}{2} EAu'^2 dx$ in the optimization problem to find the stiffest bar for a given volume. Which of the following change(s)?

a) Only the design equation.
b) Only the adjoint equation.

c) Both design and adjoint equations.
d) None of the above.

5.Which of the following mathematical concepts would you need to arrive at Euler-Lagrange equations for a functional with three independent variables ?

a) Divergence theorem
b) Fundamental lemma of calculus of variations
c) First variation of a functional at optimum should be zero
d) All of the above

6. Which of the following represents Euler-Lagrange equation for $F(z, z_x, z_y)$?

a)
$$\frac{\partial F}{\partial z} - \frac{d}{dx}\left(\frac{\partial F}{\partial z_x}\right) = 0$$
$$\frac{\partial F}{\partial z} - \frac{d}{dy}\left(\frac{\partial F}{\partial z_y}\right) = 0$$

b)
$$\frac{\partial F}{\partial z} + \frac{d}{dx}\left(\frac{\partial F}{\partial z_x}\right) = 0$$
$$\frac{\partial F}{\partial z} + \frac{d}{dy}\left(\frac{\partial F}{\partial z_y}\right) = 0$$

c) $$\frac{\partial F}{\partial z} - \frac{d}{dy}\left(\frac{\partial F}{\partial z_x}\right) - \frac{d}{dx}\left(\frac{\partial F}{\partial z_y}\right) = 0$$

d) $$\frac{\partial F}{\partial z} - \frac{d}{dx}\left(\frac{\partial F}{\partial z_x}\right) - \frac{d}{dy}\left(\frac{\partial F}{\partial z_y}\right) = 0$$

7. Identify the equation obtained by minimizing $\int \left\{ \frac{1}{2}\left[\left(\frac{\partial \phi(x,y)}{\partial x}\right)^2 + \left(\frac{\partial \phi(x,y)}{\partial y}\right)^2 \right] + f(x,y)\phi(x,y) \right\} dxdy = 0$.

a) Laplace's Equation in 2D
b) Poisson's Equation in 2D
c) Laplace's Equation in 3D
d) Poisson's Equation in 2D

Study the Matlab code provided, BarOpt2.m, and answer questions from 8-10.

8. Identify the boundary condition corresponding to the Matlab variables:

dispID=[n+1];

dispVal=[0];

a) free-fixed
b) fixed-fixed
c) free-free
d) fixed-free

9. Which of the following Matlab script definition gives a uniform distributed force ?

a. F = 10*ones(n+1,1)
b. F(n/2,1)=50;
c. F(n+1,1)=100;
d. F(1,1)=100;

10. How did we compute first derivative of the axial displacement while implementing optimality criteria code in Matlab?

a) Analytically; from the governing equation of the bar.
b) Analytically; from the design equation of the stiffest bar.
c) Numerically; using forward-difference.
d) Numerically; using central-difference.