Combustion in Air-breathing Aero Engines
Assignment No. 7

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This assignment contains 8 multiple choice questions with 4 possible answers to each. Only one of the choice is correct and so select the choice that best answers the question. Correct choice rewards you with 1 point for each question. Wrong answers will reward you with 0 points (no negative marking). The questionnaire contains both numerical and concept-based questions. All the best!!!

Q1: For a material volume evolving in a non-reacting incompressible turbulent flow, which of the following relations hold true for the strain rates. Choose the correct answer from the following choices:

1. Tangential strain rate increases and normal strain rate increases

2. Tangential strain rate increases and normal strain rate decreases

3. Tangential strain rate and normal strain rate are constants and do not change

4. Tangential strain rate decreases and normal strain rate decreases

Ans: The correct choice is 2.
Reason: In a non-reacting incompressible turbulent flow, dilatation is zero.

Q2: Consider the evolution of a scalar variable ψ in a turbulent flow. The Favre averaged value ($\tilde{\psi}$) is defined as
Choose the correct answer from the following choices:

1. $\widetilde{\psi} = \frac{\overline{\psi}}{\overline{\rho}}$

2. $\widetilde{\psi} = \overline{\rho\psi}$

3. $\widetilde{\psi} = \frac{\overline{\rho\psi}}{\overline{\rho}}$

4. $\widetilde{\psi} = \overline{\rho\psi} + \widetilde{\overline{\rho}\psi''}$

Ans: The correct choice is 3.

Q3: To generate synthetic turbulent flow field, a system need to be forced using a forcing function in the wavenumber space. Which among the following wavenumbers you choose to force.
Choose the correct answer from the following choices:

1. Smallest wavenumber

2. Largest wavenumber

3. Intermediate wavenumber between the largest and the smallest

4. Random wavenumber

Ans: The correct choice is 1.

Reason: Smallest wavenumber corresponds to largest length scales. Largest length scales contain the energy which is cascaded down to the smallest scales (Laargest wavenumber).

Q4: From Kolmogorov's 2nd similarity hypothesis, identify which of the following parameter determines the statistics of motion of length scale ℓ ($\ell_o >> \ell >> \eta$). Here, η is the Kolmogorov length scale, ℓ_o is the largest length scale

Choose the correct answer from the following choices:

1. Kinematic viscosity (ν)

2. Density (ρ)

3. Dynamic viscosity (μ)

4. Dissipation rate (ε)

Ans: The correct choice is 4.

Q5: Two direct numerical simulation studies need to be performed to understand the small scale wrinkling phenomena of turbulent premixed flame. Number of grid points required need to be computed a priori to start the simulation. The turbulent Reynolds number for the two cases are: 1)500 and 2)1000. Calculate the ratio by which the number of grid points increase for case 2 compared to case 1 (N_2^3/N_1^3) considering the both simulations are carried out in thin reaction zones regime.

Choose the correct answer from the following choices:

1. 2

2. 4.76

3. 8

4. 3

Ans: The correct choice is 2.

Q6: A Favre averaged momentum equation is derived. An additional stress term is obtained after the derivation and eddy viscosity approach is used to model this stress term. Which of the following form of transport equations are used to calculate the eddy viscosity using kinetic energy and dissipation rate

Choose the correct answer from the following choices:

1. Reynolds averaged kinetic energy equation

2. Favre averaged energy equation

3. Favre averaged kinetic energy and dissipation rate equations

4. From the property of the mixture

Ans: The correct choice is 3.

Reason: k-ε model

Q7: In a homogeneous isotropic turbulence without forcing and without mean shear, production of turbulent kinetic energy is

Choose the correct answer from the following choices:

1. zero

2. $-\langle u_i' u_j' \rangle \frac{\partial}{\partial x_j} \langle \overline{u_i} \rangle$

3. $\frac{1}{2} \langle u_i' \rangle \langle u_j' \rangle$

4. $\frac{1}{2} \langle u'.u' \rangle$

Ans: The correct choice is 1.

Reason: There no production source.

Q8: The increase in burning rate through turbulence is best explained by

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(a) Enhanced mixing

(b) Increasing the flame surface area

(c) Increasing the flame thickness

(d) Enhanced dissipation of energy

Choose the correct answer from the following choices:

1. only (a)

2. Both (b) or (c)

3. Both (a) or (b)

4. Both (a) and (d)

Ans: The correct choice is **3**.