AE 234/711 Aircraft Propulsion
EndSem

- This exam is for 3 hours, and **counts for 30 points**
- Keep your mic and webcam turned ON during the exam
- You are allowed to look at your notes and any textbooks and references online
- You can contact the instructor and TAs on Teams Chat
- Avoid any activity during the exam that can be considered *cheating*

The B2 stealth bomber cruises at Mach 0.85 at an altitude of 41,000 ft. The maximum take-off weight is 170,600 kg, and an empty weight of 71,700 kg. The maximum fuel that can be carried at the time of take-off is 75,750 kg. Assume that take-off and landing consume negligible quantity of fuel.

The aircraft is powered by four F118 engines, each of which weighs 1450 kg. An F118 engine has an overall compression ratio of 35.1 and can produce a maximum thrust of 85 kN. In this problem, we will treat it as a turbojet engine.

Note: The overall compression is defined as the ratio of the total pressure after compressor and the ambient air pressure. Also, assume $\eta_c = \eta_t = 0.90$, and $\mathcal{Q}_R = 45MJ/kg$ for the calculations.

Question 1 ..... *12 points*
Draw a schematic of the engine, and number the various stages. Find out the properties at the end of each stage in the engine.

Question 2 ..... *4 points*
Represent the various processes and stages in the engine using $p - v$ and $T - s$ plots. Mention the expressions for each of the processs, and the units for each of these properties.

Question 3 ..... *3 points*
Obtain the TSFC, the propulsive, thermal, and overall efficiencies for the engine.

Question 4 ..... *1 points*
If the engine intake diameter is 1.2 m, what is the engine thrust during cruise?

Question 5 ..... *1 points*
Obtain the Range value assuming the aircraft maintains constant attitude and speed.

Question 6 ..... *4 points*
How would the exhaust velocity, thrust, TSFC and range change if we consider $\gamma = 1.33$ for the flow after combustor in our calculations.

Question 7 ..... *5 points*
One proposal to improve the engine is to increase the overall compression ratio to 45. What will be the thrust per unit mass and TSFC for this updated overall compression ratio (continue using $\gamma = 1.33$ for the flow after the combustor).

Information given during the exam: $T_{t4} = 1400K$, $\mathcal{L}/\mathcal{D} = 20$.