The Papua New Guinea University of Technology

Department of Mechanical Engineering

ME 211: Basic Thermodynamics and Cycles

First Semester Examination – 2022

Second Year Mechanical Engineering

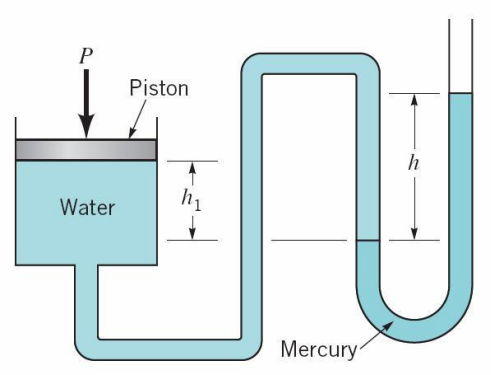
Wednesday, June 08, 2022 – 12:50 pm

## Time Allowed: Two (2) Hours

**Instructions**

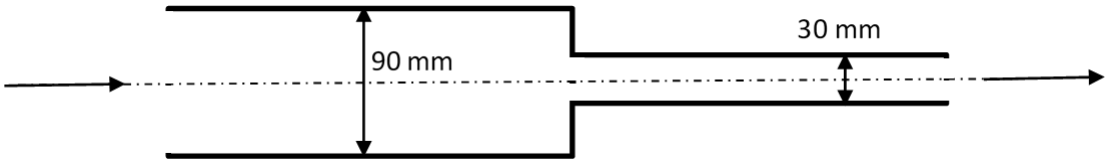
1) You have 10 minutes to read the paper. Do not write anything during this time.
2) There are **four (4)** questions. Answer each question.
3) All questions must be answered in the booklet provided.
4) Calculators are permitted in the examination room.
5) Thermodynamic tables are not required.
6) Write your name and student ID clearly on the front page of the answer booklet.
7) All questions carry equal marks.

**Q1.** A piston having a cross-sectional area of 0.07 m$^2$ is located in a cylinder containing water as shown in the figure below. An open U-tube manometer with mercury ($SG_{Hg} = 13.6$) is exposed to the atmosphere at its open end and is connected at its other end to the cylinder as shown. For $h_1 = 60\ mm$ and $h = 100\ mm$, what is the value of the applied force P, acting on the piston exposed to the atmosphere at its top? The weight of the piston is 10 N. ***(25 Marks)***




**Q2.** A piston-cylinder device contains 0.06 m$^3$ of a gas initially at 250 KPa. At this state, a linear spring, $F = k\,x$, that has a spring constant of 160 KN/m$^2$ is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder becomes three times. If the cross-sectional area of the piston is 0.3 m$^2$, determine (a) the final pressure inside the cylinder, (b) the total work done by the gas, and (c) the fraction of this work done against the spring to compress it. Also show the process on *P-v* diagram. ***(25 Marks)***

**Q3.** A long, well insulated pipe-line consist of two pipes connected in series, the internal diameters of which are 90 mm and 30 mm respectively. A steady flow of steam enters the 90-mm diameter pipe at a pressure of 3.5 bars, a specific volume of 0.684 m$^3$/Kg, and an enthalpy of 2.98 MJ/Kg. At the outlet in the 30-mm diameter pipe, the pressure is 3 bars, the specific volume is 0.79 m$^3$/Kg, and the enthalpy is 2.968 MJ/Kg. Determine the velocity of the steam at the inlet and the outlet in the pipeline, and the mass flow rate of steam. Also write simplifying assumptions required in your analysis. ***(25 Marks)***




**Q4.** It is desired to maintain a low-temperature region of $T_{L,R}$ equal to 0 ºC by removing 1000 kJ/h with a Carnot refrigerator. The energy $Q_{H,R}$ from the refrigerator is transferred to the atmosphere at 22 ºC. The work to drive the refrigerator is provided by a Carnot heat engine which operates between a supply reservoir $T_{H,E}$ of 282 ºC and the atmosphere. Determine the heat $Q_{H,E}$ which must be supplied by the high-temperature reservoir to the heat engine, in kJ/h, if all the work output of the heat engine is used to drive the refrigerator. Also sketch the diagram which matches the description of the problem given above. The diagram should be labelled with all the temperatures along with heat and work inflows and outflows. ***(25 Marks)***