(b) The velocity of steam leaving the nozzle of an impulse turbine is 900 m/s and the nozzle angle is 20°. The blade velocity is 300 m/s and the blade friction factor is 0.7. Calculate for a mass flow rate of 1 kg/s and assuming symmetrical blading, (i) the blade inlet angle, (ii) the driving force on the wheel (iii) the axial thrust (iv) diagram power and (v) the diagram efficiency.

6 + 6 = 12

7. (a) Prove that for 50% reaction turbine, the turbine blades are equiangular.

(b) A stage of 50% reaction turbine delivers dry saturated steam at 2.7 bar from the fixed blades at 90 m/s. The mean blade height is 40 mm, and the moving blade exit angle is 20°. The axial velocity of the steam is $3/4^{th}$ of the mean blade velocity. Steam flow rate is 9000 kg/hr. Calculate (i) the wheel speed in rpm (ii) the diagram power (iii) diagram efficiency and (iv) the enthalpy drop at this stage.

6 + 6 = 12

Group - E

8. (a) Prove that the thermal efficiency of a Dual cycle is given by $\eta_{dual} = 1 - \frac{1}{r_k^{\gamma-1}}\left[\frac{r_p.r_c^{\gamma} - 1}{r_p - 1 + \gamma r_p(r_c - 1)}\right]$, where, the compression ratio, the cut-off ratio and the pressure ratio are respectively denoted as r_k, r_c and r_p.

(b) In an Otto cycle, air at 17°C and 1 bar is compressed adiabatically until the pressure is 18 bar. Heat is added at constant volume until the pressure rises to 45 bar. Calculate the (i) Otto cycle efficiency (ii) compression ratio and (iii) mean effective pressure of the cycle. Take c_v = 0.717 kJ/kg and c_p = 1.004 kJ/kg.

6 + 6 = 12

9. (a) Define (i) brake specific fuel consumption (ii) volumetric efficiency. The following observations were recorded during the test of a four cylinder four stroke petrol engine. Diameter of orifice = 7.5 cm; C_d = 0.6; bore = 11 cm; stroke =13 cm ; engine speed = 2250 rpm; brake power = 36 kW, fuel consumption 10.5 kg/h ; calorific value of fuel = 42000 kJ/kg; manometer reading = 4.1 cm of water. Ambient conditions are : 15°C and 1.013 bar.

(b) Calculate (i) brake thermal efficiency (ii) brake mean effective pressure (iii) volumetric efficiency.

4 + 8 = 12

THERMAL POWER ENGINEERING
(ELEC 2203)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The bomb calorimeter is used to determine the calorific value of
(a) solid fuels and liquid fuels (b) solid fuels and gaseous fuels
(c) solid fuels and gaseous fuels (d) liquid fuels only.

(ii) The constant pressure lines in superheated region of the $T - s$ plot will have
(a) zero slope
(b) negative slope
(c) positive slope
(d) positive or negative, depending on its magnitude.

(iii) For the same maximum pressure and temperature which of the following cycles has the best efficiency?
(a) Otto cycle (b) Dual cycle (c) Diesel cycle (d) Mixed cycle.

(iv) By using rope brake dynamometer, one can measure
(a) frictional power (b) brake power
(c) indicated power (d) air/fuel ratio.

(v) In the regenerative cycle feed water is heated by
(a) flue gases (b) boiler reheater
(c) draining steam from the turbine (d) all of the above.

(vi) Which of the following is not a boiler mounting:
(a) safety valve (b) fusible plug
(c) steam stop valve (d) steam injector.

(vii) In a steam nozzle steam expands isentropically from 5 bar, 200°C to 1 bar. The quality of steam at the exit of the nozzle is
(a) 1.25 (b) 0.95 (c) 0.85 (d) 0.65.

(viii) An ideal Rankine cycle does *not* have the following process:
(a) reversible adiabatic (b) isobaric
(c) isenthalpic (d) isothermal.

(ix) The ratio of work done per cycle to the swept volume is called
(a) brake thermal efficiency (b) volumetric efficiency
(c) mean effective pressure (d) compression ratio.

(x) In a steam power plant, the function of a condenser is
(a) to maintain vacuum to increase work output from the prime mover
(b) to receive large volumes of seam exhausted from the steam prime mover
(c) to condense large volumes of steam to water that may be reused in boiler
(d) all of the above.

Group - B

2. (a) A simple Rankine cycle works between the boiler pressure at 3 MPa and condenser pressure at 4 kPa. The steam is dry saturated at the inlet to the turbine. Do not neglect pump work. Determine (i) Rankine cycle efficiency (ii) work ratio (iii) specific steam consumption in kg/kWh.

(b) Name any two commonly used boiler accessories.

(6 + 2 + 2) + 2 = 12

3. (a) An ideal reheat cycle has pressure and temperature at the HPT inlet equal to 9 MPa and 500°C, respectively. The steam expands to dry saturated state before entering the reheater. The reheat pressure is equal to 1.6 MPa and the exhaust pressure is 7 kPa. The useful work developed by the turbine is 1400 kJ/kg. Determine the temperature of steam leaving the reheater, if the thermal efficiency of the cycle is 38%.

(b) Explain the effect of regeneration on steam cycle output and efficiency.

8 + (2 + 2) = 12

Group - C

4. (a) The following is the dry volumetric analysis of the products of an engine test: CO_2 = 5.27%, O_2 = 13.38%, N_2 = 81.35%. Assuming that the fuel is a pure hydrocarbon and that it is completely burnt, estimate (i) the percentages of carbon and hydrogen in the fuel by mass and (ii) the air-fuel ratio by mass.

(b) The following data refer to a boiler plant consisting of an economiser, a boiler and a superheater:
Mass of water evaporated per hour = 5940 kg, mass of coal burnt per hour = 675 kg, the LCV of coal = 31600 kJ/kg, the pressure of steam at the boiler stop valve = 14 bar, the temperature of feedwater entering the economiser = 32°C, the temperature of feedwater leaving the economiser = 115°C, the dryness fraction of steam leaving the boiler and entering the superheater = 0.96, the temperature of steam leaving the superheater = 260°C, and the specific heat of superheated steam may be taken as 2.33 kJ/kgK. Determine (i) the percentage of heat utilized in economiser, boiler and superheater, and (ii) the overall efficiency of the boiler plant.

(3 + 3) + (5 + 1) = 12

5. (a) In a condenser test, the following observations were made:
Vacuum in condenser = 720 $mm\ Hg$;
Barometer reading = 765 $mm\ Hg$;
Mean temperature of condensation = 34°C ;
Hot well temperature = 29°C ;
Inlet and outlet temperatures of cooling water are 15°C and 25°C respectively;
Determine (i) vacuum corrected to standard barometer reading (ii) undercooling of condensate (iii) undercooling efficiency and (iv) condenser efficiency.

(b) What is a fabric filter? What is meant by 'air-to-cloth' ratio?

(2 + 2 + 1 + 2) + (2 + 3) = 12

Group - D

6. (a) The inlet condition of steam at the entry of a nozzle are 10 bar 250° C. The exit pressure is 2 bar. Assuming isentropic expansion and negligible inlet velocity, determine (i) the throat area (ii) exit velocity (iii) exit area of the nozzle.