

**B.E. MECHANICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAMINATION,
2025**

Hybrid and Electric Vehicles (Honours)

Time: Three hours

Full Marks 100

All parts of the same question must be answered together.

Assume any unfurnished data suitably

Answer any five questions

- Q:1(a) What are the different resistances opposing the motion of a vehicle? Explain each of the resistances briefly and derive expressions for them in terms of standard vehicle parameters. 2+10
- (b) Classify hybrid vehicles on the basis of extent of hybridization and briefly discuss the main features available in each type. 8
- Q:2. Consider coal (molecular formula: $C_{240}H_{90}O_4NS$ and specific energy: 28.8 MJ/kg) and natural gas (mainly methane, molecular formula: CH_4 and specific energy: 42 MJ/kg). Calculate (a) gCO_2 emission per kWh for coal and natural gas (b) gCO_2 per kWh (electrical) if the grid electricity is obtained from coal (50%), natural gas (25%) and carbon free renewable sources (25%). Consider power plant efficiencies of 30% for coal and 35% for natural gas 20
- Q:3 A test vehicle, is being tested on the basis of an 1 hour drive cycle on a flat road with the vehicle is cruising at 65 km/h for a time period $t_1 = 1800$ s, cruising at 85 km/h for $t_2 = 1200$ s, and in idle mode for $t_3 = 600$ s. The vehicle road load force is given by where F_v is in N and v is the vehicle speed in m/s. If $A = 82.3$ N, $B = 0.222$ N/ms⁻¹ and $C = 0.403$ N/m²s⁻², calculate (i) motive powers and traction powers required at the two speeds (ii) total traction energy required and (iii) total distance travelled in one drive cycle. Assume a gearing and transmission efficiency, and wheel radius 0.3 m 20
- Q:4(a) Explain the terms (a) capacity rate (b) state of charge (c) depth of discharge (d) state of health in connection with batteries for electric vehicles. 8
- (b) A battery has 96 cells in series per string with two parallel strings. Each cell has a no-load voltage of 4.18 V and an internal resistance of 2.8 mΩ. Determine (i) the pack current and voltage under a 80 kW discharge if the battery is fully charged and (ii) the discharge efficiency of the battery. 7
- (c) How would you define well-to-wheel efficiency for an internal combustion engine vehicle and an electric vehicle? 5
- Q:5 Consider a series hybrid vehicle running for 3 hours at 50 km/h for which the traction power required is 3.5 kW. The combined battery and electric drive efficiency is 85% and the generating efficiency for the engine output through the generator and inverter to

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- recharge the battery is 85%. The gasoline engine is run at an optimum operating condition of 80 Nm torque and 2000 rpm speed for which BSFC of gasoline is 230 g/kWh. Calculate the time required to charge the battery, fuel consumed to charge the battery for the full run, fuel consumption rate in l/km and range of the vehicle for a fuel tank volume of 40 l. Density of gasoline = 0.749kg/l. 20
- Q:6(a) Determine the beginning-of-life kilowatt-hour storage required in a BEV battery pack based on the following requirements: eight years of operation, an average of 48 km of driving per day s_{day} over the 365 days of the year, daily charging, and an average battery output energy per kilometer $E_{km} = 180$ Wh/km. Assume $L = 1$ and $N_{100\%} = 1000$. Assume two parallel battery strings with 96 Li-ion cells per string, with a total number of cells $N_{cell} = 192$, and a nominal voltage of 3.75 V per cell. Determine the ampere-hours per cell. What are the vehicle ranges at BOL and EOL? 10
- (b) What kind of cell arrangement would give (i) high voltage and power (ii) high current and power and (iii) high voltage, current and power? 5
- (c) What are the tasks of a typical battery management system? 5
- Q:7(a) With the help of a schematic diagram, describe the configuration of a series hybrid architecture. 6
- (b) Briefly discuss the different operational modes of a series hybrid architecture 6
- (c) What are the major advantages and disadvantages of series hybrid architecture. 8
- Q:8(a) What are the different types of DC motors? Derive expressions for the characteristics of each type of motor and show them in qualitative sketches 16
- (b) What are the different modes of operation of an induction motor? Show the torque-slip characteristics of an induction motor with fixed voltage and frequency under these modes of operation. 4