

M.E. AUTOMOBILE ENGINEERING FIRST YEAR SECOND SEMESTER EXAM 2025

Electric and Hybrid Vehicles

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)** Classify electric and hybrid vehicles with respect to propulsion devices, energy sources and energy carriers. 8
- (b)** How would you define well-to-wheel efficiency for an internal combustion engine vehicle and an electric vehicle? 4
- (c)** 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: 45 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 (40%), natural gas (30%) and carbon free renewable sources (30%). Consider power plant efficiencies of 35% for coal and 40% for natural gas 20
- Q:3(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:4(a)** What do you mean by constant torque mode and constant power mode of operation of an automobile? Explain the variation of torque and power with speed during the two modes of operation. How is the rated speed obtained? 7
- (b)** The rated motor torque and power of the electric motor of an electric vehicle are 250 Nm and 80 kW, respectively. Determine the rated speeds of the electric motor and vehicle considering a gear ratio of 8 and a wheel radius of 30 cm 7
- (c)** Consider the vehicle road load force given by

$$F = A + Bv + Cv^2$$
 What forces are represented by the three terms on the right hand side?
 Using this equation, derive an expression for traction torque for a vehicle moving on a horizontal road. 6
- Q:5.** 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 60 km/h for a time period $t_1 = 1800$ s, cruising at 85 km/h for $t_2 =$

1400 s, and at 100 km/h for $t_3 = 400$ s. The vehicle road load force is given by $F_v = A + Bv + Cv^2$ 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, $\eta_g = 90\%$ and wheel radius 0.3 m

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- Q:6** 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 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 = 0.749 kg/l. 20
- Q:7(a)** Derive the expression for the terminal voltage of a cell for a given no-load voltage and given output power during cell discharge. 5
- (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)** Mention the various factors that affect the life of a battery and discuss briefly how any two of these affect the battery life. 8
- Q:8(a)** With the help of a schematic diagram, describe the configuration of a parallel hybrid architecture. 6
- (b)** Briefly discuss the different operational modes of a parallel hybrid architecture 6
- (c)** What are the major advantages and disadvantages of parallel hybrid architecture? 8

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