(3 Hours) [**Total Marks: 80]**

N.B.: 1. **Q.1 is compulsory**
2. Answer **any Three** out of remaining **Five** questions
3. Assume any suitable data wherever required but justify the same
4. Use graph paper wherever necessary

Q.1 (A) Draw the schematic of general configuration of electrical subsystem of an Electric Vehicle (EV) and a Hybrid Electric Vehicle (HEV). **05**

(B) Calculate the Ahr capacity of a Lithium Ion battery pack 72V used for an EV for the following specifications: EV drive average power requirement: 130Whr/ km and distance in kilometers to be travelled in a single charge = 120km. Also calculate the Ahr capacity for the same requirement if a Lead Acid battery is used instead of Lithium Ion. **05**
What is Peukert's capacity of a battery? What is its significance in EV applications?

(C) Calculate the Peukert's capacity of a 130Ahr battery with C/5 (5hr) rating (Peukert's Coefficient as 1.2). **05**

(D) Describe the concept of "Hybridness" and classify the HEV based on hybridness. **05**

Q.2 (A) Illustrate the historical background of EV / HEVs technology in brief. Also describe the current scenario of EV technology along with technology challenges associated it. **05**

(B) Illustrate the fuel efficiency of ICE based conventional vehicles and Electric Vehicle with the help of neat diagrams and compare their overall performance. **05**

(C) Describe the power flow scenario in a Parallel Hybrid and Series-Parallel Hybrid electric drive-train topologies. Also explain different modes of operation for both types of HEVs. **10**

Q.3 (A) Draw and explain the ideal traction energy source (power plant) characteristic and various energy source characteristics used in EV/HEVs. **08**

(B) Calculate the net energy transferred in an ultra-capacitor (UC) of 150F used in an EV drive when the voltage applied across the UC is varied as follows: The potential difference is varied uniformly from 0 to 120 V in 10 seconds. It is then maintained at 120 V for 12 second, and then decreased uniformly to 48V, in 100 seconds. **06**

(C) State and define the key battery parameters (i) Battery capacity (ii) C rate (iii) SoC (iv) DoD (v) Specific Energy (vi) Energy Density. **06**

Q.4 (A) Compare various types of DC and AC machine used for EV applications. For any one of them, describe the typical power topology and drive control scheme typical adopted in EV. **10**

(B) Illustrate the design considerations for the selection and sizing of battery, electric motor and power converter to be used for (i) a standard four wheeler EV car and (ii) a small EV scooter (two wheeler) **10**

Q.5 (A) Classify and describe in brief about the basic principle of optimization-based energy management system used in EV/HEVs. Elaborate on any one of the optimization-based energy management system **10**

(B) Illustrate with the help of diagrams, various components which contribute to the total tractive effort (F_{TE}) needed in EV. Describe each in brief and also derive the expression for F_{TE} by means of electric vehicle performance modeling. **10**

Q.6 (A) What are the different battery charging modalities adopted for EV? Explain each one in brief and also elaborate on standards adopted for the same worldwide. **10**

(B) Draw any one standard driving cycle and relate its application for EV performance analysis. **05**

(C) Illustrate the use of battery & ultra-capacitor as well fuel-cell & flywheel to form a hybrid energy source for EV application. **05**

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