B.E. MECHANICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAMINATION, 2024
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)   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 (60%), natural gas (15%) and carbon free renewable sources (25%). Consider power plant efficiencies of 35% for coal and 40% for natural gas   20

Q:3(a)   Explain how hysteresis in deformation of tire material affects the resistance force on the wheels of a vehicle. With the help of schematic diagram, illustrate the difference in tire deflection and rolling resistance of an automobile wheel on a hard and a soft road.   10

   (b)   Derive the expression for maximum tractive effort that can be supported by tyre-ground contact for a front wheel drive. Assume the expressions for the resistance forces in terms of vehicle parameters   10

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 radtio of 8 and a wheel radius of 30 cm   7

   (c)   Consider the vehicle road load force given by

         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 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 =

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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:6(a) Explain the following terms with respect to a battery for an electric vehicle: (a) capacity rate (b) state of charge (c) state of health (d) beginning of life (e) end of life (f) depth of discharge   12

(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?   3

(c) What are the tasks of a typical battery management system?   5

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 lifer.   8

Q:8(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