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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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FIRST SEMESTER M.TECH. (ELECTRIC VEHICLE TECHNOLOGY)
END SEMESTER EXAMINATIONS, JANUARY 2023

ELECTRIC VEHICLES [ELE 5181]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 10 January 2023** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Explain the advantages of decentralized solar energy generation. Outline its limitations. ***(03)***

1B. Estimate the overall carbon emissions from the electrical grid in gCO_2/kWh (electrical) if 50 % of the electricity is generated using coal, 15 % from hydel projects, 10 % from nuclear power, 10 % from solar park, 5 % from diesel power plant, 5 % from gas-based power plant, and 5 % from wind power project. Adjust your answer higher by 20 % to allow for fuel production and distribution, and electricity transmission and distribution. Representative power plant efficiency values based on primary energy of the fuel are 38 % (for coal), 55 % (for nuclear power), 35 % (for diesel), and 50 % (for gas). Table Q1B:

		Specific energy				CO_2 emissions	
Fuel	Representative formula	(kWh/kg)	(kJ/g)	Density (kg/L)	Energy density (kWh/L)	($kgCO_2$/kg fuel)	(gCO_2 /kWh)
Gasoline	C_8H_{18} (iso-octane)	11.1–11.6	40.1–41.9 [10]	0.72–0.775 [10]	8.0–9.0	3.09	266
Diesel	$C_{12}H_{23}$	11.9–12.0	42.9–43.1 [10]	0.82–0.845 [10]	9.8–10.1	3.16	268
Gas	CH_4 (methane)	13.9	50 [10]	0.2	2.8	2.75	198
	Natural (mostly CH_4)	11.2–13.0	40.2–46.7 [10]				
Coal	$C_{240}H_{90}O_4NS$ (anthracite)	8	28.8	0.85	6.8	2.8	350

(03)

1C. A popular hybrid car has a petrol engine rated at 150 hp and a motor rated at 44 hp. Calculate its degree of hybridization. Classify and compare different hybrid electric vehicles based on this factor. ***(04)***

2A. An electric vehicle has a coefficient of rolling resistance of 0.0083 and vehicle mass of 1,477 kg. Instantaneously at a vehicle speed of 70 kmph, calculate the rolling resistance and the corresponding power. ***(03)***

2B. Specifications of Tesla Model S are as listed in Fig. Q2B. Available battery energy is 75 kWh. Powertrain is 85 % efficient. While travelling, a continuous HVAC load of 5.5 kW is kept on. Estimate this BEV's range at 160 km/h. ***(04)***

Parameters	Tesla Model S
Model Year	2014
Vehicle Type	BEV
Model	85D
Drag Coefficient	0.24
Rolling Resistance Coefficient	0.0084
Kerb Weight (kg)	2100
EPA Test Weight (kg)	2155
Rated Power (kW)	270
Rated Torque (Nm)	440
Max Speed (km/h) [mph]	224 [140]
0-60mph (s) *0-100 km/h	5.4
A (N)	177.2
B (N/ms^{-1})	1.445
C (N/m^{2}s^{-2})	0.354
Gear Ratio	9.73
Wheel radius (m)	0.352

Fig. Q2B

2C. For the drive cycle shown in Fig. Q2C, t_1 = 1,800 s, V_1=50 km/h, V_2 = 90 km/h and V_3 = 0. EPA coast-down test coefficients are A = 82.3 N, B = 0.222 N/ms^{-1} and C = 0.403 N/m^{2}s^{-2}. Gear efficiency is 95 %. Solve for the following:

a) Total motive power
b) Total traction energy consumption and
c) Range of the vehicle

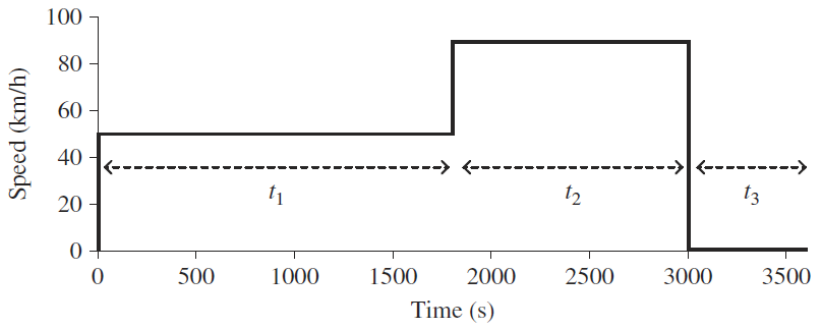

Fig. Q2C ***(03)***

3A. Battery pack of a battery electric vehicle should be designed to last for eight years of operation at an average of 24,000 km per year-averaged out over 365 days per year, average battery output of 204 Wh/km, rated cell voltage of 3.6 V, rated cell capacity of 3.4 Ah, lifetime index of 1 and $N_{100\%}$ of 1,000. If the peak power requirement is 325 kW, solve for the P/E ratio of this battery pack at the beginning of life. ***(04)***

3B. a) On a LiPo battery pack, the specifications mentioned are: 3S, 11.1V, 3,000mAh, 30C. Analyze each of these ratings. Also, calculate the energy storage possible in this battery pack.
b) With a schematic, explain working of an EV DC fast charger. ***(03)***

3C. We have an electric formula car and an IC engine based car of comparable specifications. Tyre of each car has a radius of 0.34 m.

a) The electric car can run at a top speed of 225 kmph corresponding to its motor's redline rpm of 20,000. What is the gear ratio needed for the car to run at the top speed?
b) If the ICE car has the engine redline rpm of 6,000, what will be its top speed if the gear ratio used is the same as that of the electric car of part (a)?
c) Based on answer to part (b), infer the need for a gearbox with multiple gear ratios in the ICE vehicle. ***(03)***

4A. A vehicle needs to run continuously at 60 kmph and should have a peak torque of 150 Nm. It is planned to use a traction motor which outputs a peak torque of 25 Nm at 3000 rpm. Gears have 2 % losses. Estimate the gear ratio and minimum tyre radius if this motor must be installed in the vehicle. ***(03)***

4B. Discuss the implementation of constant volts/Hz control strategy for closed loop control of 3-phase induction motor used in a BEV application. Draw the block diagram. Also, analyze the variation of the following characteristics:

a) torque versus speed, and
b) torque versus speed for a higher offset voltage. ***(04)***

4C. An all-electric vehicle uses a PMDC machine as a traction motor. The machine can output a rated power of 80 kW, and rated torque of 280 Nm at rated speed, gear ratio is 8.19 and wheel radius is 31.5 cm. Assume back emf of 220 V at rated speed, armature resistance of 50 mΩ and no-load torque is 2 Nm. Determine the armature voltage and current output by the dc-dc converter when the vehicle is cruising and developing 70 Nm at half the rated speed. ***(03)***

5A. a) A four-wheeler car weighing 1,500 kg decelerates at 1 ms^{-2} due to braking. Solve for the braking forces acting on the front and rear wheels. The car has a wheelbase of 2.7 m. Horizontal distances between the vehicle gravity center to the center of the front and rear wheels, are 40 % and 60 % of the wheelbase, respectively. Vertical height of the car's gravity center to the ground is 0.55 m. Ignore aerodynamic drag forces.

b) If regenerative braking can be provided only on one axle of this car, where will it be more effective? Justify your answer based on the solution for part (a). ***(04)***

5B. In the context of charging of plugin electric vehicles, describe the causes, effects and mitigation of the following power quality phenomena:

a) Voltage unbalance
b) Supraharmonics
c) Notch ***(06)***