MANIPAL INSTITUTE OF TECHNOLOGY
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VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
PROCTORED ONLINE MAKEUP EXAMINATIONS, FEBRAUARY 2022

INTRODUCTION TO ELECTRIC VEHICLES [ELE 4084]
REVISED CREDIT SYSTEM

Time: 75 Minutes + 10 Minutes **Date: 22 February 2022** **Max. Marks: 20**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Time: 75 minutes for writing + 10 minutes for uploading.

1A. An electric car is climbing at 80 kmph up a 5° gradient and encounters a 10 kmph headwind. The vehicle has a mass of 1.40 tonne, drag coefficient of 0.19, vehicle cross section of 2.4 m^2, rolling resistance coefficient of 0.0044, wheel radius of 300 mm, gear ratio from rotor to drive axle of 11 and a gear efficiency of 95 %. Assume a density of air of 1.2 kgm^{-3}.

a) Determine the rotor output torque and speed.
b) How much greater is the power requirement for climbing the 5° gradient compared to a flat road? ***(05)***

1B. Specifications of Tesla Model S BEV are as listed in the table. It has an available battery energy of 75 kWh and a powertrain efficiency of 85 %. While travelling, a 5.5 kW of continuous HVAC load is kept on. Estimate this BEV's range at 160 km/h.

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^2s^{-2})	0.354
Gear Ratio	9.73
Wheel radius (m)	0.352

(03)

1C. An electric vehicle decelerates linearly from 54 km/h to zero km/h in 6 s on a flat road surface under calm wind conditions. Neglecting road load forces, calculate the regenerative torque to the electric motor instantaneously at 36 km/h to achieve this braking. The EV weighs 800 kg. It has a wheel radius of 350 mm, gear ratio from motor rotor to drive axle of 10 and gear losses of 5%. ***(02)***

2A. A battery electric vehicle should be designed for 8 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.

a) Determine the beginning-of-life (BOL) kWh storage.
b) How many cells do you need and what is the BOL range?
c) For a larger pack - in order to increase the BOL range to 425 km, what is the BOL storage and how many cells are required if the battery pack uses one string of series-connected cells?
d) What is the larger battery pack's mass, assuming a battery with a pack density of 150 Wh/kg?
e) If the peak power is 325 kW, what is the P/E ratio of the battery for the larger pack? ***(05)***

2B. A pure electric vehicle uses permanent manet DC machine for propulsion. The output ratings of this machine are 100 kW and 330 Nm at rated speed. Gear ratio is 10. Wheel radius is 30 cm. At rated speed, armature back emf is 220 V. Armature resistance is 0.045 ohm. The motor develops a gross torque of 3 Nm on no-load. When this vehicle is going uphill on a gradient and developing rated torque at rated speed, determine the armature voltage, output current of the dc-dc converter and the machine efficiency. ***(03)***

2C. Solve for the braking forces acting on the front and rear wheels of a passenger car of 1,500 kg, decelerating at 1 m/s^2. Its wheelbase is 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. Height of the gravity center of the vehicle to the ground is 0.55 m. Ignore aerodynamic drag forces.

To keep the vehicle's cost low, if regenerative braking can be provided only on one axle of this car, where will it be more effective? Justify your answer based on your solution. ***(02)***