



## UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: December 2020

Module Number: ME 5210

Module Name: Electric and Hybrid Vehicle  
Engineering (TE)

[Three Hours]

[Answer all questions in separate booklets (Part A and Part B), each part carries twenty five marks]

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**All assumptions must be stated clearly. Sketches and diagrams are to be provided where required. Symbols stated herein denote standard parameters.**

### Part A

Q1 a) Electric vehicle (EVs) use one or more electric motors or traction motors for propulsion purpose. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity and regenerative braking system to eliminate the waste of energy.  
Discuss the six (6) types of electric vehicles available in today with the aid of suitable details and sketches.

[3.0 Marks]

b) Discuss the six (6) possible EV configurations of clutch, differential, fixed gearing, gear box and electric motor briefly with the aid of suitable details and sketches.

[2.0 Marks]

c) With the aid of **Traction Motor Characteristic diagram**, discuss the **Tractive Effort and Transmission Requirement** and the effect of rolling resistant and aerodynamic drag for the following incidents.

- i) 3 gear operation regions with motor speed ratio  $x=2$
- ii) 2 gear operation regions with motor speed ratio  $x=4$
- iii) Single gear operation region with motor speed ratio  $x=6$

[5.0 Marks]

Q2 a) Discuss the basic requirements of a vehicle power train which will be beneficial to develop a new concept of a drive train.

[1.0 Mark]

b) A hybrid drive train of Hybrid Electric Vehicles (HEVs) can supply its power to the load by a selective power train. Further, for the purpose of recapturing braking energy that is dissipated in the form of heat in conventional IC engine vehicles, a hybrid drive train usually has a separate power train that allows energy to flow bidirectionally.

Discuss all possible power train patterns briefly (with two power sources) with the aid of suitable details and sketches.

[2.0 Marks]

- b) HEVs can be classified mainly into four architectures. Discuss all four architectures briefly with the aid of suitable details and sketches.

**Note:**

Electrical links, hydraulic links and mechanical links must be clearly mentioned with the suitable legends.

- c) Discuss the advantages and disadvantages of series hybrid drive trains in HEVs. [2.0 Marks]
- d) Explain the characteristics of Hybrid Systems under four main categories. [1.0 Mark]
- e) The power split device in hybrid transmission uses a planetary gear. Discuss the necessity of a power split device in HEVs with the aid of schematic powertrain. [1.0 Mark]
- f) Discuss the actions of the engine, the generator and the motor with the aid of suitable details and sketches. [2.0 Marks]

Q3 a) What are Regenerative Braking Systems? Discuss with the suitable details.

[1.0 Mark]

- b) Explain the basic techniques to improve vehicle fuel economy.

[1.0 Mark]

- c) Discuss the methods of energy conversion and storage systems and discuss the limitations when implementing/designing a regenerative braking systems in EVs and HEVs.

[3.0 Marks]

#### Part B

Q4 a) Discuss economic and environmental problems associated with the current transportation scenario in the world and the hybrid electric vehicles (HEVs) would be possible solution for that.

[3.0 Marks]

- b) Why electric vehicles (EV) are not the solution for above problems discussed in Q4 (a) in Sri Lanka?

[2.0 Marks]

Q5 "In recent decades, the application of fuel cells in vehicles has been the focus of increased attention".

- a) What is the definition of a fuel cell?

[1.0 Mark]

- b) By providing a neatly drawn sketch and labeling all important parts, explain the working principle of a fuel cell.

[4.0 Marks]

- c) List out five (5) available types of fuel cells in the world.

[1.0 Mark]

- d) List out four (4) advantages and four (4) disadvantages of fuel cells used in vehicles.

[4.0 Marks]

Q6 “Fuel cells are considered to be one of the advanced power sources for applications in transportation. Compared with the internal combustion engines (ICE), fuel cells have the advantages of high energy efficiency and much lower emissions. However, vehicles powered solely by fuel cells have some disadvantages, such as a heavy and bulky power unit caused by the low power density of the fuel cell system, long start-up time, and slow power response. **Hybridization** of the fuel cell system with a peaking power source is an effective technology to overcome the disadvantages of the fuel cell-alone-powered vehicles”.

a) Draw the configuration of a fuel cell-powered hybrid drive trains system, name the important parts and briefly explain the working of the system. [5.0 Marks]

b) Describe the control strategies used for following operating modes of the drive train and corresponding power control strategy. [5.0 Marks]

- (i) Standstill Mode
- (ii) Braking Mode
- (iii) Traction Mode