THE HONG KONG POLYTECHNIC UNIVERSITY

DEPARTMENT OF ELECTRICAL ENGINEERING

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**Subject Code** : EE512

**Subject Title** : Electric Vehicles

**Session** : Semester 1, 2013/14 **Venue** : NROOM

**Date** : 16th December 2013 **Time** : 7:00pm - 10:00pm

**Time Allowed** : 3 Hours **Subject Examiner** : NC Cheung

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**This question paper has a total of ____5____ pages (attachments included).**

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**Instructions to Candidates** : This paper contains SIX questions.
Answer any FIVE questions.
All questions carry equal marks

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**Physical Constants** : NIL

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**Other Attachments** : NIL

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**Available from Invigilator** : Graph Paper

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**DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.**

**Question 1**

(a) Draw a typical torque-speed driving schedule chart of an electric vehicle with fixed gear ratio, when (i) it is driving along a small hilly road with many ups and downs, and (ii) it is driving along a high speed motorway. In your two schedule charts, highlight and explain the driving features. (8 marks)

(b) Draw the cross-sectional diagram of an in-wheel motor. Explain the advantages and disadvantages of using in-wheel motors, instead of using the traditional single motor drive with differential gear. (12 marks)

**Question 2**

(a) In Fig. Q2, an electric vehicle is driving at 70 km/h, going uphill at an angle of $\alpha$=5°. The loaded vehicle has the following parameters:

| | |
|---|---|
| Loaded Mass: | 1500 Kg |
| Rolling Resistance Coefficient of the 4 Tyres | 0.018 |
| Aerodynamic Drag Coefficient | 0.2 |
| Frontal Area of Car | 4 $m^2$ |

Assuming that the gravitational constant is 9.81 m/s, the air density is 1.23kg/$m^3$, calculate:

(i) The total force required to overcome this road load. (15 marks)

(ii) The total energy (in Watts-hour) required to travel 700m at this road condition, assuming the overall efficiency of the electric vehicle is 65%. (5 marks)

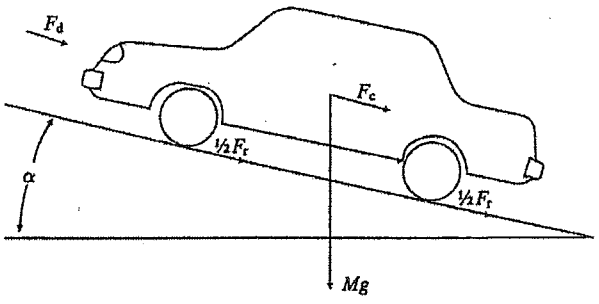



Fig. Q2

**Question 3**

(a) Fig. Q3a shows the control block diagram of a series parallel hybrid car. Explain what happens to the internal power flow under the following operating conditions (hint: either ICE heavy or electric heavy configuration is accepted):

(i) Start-up
(ii) Hard acceleration
(iii) Normal Driving
(iv) Deceleration/braking
(v) Battery charging during driving
(vi) Battery charging at standstill (12 marks)

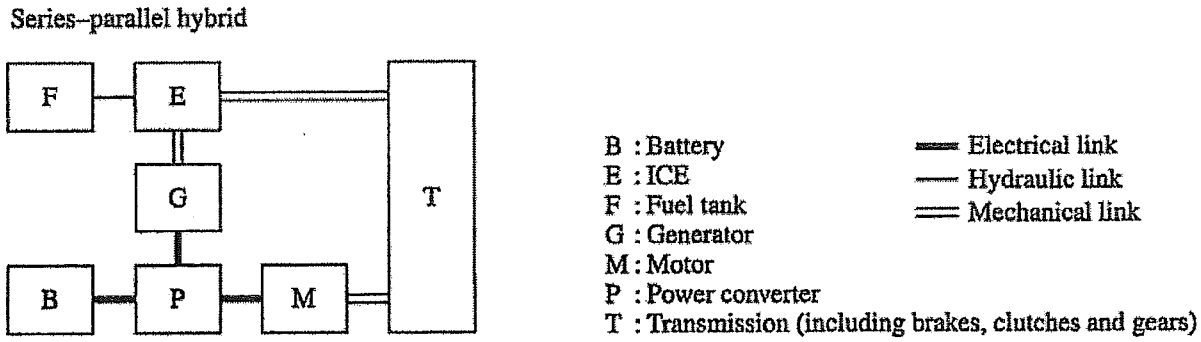
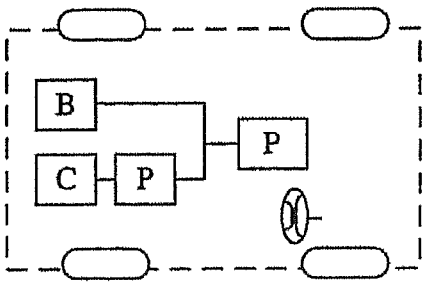



Fig. Q3a

(b) Fig. Q3b shows the configuration of a pure electric vehicle powered by both super capacitor and Lithium battery.

(i) What is the advantage of using this type of battery combination? (3 marks)

(ii) Explain what happens to the internal power flow when the vehicle is under (i) hard accelerating; (ii) hard braking; and (iii) normal driving. (5 marks)




B: Lithium Battery P: Power Converter C: Super Capacitor

Fig. Q3b

**Question 4**

(a) Give 5 reasons why motors for electric vehicles need to have a much higher specification then other domestic or industrial electric motors. (10 marks)

(b) Fig. Q4 shows the force speed characteristics of a 5 speed gear box internal combustion engine, and a fixed gearing electric motor. Using this graph, explain why electric motor is a much better choice for vehicle propulsion. (7 marks)

(c) Give reasons why brushless DC motor is a much better choice than brush type DC motor, in electric vehicle applications. (3 marks)

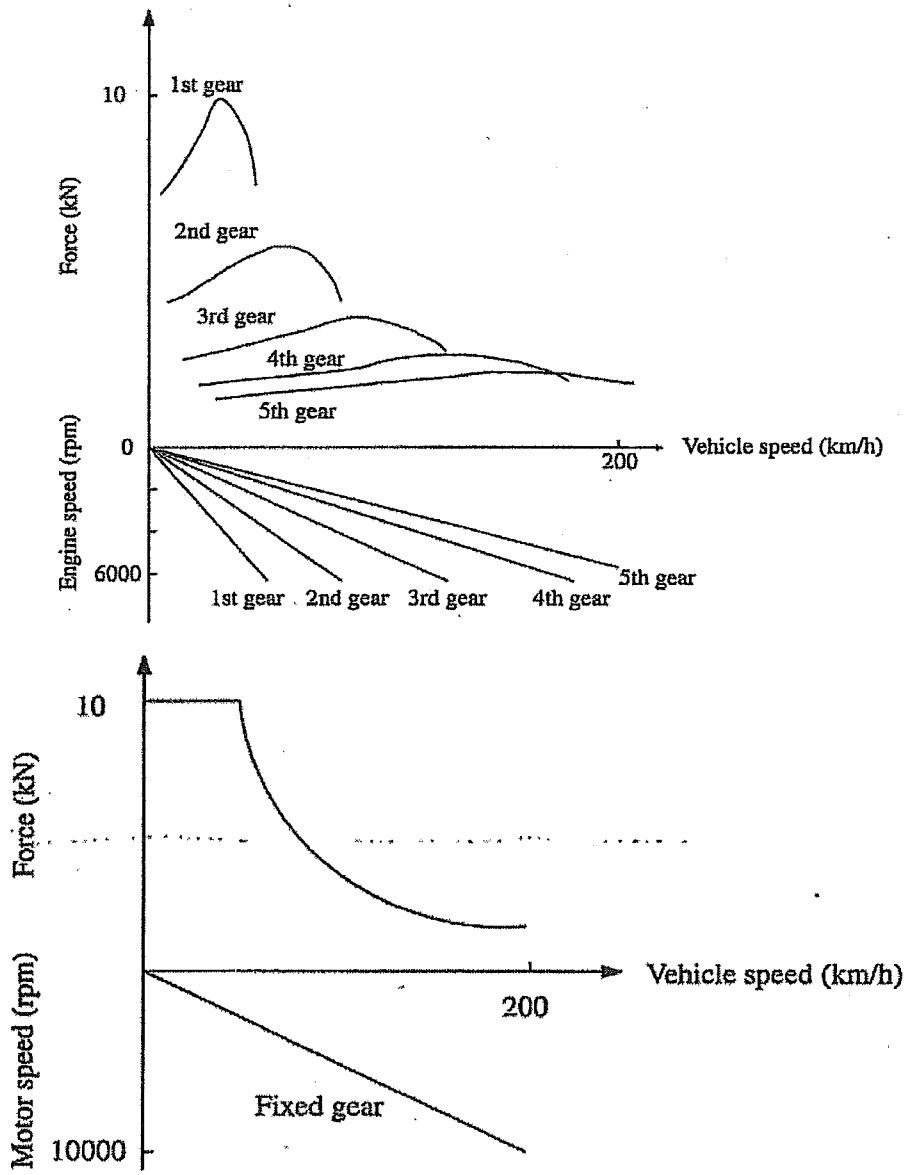



Fig. Q4

## Question 5

(a) Fig. Q5 shows the charging characteristics of a Ni-MH battery. Explain how can you make use of these characteristics to determine the charging control time of the battery. (10 marks)

(b) What are the difficulties of installing air-conditioning in an electric vehicle? Suggest a practical scheme for implementing air conditioning in electric vehicle. Support your answer with an appropriate control block diagram. (10 marks)

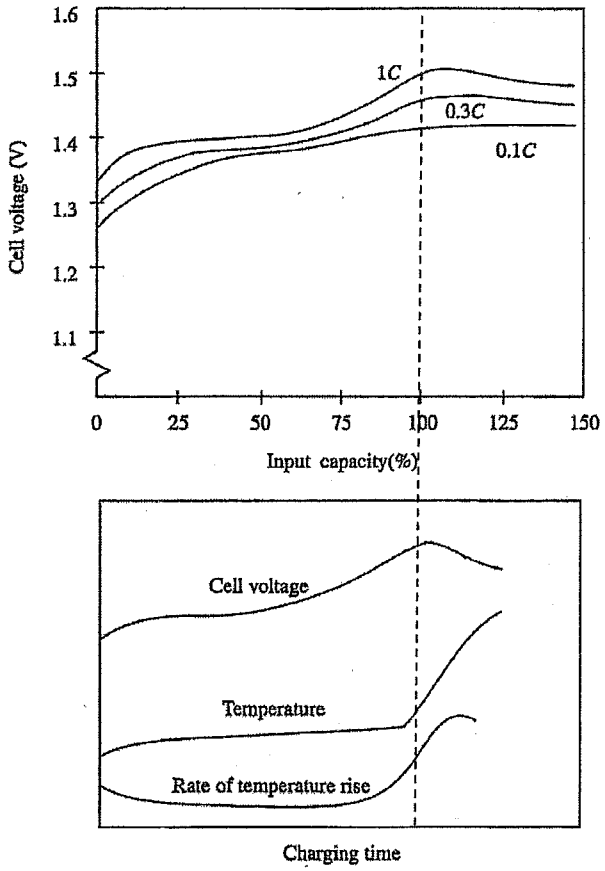



Fig. Q5

## Question 6

(a) Compare and contrast the differences between electric vehicle (EV) and internal combustion engine vehicle (ICEV), in terms of fuel requirements and energy efficiency. (10 marks)

(b) In order to avoid green house gas emission from the thermal power plant, a carbon dioxide capture and recycle system can be implemented. Describe the layout and operating principle of such a system. (10 marks)

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