

**THE HONG KONG POLYTECHNIC UNIVERSITY**  
**DEPARTMENT OF ELECTRICAL ENGINEERING**

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<b>Subject Code:</b>	EE512		
<b>Subject Title:</b>	Electric Vehicles		
<b>Session:</b>	Semester 1, 2011/12	<b>Venue:</b>	TU107
<b>Date:</b>	7 December 2011	<b>Time:</b>	7:00 pm– 10:00pm
<b>Time Allowed :</b>	3 Hours	<b>Subject Examiner:</b>	NC Cheung

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**This question paper has a total of 6 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:** NIL

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

## Question 1

Fig. Q1 shows the torque speed characteristic of a fixed gear electric vehicle.

- (a) Comment on the driving conditions of the vehicle at regions A, B, C, and D. (8 marks)
- (b) Judging from this graph, the electric vehicle being driven in the urban area. Give 3 reasons to support this judgement. (6 marks)
- (c) Predict the output of the torque-speed graph, if the electric vehicle is being driven along the highway. (6 marks)

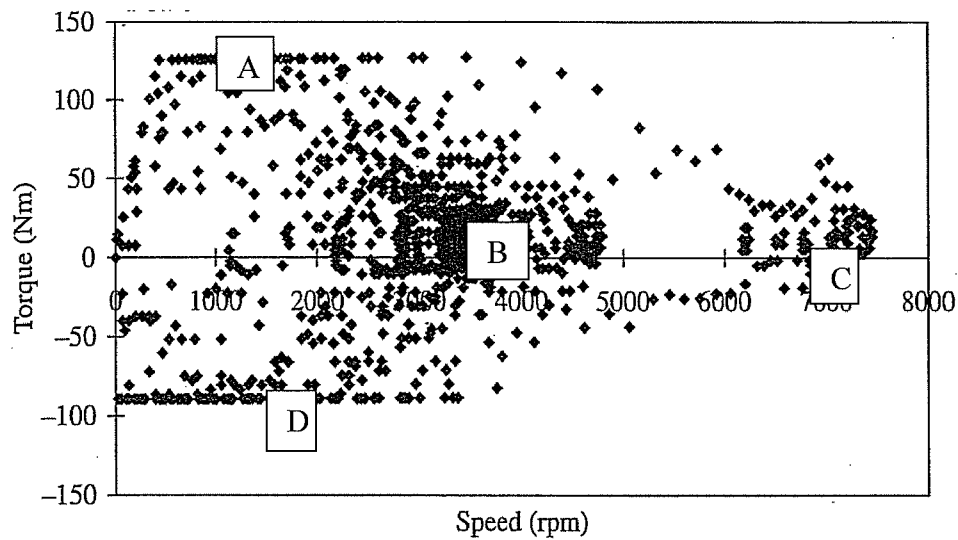


Fig. Q1

Question 2

- (a) Fig. Q2a shows two different configurations of an electric vehicle. Comment on the differences between these two configurations, in terms of (i) motor size and weight, (ii) system and control complexity, and (iii) reliability and safety issues. (9 marks)

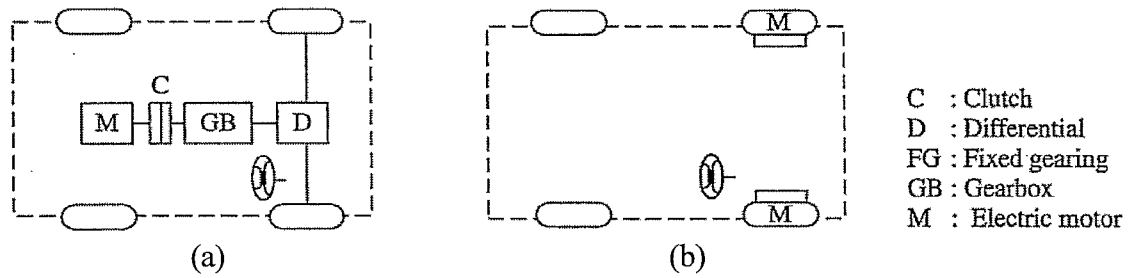


Fig. Q2a

- (b) Fig. Q2b shows the component block diagram of a parallel hybrid car. By referring to this diagram, explain the energy flow of the parallel hybrid car when it is (i) accelerating, (ii) normal driving, (iii) decelerating, and (iv) charging the battery during driving. (11 marks)

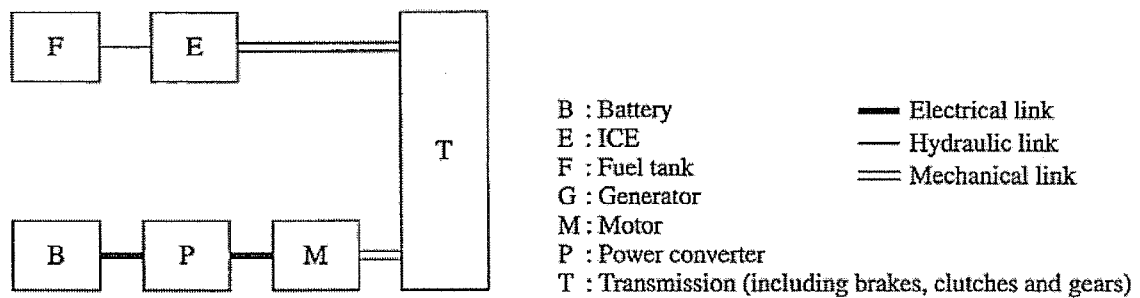


Fig. Q2b

## Question 3

- (a) It is well known that a change in the number of pole pairs of induction motor drives can adjust its rotating field synchronous speed. By referring to an example, explain how this pole changing control can extend the high speed constant power capability of induction motor driven electric vehicles. (8 marks)
- (b) Fig. Q3 shows a typical induction motor characteristic for electric vehicle. Describe how the three regions (i.e. constant torque, constant power, and high speed regions) are being utilized during the normal operation of an electric vehicle. (3 marks)
- (c) Draw the control block diagram of a variable voltage variable frequency controller for electric vehicle induction motor. Explain how the motor is being controlled in the three regions (i.e. constant torque, constant power, and high speed regions). (9 marks)

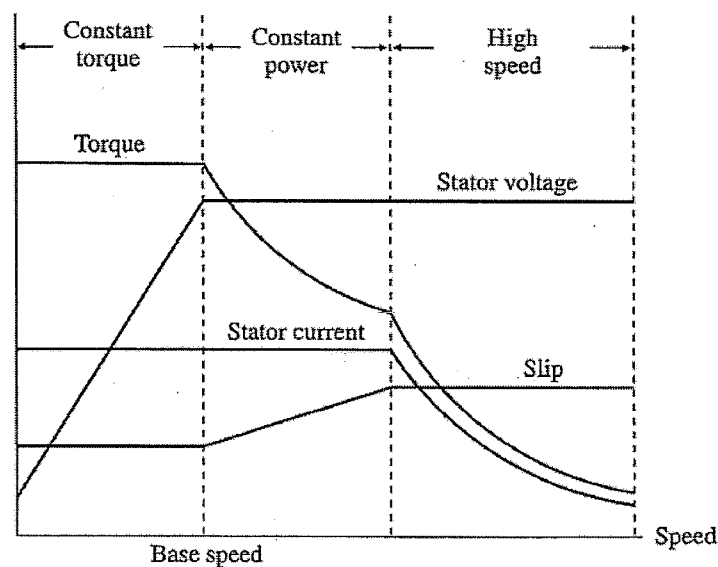


Fig. Q3

## Question 4

- (a) Explain the following terms of an electric vehicle rechargeable battery. (10 marks)
- (i) Cut Off Voltage
  - (ii) Coulometric Capacity
  - (iii) Depth of Discharge
  - (iv) State of Discharge
  - (v) Life Cycle
- (b) With the help of a diagram, explain the operation of a fuel cell. What are the major advantages of using fuel cells in electric vehicles? (10 marks)

## Question 5

- (a) Draw the schematic diagrams of an electro-hydraulic power steering unit and an electric power steering unit. Compare the two configurations, and give 3 major advantages and disadvantages between them. (12 marks)
- (b) Fig. Q5 shows the relationship between regenerative braking and hydraulic braking for an electric vehicle, at different deceleration rates and speeds.
- (i) Why is it impractical to use pure regenerative braking for car deceleration? (2 marks)
  - (ii) Suggest a practical scheme for braking torque versus brake pedal force for an electric vehicle. (6 marks)

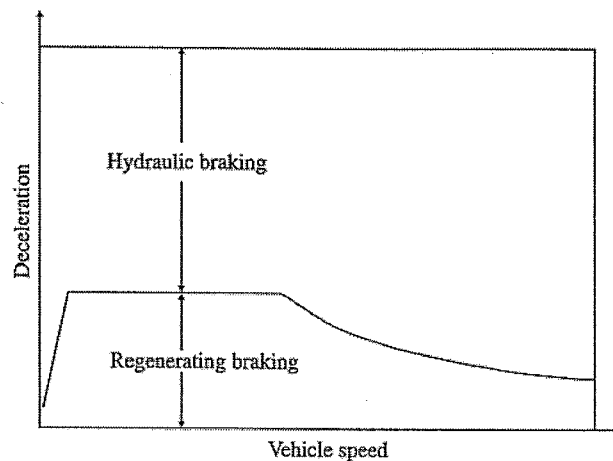


Fig. Q5

## Question 6

According to a recent estimation, under typical conditions and with the same power output, the energy efficiency of an internal combustion engine vehicle is around 18%, and that of an electric vehicle is around 13%. The energy difference is only 6%. These figures are based on the conversion of crude oil in the oil field to the motion output of the vehicle.

- (a) In terms of energy efficiency, explain why an electric vehicle does not give much superior performance than an internal combustion engine vehicle, as one would expect. (10 marks)
  
- (b) Given this energy improvement figure, explain why many countries around the world are still investing heavily on electric vehicles? Give 5 reasons. (10 marks)

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