

THE HONG KONG POLYTECHNIC UNIVERSITY
DEPARTMENT OF ELECTRICAL ENGINEERING

Subject Code : EE512
Subject Title : Electric Vehicles
Session : Semester 1, 2022/23 **Venue** : SH2
Date : 4 December 2022 **Time** : 15:15-18:15
Time Allowed : 3 Hours **Subject Examiner(s)** : Prof. Eric Cheng

This question paper has a total of 6 pages (attachments included).

Instructions to Candidates:

All together 5 questions. Answer all questions.

Question 1 is multiple-choice question. You should sketch a table in the answer book to provide the answers.

Questions 2 to 5 are long questions.

If you think there is any missing information in the question, use your best assumptions and list them in your answers clearly.

This is a closed-book examination.

Physical Constants: NIL

Other Attachments: NIL

Available from Invigilator: Additional blank answer sheets on request.

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

Question 1 (25 Marks, 2.5 Marks each)

Use the following table for your answers in your answer book.

Question	1	2	3	4	5	6	7	8	9	10
Answer										

1. An energy storage device has a specific energy of 200WH/kg. Most likely, the type of energy storage is:
 - (a) Lead-acid battery
 - (b) NMC battery
 - (c) LTO battery
 - (d) LiFePO₄ battery
 - (e) Supercapacitor
 - (f) Li-C
 - (g) No suitable answer

2. Most likely, what is the possible ex-factory price in HKD of the Li-ion battery for electric vehicles?
 - (a) \$3,000 / kWh
 - (b) \$300 / kWh
 - (c) \$30,000 / kWh
 - (d) \$300,000 / kWh
 - (e) \$30 / kWh
 - (f) No suitable answer

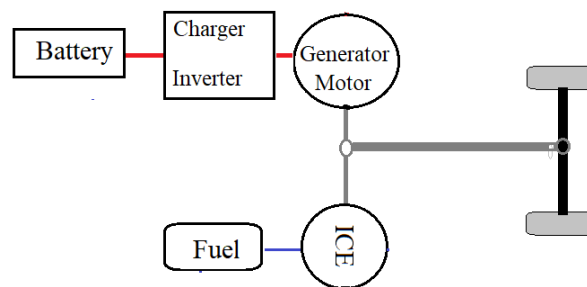
3. Which of the followings are the functions of a battery management system for an electric vehicle?
 - (i) Estimation of the SoC
 - (ii) Estimation of the SoH
 - (iii) Motor torque control
 - (iv) Charger
 - (v) Vehicle control
 - (a) All of the above
 - (b) (i) & (ii)
 - (c) (i), (iii) & (iv)
 - (d) (i), (ii) & (iii)
 - (e) No suitable answer

4. Manufacturers of electric vehicles recommend users to replace or service the battery when its SoH drops to:
 - (a) 0.8
 - (b) 0.6
 - (c) 0.4
 - (d) 0.2
 - (e) 0.1
 - (f) No suitable answer

5. Most likely, the SoH of a new Li-ion battery used in an electric vehicle is:

- (a) 115 %
- (b) 105 %
- (c) 95 %
- (d) 90 %
- (e) 85 %
- (f) No suitable answer

6. The following scheme of a vehicle looks like a:



- (a) Series hybrid
- (b) Parallel hybrid
- (c) Series-parallel hybrid
- (d) Complex hybrid
- (e) No suitable answer

7. The battery voltage of a recent electric vehicle approaches:

- (i) DC
 - (ii) AC
 - (iii) 800V
 - (iv) 300V
 - (v) 500V
- (a) (ii) and (iii)
 - (b) (i) and (iii)
 - (c) (i) and (iv)
 - (d) (ii) and (v)
 - (e) (i) and (v)
 - (f) No suitable answer

8. Battery swapping technology has not been widely used in electric vehicles. Most likely, the reason(s) is(are):
- (i) Difficult to standardize battery packs
 - (ii) Too many vehicle accidents
 - (iii) Too many competitors
 - (iv) Its technology is not yet mature
- (a) (i), (ii) & (iii)
 - (b) (i) only
 - (c) (i) and (iii)
 - (d) (i), (iii) & (iv)
 - (e) None of the above
9. Which of the followings are necessary connections for a good charger?
- (i) Power
 - (ii) Earth
 - (iii) Proximity detection
 - (iv) Control signal
- (a) (i), (ii) & (iii)
 - (b) (i) & (iii)
 - (c) (i), (iii) & (iv)
 - (d) (i) and (ii)
 - (e) All of the above
 - (f) No suitable answer
10. Most likely, the super-capacitor bus is not widely used in Hong Kong, because of:
- (i) High price
 - (ii) Short travelling distance/ charge
 - (iii) Low lifetime
 - (iv) Poor maintenance and support
- (a) (i) and (ii)
 - (b) (ii), (iii) & (iv)
 - (c) (i), (iii) & (iv)
 - (d) (i), (ii) & (iii)
 - (e) All of the above
 - (f) No suitable answer

Question 2 (15 marks)

Table Q2 indicates the number of vehicles and their average energy storage for a city. It is expected that by 2035, 50% of the vehicles of private cars, public light buses and private light buses will become all-electric.

- a) Calculate the maximum power needed when they all use 0.5C charging in 2035. (4 marks)
- b) Comment on the above result, and propose at least 3 recommendations or better methods of implementation. (4 marks)

Table Q2. Proposed Energy Storage of Different Vehicles

Type	Number	Energy Storage (kWh)
Motorcycles	90000	10
Private Cars	640000	50
Taxis	18000	60
Franchised Buses	6500	300
Non-Franchised Public Buses	7000	300
Private Buses	700	300
Public Light Buses	4300	90
Private Light Buses	3500	90
Goods Vehicles	120000	200
Special Purpose Vehicles	2000	200
Government Vehicles	6500	100

- c) If a high fault tolerance motor is recommended for all the buses, what type of motor will be recommended with at least 3 other reasons, and sketch the cross-sectional motor structure and its motor driver? (7 marks)

Question 3 (20 marks)

Sketch an active balancing system of the battery management system (BMS) for an electric vehicle for the following cases:

- a) Switched-capacitor (4 marks)
- b) Inductor-based (Buck-boost converter) (4 marks)

You should also sketch the current flow from one battery cell to another battery cell.

Annotate which transistor/diode is/are on and off.

Your sketch should use MOSFET and diode to represent the switches.

You may use only two battery cells in the above drawing.

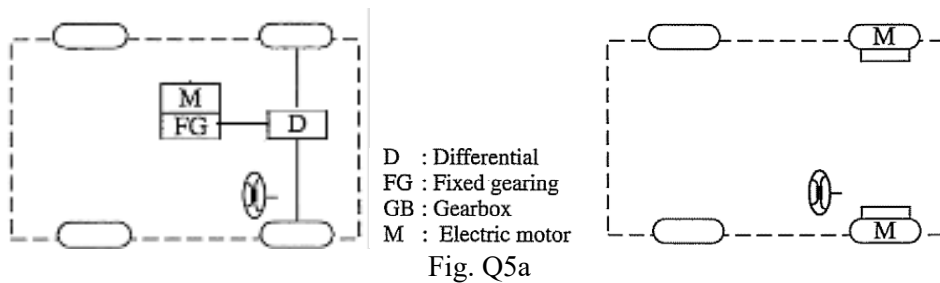
- c) Extend the circuit in (b) to 4 battery cells. (4 marks)
- d) List out 4 points why passive balancing is still a major share of the BMS market. (4 marks)
- e) Comment on if a BMS can prevent the internal short circuit of battery cells or not. (4 marks)

Question 4 (20 marks)

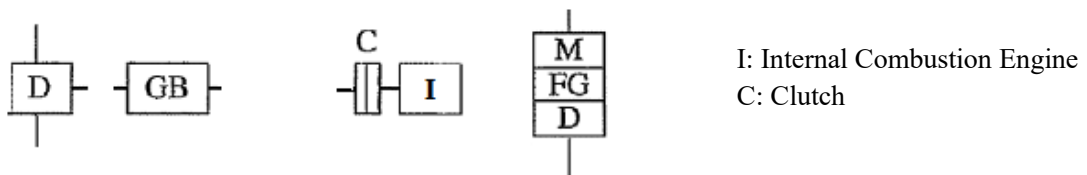
- a) Discuss why the pure electric vehicle is suitable for the Hong Kong environment. (5 marks)
- b) Explain why hydrogen fuel cell vehicles may not be suitable for the Hong Kong environment in the next 5 years. You may list 5 points. (5 marks)
- c) Comment on the possibility of converting a gasoline station to a hydrogen station for future hydrogen vehicles. (5 marks)
- d) Suggest 5 energy storage requirements in electric vehicles. (5 marks)

Question 5 (20 marks)

- a) Comment on the following two electric vehicle configurations as shown in Fig. Q5a. You may list at least 5 issues, and state and underline clearly whether it is an advantage or a disadvantage. (5 marks)



- b) Sketch a block diagram of a series-parallel schematic of a hybrid electric vehicle. Label whether the connection is electric or mechanical. (5 marks)
- c) You are provided with the following parts, as shown in Fig. Q5c.
 - i) Sketch a representation of a hybrid vehicle using these parts in a style similar to Fig. Q5a.



- ii) Explain what type of hybrid electric vehicle it is. Complete the design with a suitable energy source(s) or energy storage(s).
- iii) Discuss the advantages and disadvantages of the design (at least two points). (10 marks)

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