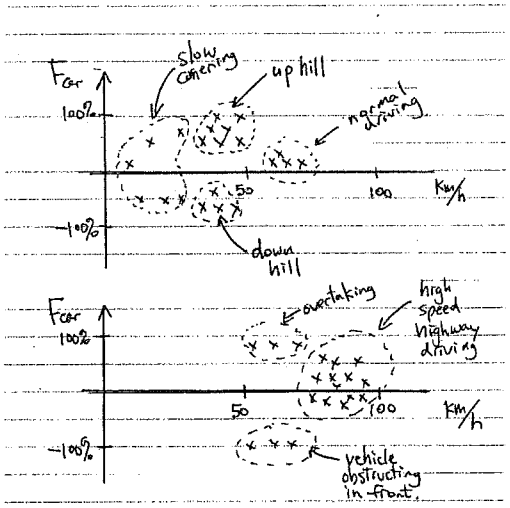
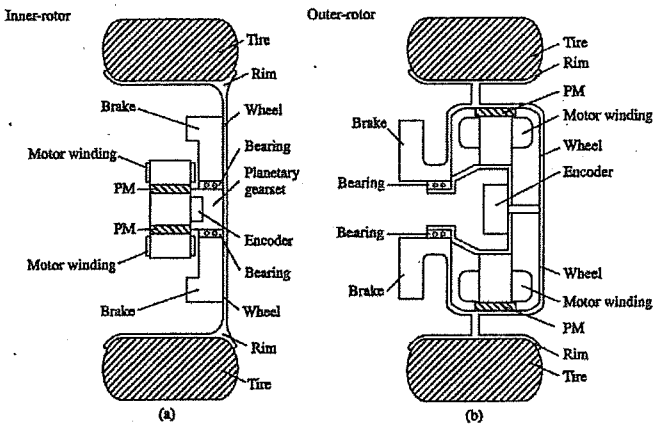
DEPARTMENT OF ELECTRICAL ENGINEERING

SOLUTION & MARKING SCHEME

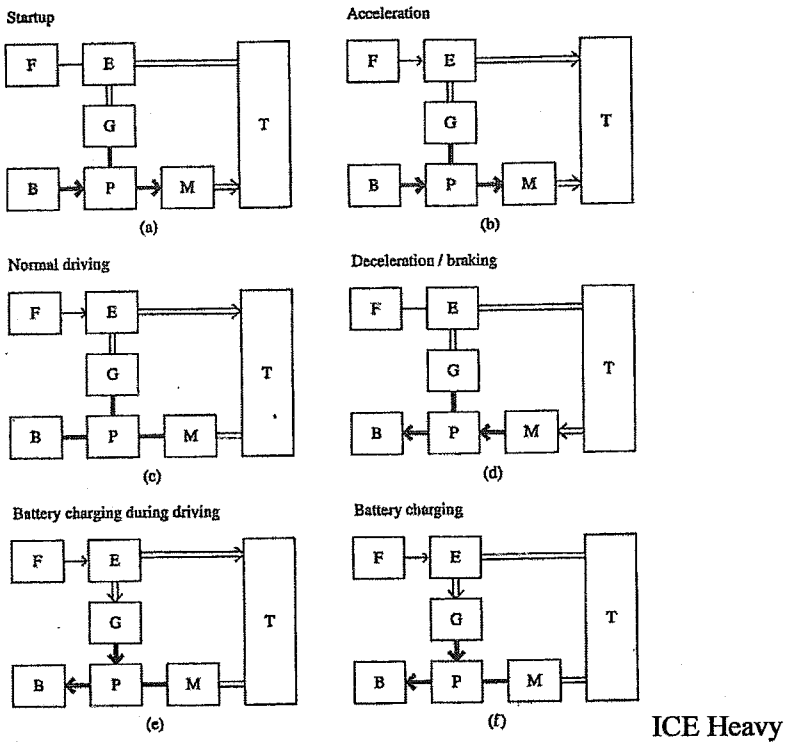
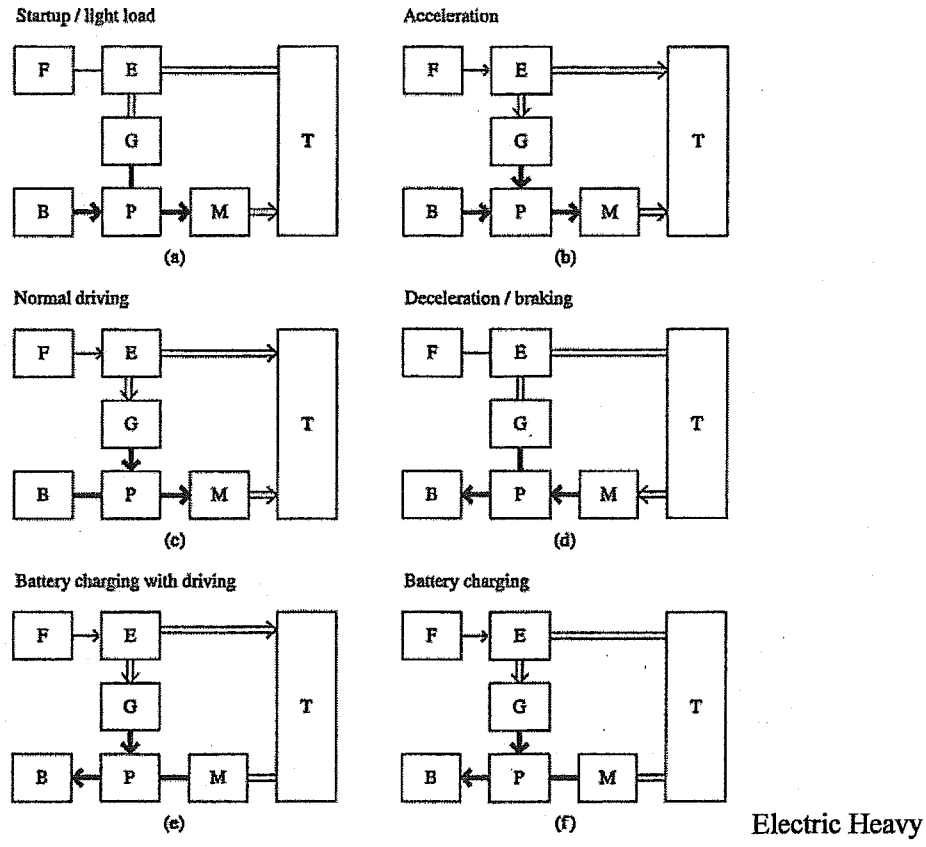
(Semester 1, 2013/14)

SUBJECT (Code & Title) : EE512 Electric Vehicles

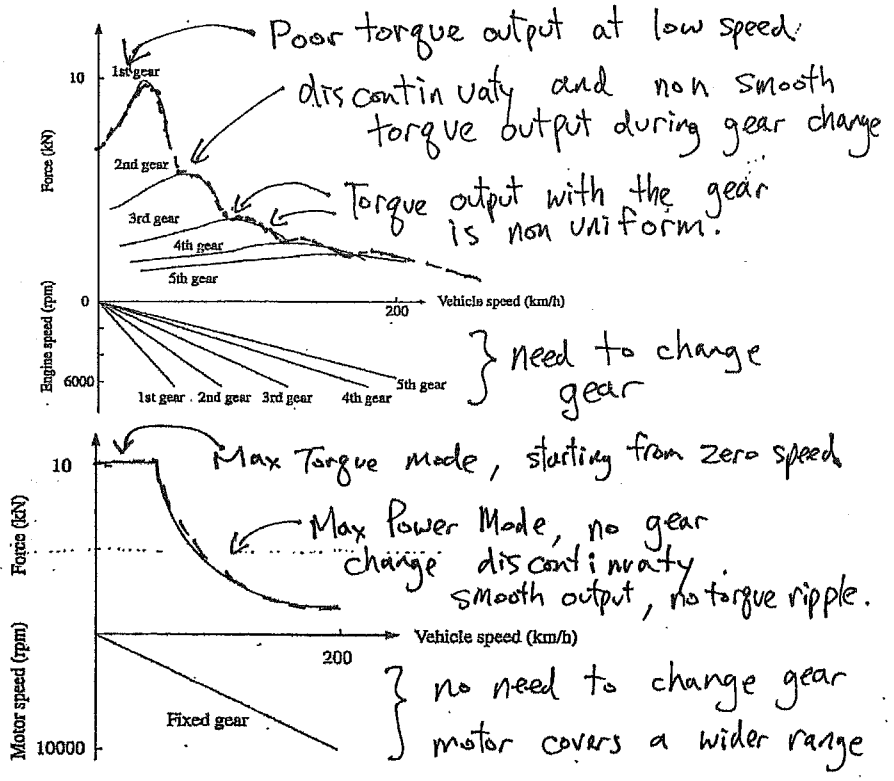
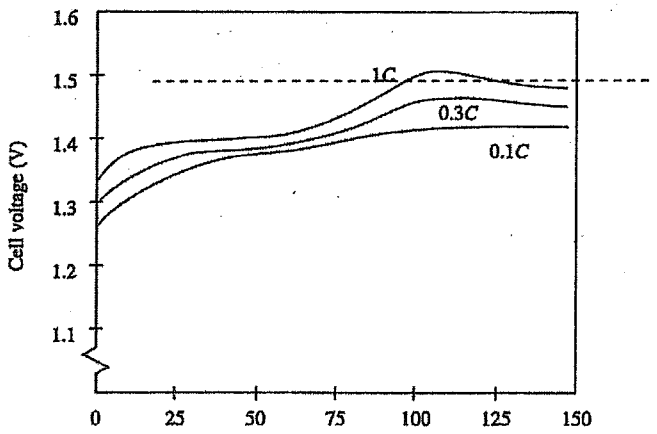
SUBJECT EXAMINER	NC Cheung
INTERNAL MODERATOR	SL Ho

QUESTION NO. ( )	SOLUTION	MARKS
Q1 (a)		4 4
(b)	 Any one of the above will do. Must include: motor winding, stator, brake, and wheel rim. Advantages: (i) No need for differential and shaft (ii) Engine does not occupy space in car. (iii) Easy customization: change wheel, change car performance. (iv) Reduced mechanical parts Disadvantages: (i) Change tyre procedure much more difficult (ii) Increase the inertia of the wheel, reduce the car's acceleration performance (iii) Direct drive with no gear, will reduce the power to size ratio of motor (iv) Safety concerns. (v) Need computer control to synchronize the wheels' motion	4 4 4

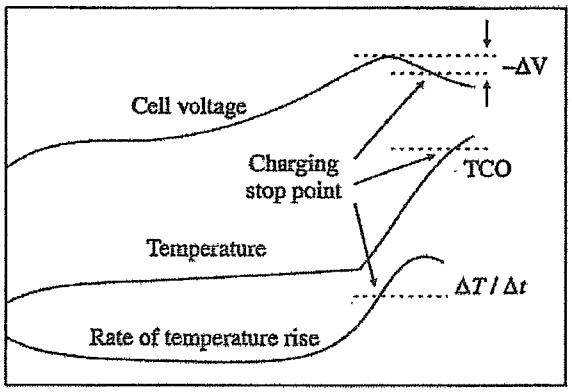
QUESTION NO. ( )	SOLUTION	MARKS
Q2 (a)	Road load = rolling resistance force + climbing force + aerodynamic force Velocity = 70 km/h = 70 x 1000 / (60 x 60) = 19.44 m/s Aerodynamic force = 0.5 x air density x drag coefficient x frontal area x (net velocity)^2 = 0.5 x 1.23 x 0.2 x 4 x 19.44 x 19.44 = <u>185.9 N</u> Rolling resistance force = mass x gravitational constant x rolling coefficient = 1500 x 9.81 x 0.018 = <u>264.9 N</u> Climbing force = mass x gravitational constant x sin 5° = 1500 x 9.81 x 0.08715 = <u>1282.4 N</u> Total Road Load = 185.9 + 264.9 + 1282.4 = <u>1733.2 N</u>	12
(b)	Energy = force x distance = 1733.2 x 700 = 1213240 J Including the 60%: 1213240 / 60% = <u>2022066.7 N or 2022066.7 W/s</u> To convert to Watt hour: 2022066.7 /(60 x 60) = <u>561.7 Watt Hour</u>	5

QUESTION NO. ( )	SOLUTION	MARKS
Q3 (a)	 ICE Heavy OR  Electric Heavy Add brief explanation for each of the operation modes.	12

QUESTION NO. ( )	SOLUTION	MARKS
(b)	• Super capacitor is too large in size and too expensive to use on its own • But it has the advantages of super quick charging and discharging • So it is used in compliment to the Lithium battery to enhance the super quick charging and discharging of the EV.	3
	For hard accelerating • At low to zero speed, the super cap will pre-charge up first. • During acceleration, super cap (together with battery) release sudden burst of energy to motor • But super cap only last for less than 1 min. • After this the super cap will charge or discharge again, according to the speed of the car and according to the driver's driving behaviour (in sports mode or in economy mode)	5
	For Regenerative Braking • Above certain speed, when the car is in high speed motion, the super cap will clear the stored energy to the battery. • During hard braking, the super cap will help to absorb the energy from the motor (generator). • But super cap only last for less than 1 min. • After this the super cap will charge or discharge again, according to the speed of the car and according to the driver's driving behaviour (in sports mode or in economy mode)	
Q4 (a)	• EV motors need to offer the maximum torque that is four to five times of the rated torque for temporary acceleration and hill-climbing, while industrial motors generally offer the maximum torque that is twice of the rated torque for overload operation. • EV motors need to achieve four to five times the base speed for highway cruising, while industrial motors generally achieve up to twice the base speed for constant-power operation. • EV motors should be designed according to the vehicle driving profiles and drivers' habits, while industrial motors are usually based on a typical working mode. • EV motors demand both high power density and good efficiency map (high efficiency over wide speed and torque ranges) for the reduction of total vehicle weight and the extension of driving range, while industrial motors generally need a compromise among power density, efficiency and cost with the efficiency optimized at a rated operating point. • EV motors desire high controllability, high steady-state accuracy and good dynamic performance for multiple-motor coordination, while only special-purpose industrial motors desire such performance. • EV motors need to be installed in mobile vehicles with harsh operating conditions such as high temperature, bad weather and frequent vibration, while industrial motors are generally located in fixed places.	10

QUESTION NO. ( )	SOLUTION	MARKS
(b)		7
(c)	Unlike DC motor…. • No brush and commutator: easy maintenance, can pass through higher current, explosion proof, can withstand more rugged condition • Winding is on the outside, heat can dissipate easily, can overdrive the motor, has a better power to size ratio.	3
Q5	1st method: Detect the voltage, stop charging when the voltage reaches 1.5V (but this method is only useful for charging current of 1C or more) 	3

QUESTION NO. ( )	SOLUTION	MARKS



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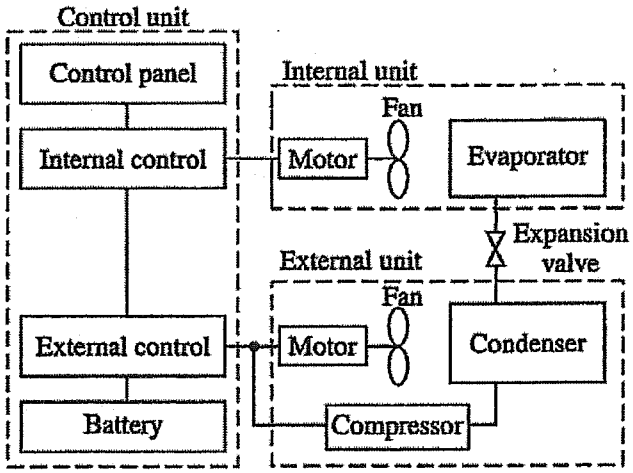
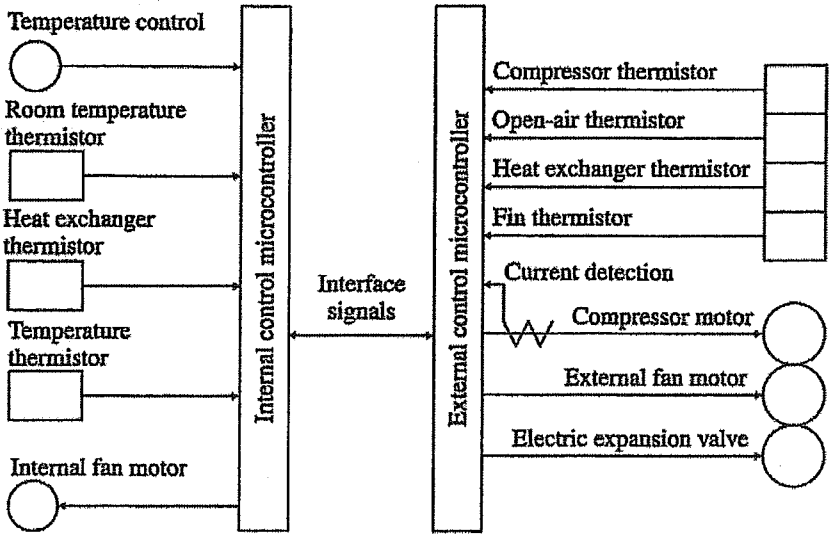
Other method(s):

- Detect the rate of change of voltage (when is goes negative)
- TCO temperature cut off. Detect when the temperature increase to certain level
- Detect the rate of temperature rise, when it reaches certain level.
- Note that in actual case, all 3 of the above methods are used in conjunction together

(b)





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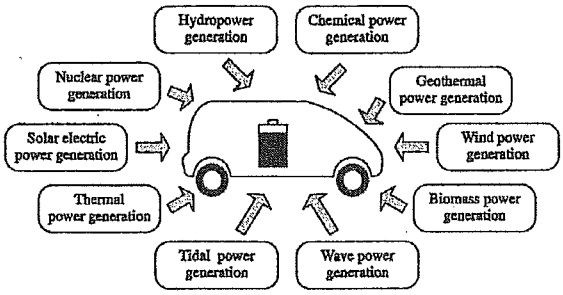
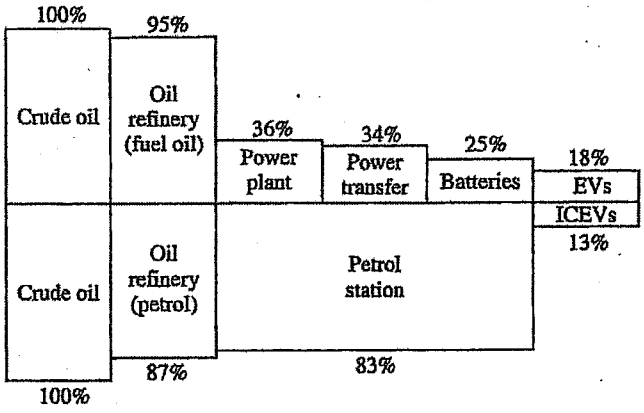
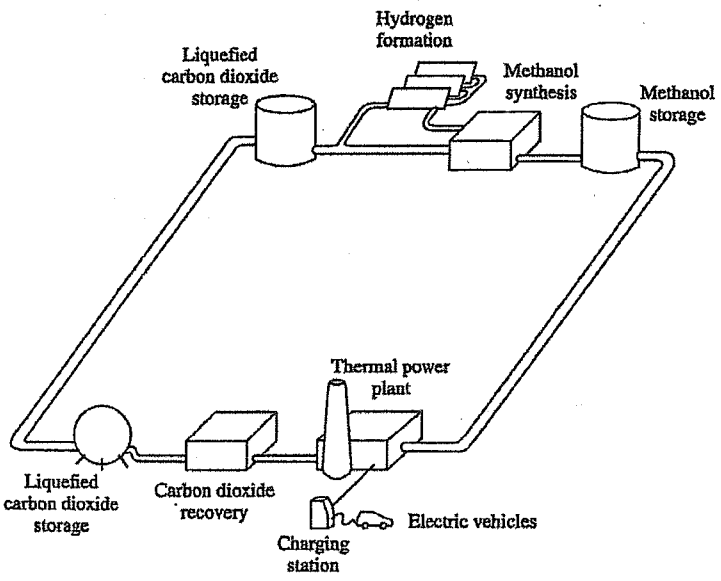
Add explanation to the block diagram

QUESTION NO. ( )	SOLUTION	MARKS
Q6	 • ICEV relies on petrol or diesel for fuel, but EV has a lot of other options. • These options can be renewable energy sources. • Thus, EV has distinct advantage • However, when ICEV and EV are compared for energy efficiency, the difference is not so big. • But ICEV is already a mature technology, but EV is a new starter. Therefore it is expected that EV fuel efficiency will continue to improve. • At present the difference is around 6% difference (when assuming that the starting energy supply is crude oil). • But when comparing 18% to 13%, EV is already 40% more energy efficient • However, the manufacture of the EV (especially the battery) requires much more energy.  **Fig. 10.6.** Energy efficiencies of EVs and ICEVs.	10
(b)	 Add explanation…	10