

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 6

LEFEL 6

EXAMINATION PERIOD
MAY 2019

CYFNOD ARHOLIADAU
MAI 2019

MODULE CODE: M6X02209
ALTERNATIVE POWERTRAIN TECHNOLOGY

TIME: 2 HOURS

ANSWER TWO QUESTIONS OUT OF THREE

Equipment or materials required – None

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ANSWER TWO QUESTIONS out of THREE

QUESTION 1



Transport for London has recently taken delivery of the first series hybrid buses for its new fleet.

The buses are equipped with a 4.5 litre Cummins diesel engine, rated at 185Kw.

A standard bus has a fuel consumption of 5.8mpg.

The hybrid bus has achieved 11.8 mpg under similar test conditions.

The bus has the following specification:

Width 2.5m. Height 4.4m

Coefficient of drag (CD) 0.8

Density of air = 1.2kg/m^3

For a bus tyre on a tarmac road: rolling (force) resistance (newtons) = $0.01\text{ N per applied N of vertical force.}$

Vehicle operating speed 30 kph

Vehicle acceleration 1.2 m/s^2

Vehicle deceleration with regenerative capacity 1.2 m/s^2

Unladen weight 11800kgs

Assume a partloaded passenger capacity 67 seated (assume one person plus luggage = 100kgs)

Assume that during acceleration and deceleration phase aerodynamic resistive forces need not be considered..

The bus utilises a direct drive electric motor. The wheel to battery driveline system.

Drive efficiency is 80%

Kinetic Energy Recovery System efficiency is 60%

The bus is fitted with a 17 Kwh traction battery

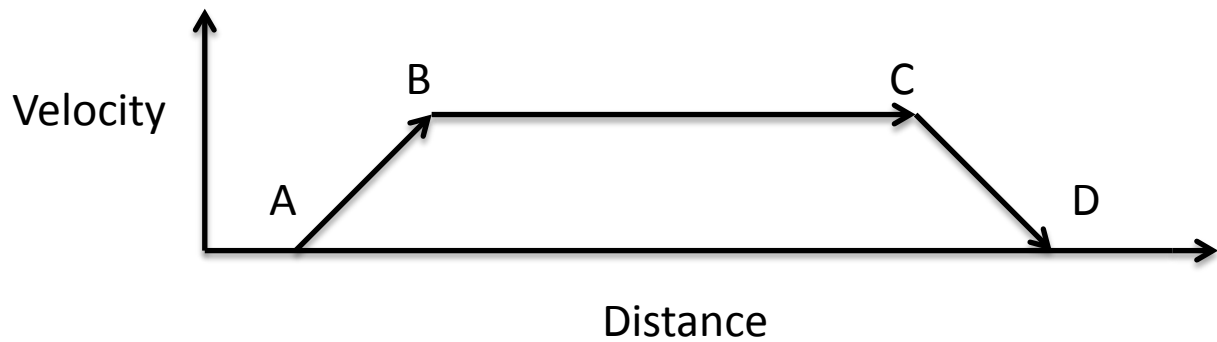
The bus begins a cycle at point A.

It then accelerates up to operational speed at point B

It continues for 150m to point C.

The bus then decelerates to a stop at point D.

This cycle is undertaken on electric battery storage energy only (i.e. the ICE is not running)



- a) What is the total force required to accelerate the vehicle?
(2 marks)
- b) What is the distance covered during the acceleration phase?
(2 marks)
- c) How much energy is required to accelerate the vehicle?
(3 marks)
- d) What is the maximum power required at the end of the acceleration at point B?
(1 mark)
- e) How much energy is required during the constant speed phase?
(3 marks)
- f) How much energy can be recovered during the deceleration phase?
(3 marks)
- g) Assuming the ICE is not operational. What is the total energy drain from battery pack per cycle?
(3 marks)
- h) If the battery pack state of charge (SOC) must not reduce to more than 50%, how many cycles can the bus achieve before the ICE must be started to provide additional power?
(3 marks)

Question 2

Intelligent Energy and Suzuki are working together to design and develop a hydrogen powered Fuel cell motorcycle.



- a) Explain the function and chemical reaction of the Proton Exchange Membrane (PEM) fuel cell (5 marks)
- b) Contrast the alternatives of burning hydrogen in an internal combustion engine against a chemical reaction within a PEM fuel cell. (5 marks)
- c) Hydrogen does not exist in a pure state and consequently it is not literally considered as a fuel but as a carrier of energy. Consequently the application of energy is required to release hydrogen from an existing compound.
Explain ways that hydrogen could be extracted from water, methanol and methane (5 marks)
- d) Hydrogen has a high calorific value and a low density. Compare three alternatives for storing hydrogen within a vehicle. Use calculations and diagrams to support your discussion. (5 marks)

QUESTION 3



Oaktec and Honda have worked together developing a Hybrid rally car based on the Honda civic. The vehicle is expected to work on both tarmac and gravel stages, as well as slower speed, on road economy rallies. The vehicle is fitted with standard 65Kw normally aspirated petrol ICE and weighs 1500kg. They hope to gain the following improvements:

- Reduced fuel consumption
- Lower emissions
- Performance advantage for the 1.4 litre class
- A greener image

Use diagrams, graphs and basic calculations to support your answers. State any assumptions made where information is missing.

- a) Analyse alternative hybrid vehicle architectures
(2 marks)
- b) Investigate and contrast alternative technologies for
 - 1. Energy storage
 - 2. Transmission and driveline
 - 3. Drive / electrical machine**(6 marks)**
- c) Develop a brief typical drive cycle
(2 marks)
- d) Recommend a Hybrid Rally Car solution and demonstrate how it may meet their requirements
(10 marks)

Equations

Potential Energy = mass x gravity x height $PE = m.g.h$

Moment of Inertia = mass x (radius of gyration)² $I = mk^2$

For a plain disc : radius of gyration $k = \text{outer radius} \times 0.707$

Aero dynamic resistance = $0.5 \times \text{area} \times cd \times \text{density of air} (1.2 \text{ kg/m}^2) \times \text{velocity}^2$

	Linear Motion		Rotational Motion
Position	x	θ	Angular position
Velocity	v	ω	Angular velocity
Acceleration	a	α	Angular acceleration
Motion equations	$x = \bar{v}t$	$\theta = \bar{\omega}t$	Motion equations
	$v = v_0 + at$	$\omega = \omega_0 + \alpha t$	
	$x = v_0t + \frac{1}{2}at^2$	$\theta = \omega_0t + \frac{1}{2}\alpha t^2$	
	$v^2 = v_0^2 + 2ax$	$\omega^2 = \omega_0^2 + 2\alpha\theta$	
Mass (linear inertia)	m	I	Moment of inertia
Newton's second law	$F = ma$	$\tau = I\alpha$	Newton's second law
Momentum	$p = mv$	$L = I\omega$	Angular momentum
Work	Fd	$\tau\theta$	Work
Kinetic energy	$\frac{1}{2}mv^2$	$\frac{1}{2}I\omega^2$	Kinetic energy
Power	Fv	$\tau\omega$	Power

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