



Prifysgol Cymru
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LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD
MAY 2017

CYFNOD ARHOLIADAU
2017

MODULE CODE:
M3X8668

TIME: 2 HOURS

ELECTRIC & HYBRID PROPULSION CONTROL

ALL CANDIDATES TO ANSWER TWO QUESTIONS FROM THREE

Equipment or materials required – Calculators may be used
Adnoddau neu ddefnyddiau sydd eu hangen - Dim

Question 1

There is a variety of motor and controller technologies available to the design engineer for selection in hybrid electric and electric vehicles.

- a) Contrast the advantages and disadvantages of permanent magnet and electrically field excited dc machines when used on an airport terminal internal four seater passenger shuttle transport vehicle.:-

(5 marks)

Explain the basic operation of; limitations of and control requirements for:

- b) Brushed dc machines (5 marks)
- c) Brushless dc machines (5 marks)
- d) AC Induction machines (5 marks)

Question 2

The company 'Still' produce a range of all electric forklift trucks.



The RX 60-40 has the following specification:

Unladen mass 6477kg
Max carry load 4000kg
Battery voltage 80V
Motor and controller efficiency for drive and regeneration 81% each way
Tyre coefficient of rolling resistance 0.015 N/N
Max laden speed 19 kph
As speeds are low you may ignore aerodynamic effects.

Gradients, maximum distance that can be driven in 60 minutes

Example: An RX 60-40 with a load of 4,000 kg and a gradient of 13% can drive a distance of 215m 10 times per hour.

Unladen		RX 60-40	RX 60-45	RX 60-50	RX 60-50/600
	23%	1850 m	1470 m	1430 m	-
	20%	2700 m	2290 m	2030 m	1850
	15%	5390 m	5060 m	4350 m	4140
	10%	7180 m	6930 m	6700 m	6250
	5%	11660 m	11170 m	10720 m	10260
Laden					
	13%	2150 m	1590 m	1380 m	-
	9%	5030 m	4200 m	3620 m	3440
	7%	6070 m	5750 m	5380 m	5150
	5%	7580 m	7130 m	6670 m	6440

(dry rough concrete surface = Coefficient of friction 0.80)

- Calculate the tractive effort to enable the fully laden vehicle to achieve the required 13% (or 7.4 degs) gradient. **(5 marks)**
- Calculate the required useable battery capacity to enable the fully laden vehicle to achieve the required 13% gradient for 2150m. **(5 marks)**
- To improve operational effectiveness and to reduce charging costs and charging time-out events and brake wear the vehicle is equipped with regenerative braking.
 - How much power could be captured if the vehicle returned down the 13% gradient at 19kph? **(3 marks)**
 - How much energy would be captured back into the batteries? **(3 marks)**
- A similar vehicle uses lead acid battery technology. With the following specification:
 80V dc
 Useable capacity 1000 Amp hours
 Required minimum battery charge level 30%
 Energy Density 35 Wh/kg
 Power Density 250 W/kg
 Calculate the mass of the pack of batteries. **(4 marks)**

Question 3



Thwaites of Warwickshire produce a range of light and heavy dump trucks. Their all wheel drive 2 tonne articulated dump truck has proved very popular especially in the new high density developments. It is being increasingly used in smaller urban land 'in-fill' developments. The small size and manoeuvrability are it's best assets.

Some developers have enquired whether a hybrid version may become available.

Potential customers are interest in:

Reduced fuel consumption

Lower emissions

Reduced running costs

Quieter operation to enable a longer working day in residential areas whilst retaining current operational effectiveness

a) Analyse alternative hybrid vehicle architectures

(2 marks)

b) Investigate and contrast alternative technologies for

1. Combustion engine
2. Energy storage
3. Transmission and driveline
4. Drive / electrical machine

(6 marks)

c) Develop a brief typical drive cycle

(2 marks)

d) Recommend a hybrid 'dumper solution' and demonstrate how it may meet the requirements of the urban construction industry requirements.

State assumptions made

Uses sketches, diagrams and calculations as appropriate.

(10 marks)

Relevant equations:

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

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

	Linear Motion	Rotational Motion	
Position	x	θ	Angular position
Velocity	v	ω	Angular velocity
Acceleration	a	α	Angular acceleration
Motion equations	$x = \bar{v}t$ $v = v_0 + at$ $x = v_0t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2ax$	$\theta = \bar{\omega}t$ $\omega = \omega_0 + \alpha t$ $\theta = \omega_0t + \frac{1}{2}\alpha t^2$ $\omega^2 = \omega_0^2 + 2\alpha\theta$	Motion equations
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