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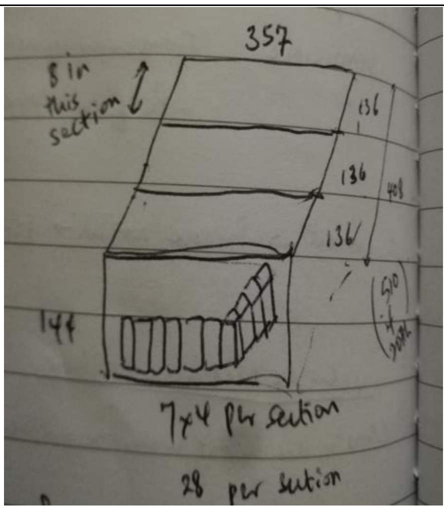
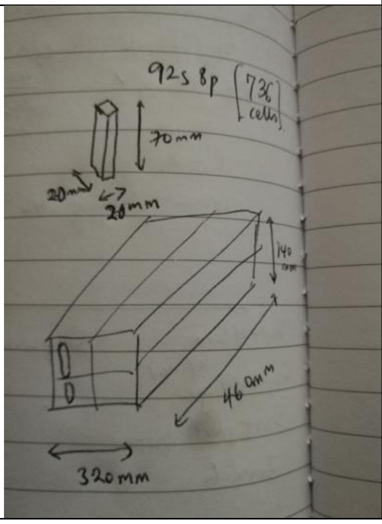
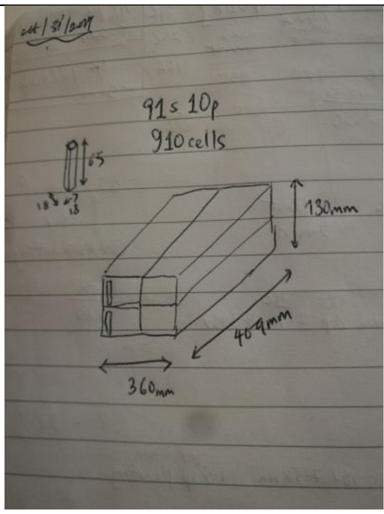
Programme & Part: Electrical & Electronics Eng. Part 4
Project Role: Tractive System
Subgroup: Electric Vehicle
Frontline Task: Electric Vehicle Project Manager

Design II – Conceptual Design

Morphological chart - different options

	Concept 1	Concept 2	Concept 3
Cell Structure			
Assembly Concept			

Regenerative braking power requirement – 63kW (see table below)
Max motor power draw - 80kW (Emrax 208)
It was decided that it would be more beneficial to make the project as simple as possible i.e. use robust and well tested schemes that have been widely used before. It was for this reason that the regenerative braking system was de-emphasized

Tabular comparison of the three cell choices

SI Unit		Turnigy graphene-4000mAh (advertised)	Turnigy Graphene realistic performance	LG HB2 18650	Sanyo NCR20700A
	Cells	4	4	1	1
Ah	Ah	4	4	1.5	3.1
V	Volts nom	14.8	14.8	3.65	3.6

A	Max Discharge Current	180	116	30	30.07
	Discharge C rating	45	29	20	9.7
	Charge C rating	10	6	5.33	3
kg	Mass	0.484	0.484	0.044	0.06
mm	Size	144	144	65	**70.3**
mm		51	51	18	20.35
mm		34	34	18	20.35
	Cost	£41.90	£41.90	£3.00	£3.60
	Energy Derived				
W/kg	Power to mass	122	122	124	186
kg	Total battery wt	40.9	40.9	40.2	26.9
	# Units for 5kWh	84	84	913	448
	Car cost	£3,520	£3,520	£2,739	£1,613
	Power derived				
kW	Max power per cell	2.66	1.72	0.11	0.11
	# cells for 80kW	30	47	731	739
	Cost to meet power	£1,257	£1,969	£2,193	£2,660
kg	Mass	14.5	22.7	32.2	44.3
	Simple car derived				
	# cells	84	84	913	739
	Cost	£3,520	£3,520	£2,739	£2,660
kg	Mass	40.9	40.9	40.2	44.3
kW	Max regen power	49.7	29.8	26.6	24.7
	Assumed regen efficiency	75%	75%	75%	75%
kW	Braking power available	66.3	39.8	35.5	33.0
m/s	Assumed average speed	17.3	17.3	17.3	17.3
kW	Assumed braking power required	63	63	63	63
	Amount of electrical braking	79.1%	47.4%	42.4%	39.3%

kWh	Nominal(1C) capacity	4.9728	4.9728	4.998675	8.24724

Concept 1
Turnigy 4000mAh 4S 45C LiPo (Lithium Polymer) pack is a high capacity cell from Hobbyking. Although the specifications show a very high charge and very high discharge rating, there is evidence online that the cells might be overrated and do not actually perform at advertised specifications. The tests I saw for a different cell reached about 65% of the advertised rating before overheating (a model advertised as 65C performed at a maximum of 41C) so I cut down the advertised ratings in the second tab to better anticipate the real conditions of this cell. It was also given a bad reliability rating in the decision matrix because of this

Concept 2
Sanyo 20700A is a high discharge cell made specifically for electric vehicles. Although it is quite a versatile cell, it was not chosen as it is quite difficult to find it for purchase. Another difficulty associated with it is one that is general to cylindrical cells. The structure makes it quite difficult to attach electrical leads to its terminal as it must be welded. The advantage of cylindrical over pouch cells is that the construction helps to keep the cell at an ideal pressure.

Concept 3
The LG HB2 is a cheap 18650 cell. The 18650 has been tested in numerous automotive applications (e.g. Tesla Vehicles and other FSAE vehicles) but the drawbacks of the cylindrical cell remain. Connecting it in a 91s10p configuration we get a total rating of 332V,15A (with a maximum burst of up to 300A) which is sufficient for our chosen motor.

Decision Matrix

		Concept 1	Concept 2	Concept 3
Cost		7	9	10
Reliability		5	9	8
Weight		9	9	8
Ease of Setup		10	7	7
		31	34	33

From the decision matrix, we can see that the Concept 2 best fulfils our requirements as it is the lightest cell while being the second cheapest. The only drawback would be in the setup of the cell as it would be more difficult to assemble it because of the soldering required. This is considered an acceptable trade-off for the cost and weight.

Buy vs Make Analysis
It would not be practical to make the battery cells, so the best option is to buy.