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Engine Performance Characteristics

Motorsport Technology ACHA4012

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1 Introduction

Be able to understand and demonstrate the knowledge of the principles of engines and practices for analysis from the dyno session. Collecting raw data from the session to calculate other data and generate graphs.

2 Dyno Session Equipment

In the dyno session, the dynamometer used is an Eddy current dynamometer, and the model is a Schenck WS230, limited to 10,000 RPM and with a maximum load of 230 kilowatts. How the dynamometer works is that the inner core is powered by the engine spinning freely, and the outer casing has an electromagnetic field by being fed with currents. This causes a load on the engine, slowing it down. The reaction is that the outer casing tries to turn but is restricted by the strain gauge. This gauge sends 0 to 10V to the computer system, where the data is sent to the system. Calibration arms on both sides of the outer casing are specifically designed to be 815.776mm from the dyno centre to the hook eye. This affects how many Volts the strain gauge sends to the system when adding weights to the arm (UWTSD WISA Workshops, 2021).

The engine used for the dyno test is a 2000 Honda CRX 1.6 VTec engine connected to the dynamometer via the driveshaft from the crankshaft. There are parameters installed in the engine. The fuel supply board delivers the fuel via a lift pump from the fuel safe to the fuel supply board. It delivers through the filter then to a fuel flow meter. It then flows into a swirl pot to a fuel pump then through a regulator and into the engine. On the engine itself, there is the coolant temperature, flow meter, a lambda sensor and an exhaust extraction system. The throttle is controlled by the computer from the throttle actuated box and records the input of the throttle position. The basic functions of the engine is controlled by the sensor modules and controls from the computer (UWTSD WISA Workshops, 2021).

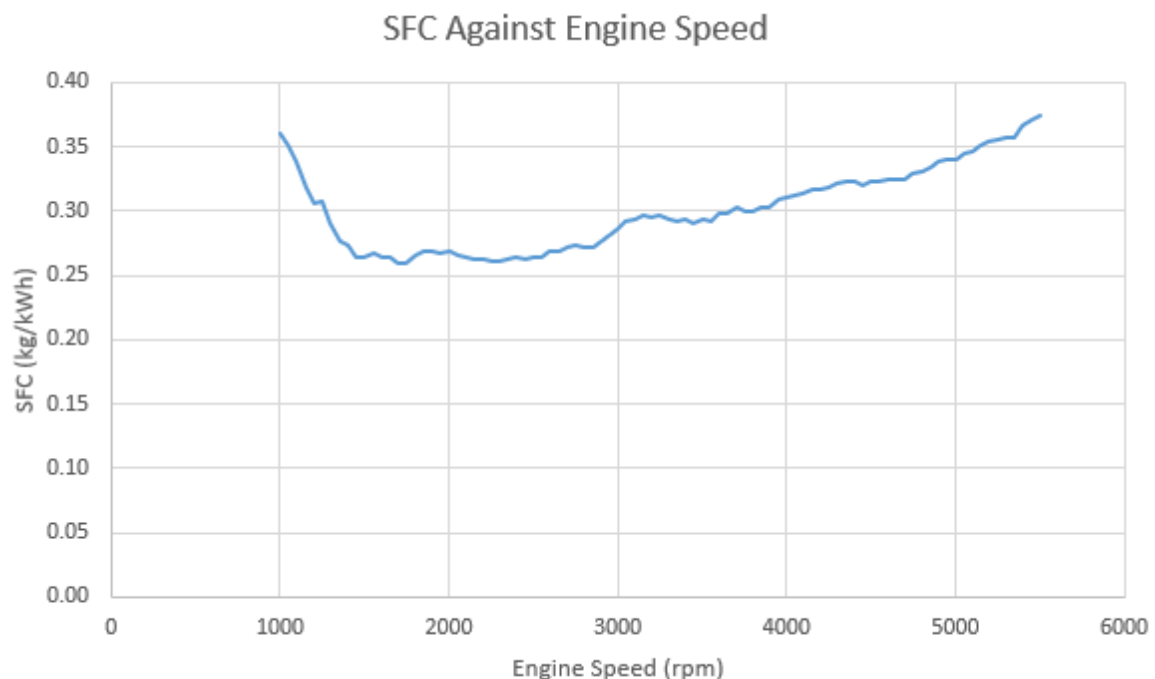
3 Data Results

						Baro	Humidity	Ambient temp	Standard	Standard Temp	Stroke	Bore	Fuel Density	Calorific Fuel Value
						mBar	%	Deg C	Bar	Deg C	m	m	kg/L	J/kg
						1018.9	46	27	1.013	25	0.09	0.075	0.75	44000000
Load	Dyno Speed	Fuel Flow Rate	Lambda		Torque	Power	Corrected Power	BMEP	Fuel Flow Rate	SFC	Total Energy Input	Overall Thermal Efficiency		
Newtons	rpm	l/min	Lambda		N/m	kW	kW	kPa	kg/h	kg/kWh	kW	%		
102.275	1000	0.0704	1.2658		83.43	8.74	8.79	1326.13	3.17	0.36	38.72	22.70		
102.756	1050	0.0724	1.26783		83.83	9.22	9.27	1332.37	3.26	0.35	39.82	23.28		
103.689	1100	0.0737	1.27344		84.59	9.74	9.80	1344.47	3.32	0.34	40.54	24.18		
104.209	1150	0.0728	1.28476		85.01	10.24	10.30	1351.21	3.28	0.32	40.04	25.72		
105.811	1200	0.0744	1.29181		86.32	10.85	10.91	1371.98	3.35	0.31	40.92	26.66		
107.51	1250	0.07895	1.29729		87.70	11.48	11.55	1394.01	3.55	0.31	43.42	26.59		
109.488	1300	0.079	1.29895		89.32	12.16	12.23	1419.66	3.56	0.29	43.45	28.15		
111.797	1350	0.0796	1.29469		91.20	12.89	12.97	1449.60	3.58	0.28	43.78	29.62		
114.268	1400	0.0835	1.2855		93.22	13.67	13.75	1481.64	3.76	0.27	45.93	29.93		
115.783	1450	0.0847	1.27818		94.45	14.34	14.43	1501.28	3.81	0.26	46.59	30.97		
116.985	1500	0.08865	1.2795		95.43	14.99	15.08	1516.87	3.99	0.26	48.76	30.93		
117.788	1550	0.0932	1.27766		96.09	15.60	15.69	1527.28	4.19	0.27	51.26	30.60		
118.471	1600	0.0959	1.28235		96.65	16.19	16.29	1536.14	4.32	0.26	52.75	30.88		
118.772	1650	0.09875	1.29028		96.89	16.74	16.84	1540.04	4.44	0.26	54.31	31.01		
118.656	1700	0.10005	1.29942		96.80	17.23	17.33	1538.53	4.50	0.26	55.03	31.50		
118.861	1750	0.10305	1.31053		96.96	17.77	17.87	1541.19	4.64	0.26	56.68	31.54		
119.584	1800	0.1093	1.3149		97.55	18.39	18.50	1550.57	4.92	0.27	60.12	30.77		
119.934	1850	0.11415	1.31849		97.84	18.95	19.07	1555.11	5.14	0.27	62.78	30.37		
120.176	1900	0.11745	1.31892		98.04	19.50	19.62	1558.24	5.29	0.27	64.60	30.37		
120.948	1950	0.12055	1.31484		98.67	20.15	20.27	1568.25	5.42	0.27	66.30	30.57		
122.157	2000	0.12555	1.31653		99.65	20.87	20.99	1583.93	5.65	0.27	69.05	30.40		
122.845	2050	0.12785	1.32098		100.21	21.51	21.64	1592.85	5.75	0.27	70.32	30.77		
123.796	2100	0.1309	1.32287		100.99	22.21	22.34	1605.18	5.89	0.26	72.00	31.03		
124.794	2150	0.13435	1.32164		101.80	22.92	23.06	1618.12	6.05	0.26	73.89	31.20		
125.137	2200	0.1377	1.31652		102.08	23.52	23.66	1622.57	6.20	0.26	75.74	31.24		
126.028	2250	0.14105	1.30465		102.81	24.22	24.37	1634.12	6.35	0.26	77.58	31.41		
126.66	2300	0.14495	1.29646		103.33	24.88	25.03	1642.32	6.52	0.26	79.72	31.40		
126.822	2350	0.14985	1.28229		103.46	25.46	25.61	1644.42	6.74	0.26	82.42	31.07		
126.69	2400	0.1537	1.27304		103.35	25.97	26.13	1642.71	6.92	0.26	84.54	30.91		
126.552	2450	0.15565	1.26984		103.24	26.49	26.64	1640.92	7.00	0.26	85.61	31.12		
126.438	2500	0.1596	1.27446		103.15	27.00	27.16	1639.44	7.18	0.26	87.78	30.94		
126.239	2550	0.1626	1.27876		102.98	27.50	27.66	1636.86	7.32	0.26	89.43	30.93		
126.161	2600	0.16805	1.27634		102.92	28.02	28.19	1635.85	7.56	0.27	92.43	30.50		
125.847	2650	0.17145	1.28027		102.66	28.49	28.66	1631.78	7.72	0.27	94.30	30.39		
124.911	2700	0.17465	1.28371		101.90	28.81	28.98	1619.64	7.86	0.27	96.06	30.17		
123.927	2750	0.1784	1.2812		101.10	29.11	29.28	1606.88	8.03	0.27	98.12	29.85		
123.689	2800	0.18005	1.27448		100.90	29.58	29.76	1603.79	8.10	0.27	99.03	30.05		
123.389	2850	0.1831	1.26036		100.66	30.04	30.22	1599.90	8.24	0.27	100.71	30.01		
122.519	2900	0.1879	1.2531		99.95	30.35	30.53	1588.62	8.46	0.28	103.35	29.54		
121.837	2950	0.19255	1.23943		99.39	30.70	30.88	1579.78	8.66	0.28	105.90	29.16		
121.709	3000	0.199	1.22735		99.29	31.19	31.37	1578.12	8.96	0.29	109.45	28.67		
121.123	3050	0.20605	1.2193		98.81	31.56	31.74	1570.52	9.27	0.29	113.33	28.01		
121.124	3100	0.21005	1.20692		98.81	32.07	32.26	1570.54	9.45	0.29	115.53	27.93		
120.851	3150	0.21605	1.19274		98.59	32.52	32.71	1567.00	9.72	0.30	118.83	27.53		
120.596	3200	0.21795	1.18481		98.38	32.96	33.16	1563.69	9.81	0.30	119.87	27.66		
120.84	3250	0.22305	1.17378		98.58	33.55	33.75	1566.85	10.04	0.30	122.68	27.51		
121.633	3300	0.2255	1.16118		99.23	34.29	34.49	1577.14	10.15	0.29	124.03	27.81		
122.181	3350	0.2285	1.15104		99.67	34.96	35.17	1584.24	10.28	0.29	125.68	27.99		
122.933	3400	0.2342	1.14117		100.29	35.70	35.92	1593.99	10.54	0.29	128.81	27.88		
123.475	3450	0.23605	1.12669		100.73	36.39	36.60	1601.02	10.62	0.29	129.83	28.19		
123.428	3500	0.24195	1.11975		100.69	36.90	37.12	1600.41	10.89	0.29	133.07	27.90		
124.205	3550	0.24545	1.10622		101.32	37.66	37.89	1610.48	11.05	0.29	135.00	28.07		
124.066	3600	0.25505	1.09697		101.21	38.15	38.38	1608.68	11.48	0.30	140.28	27.36		
123.967	3650	0.25755	1.09401		101.13	38.65	38.88	1607.40	11.59	0.30	141.65	27.45		
123.815	3700	0.26445	1.09569		101.01	39.13	39.36	1605.43	11.90	0.30	145.45	27.06		
123.767	3750	0.2651	1.09808		100.97	39.65	39.88	1604.81	11.93	0.30	145.81	27.35		
123.509	3800	0.2693	1.09907		100.76	40.09	40.33	1601.46	12.12	0.30	148.12	27.23		
122.672	3850	0.27375	1.10533		100.07	40.34	40.58	1590.61	12.32	0.30	150.56	26.95		
122.157	3900	0.2759	1.11704		99.65	40.70	40.94	1583.93	12.42	0.30	151.75	26.98		
121.184	3950	0.28285	1.12259		98.86	40.89	41.13	1571.31	12.73	0.31	155.57	26.44		
120.004	4000	0.28455	1.12461		97.90	41.00	41.25	1556.01	12.80	0.31	156.50	26.36		
118.734	4050	0.2871	1.1222		96.86	41.08	41.32	1539.55	12.92	0.31	157.91	26.17		
117.442	4100	0.28895	1.12394		95.81	41.13	41.38	1522.79	13.00	0.31	158.92	26.03		
116.5	4150	0.29305	1.12233		95.04	41.30	41.54	1510.58	13.19	0.32	161.18	25.78		
115.931	4200	0.2949	1.12179		94.57	41.59	41.84	1503.20	13.27	0.32	162.20	25.80		
115.034	4250	0.29715	1.12456		93.84	41.76	42.01	1491.57	13.37	0.32	163.43	25.70		
114.391	4300	0.3022	1.12278		93.32	42.02	42.27	1483.23	13.60	0.32	166.21	25.43		
114.016	4350	0.30605	1.11943		93.01	42.37	42.62	1478.37	13.77	0.32	168.33	25.32		
113.871	4400	0.3092	1.11986		92.89	42.80	43.05	1476.49	13.91	0.32	170.06	25.32		
113.985	4450	0.3099	1.11873		92.99	43.33	43.59	1477.97	13.95	0.32	170.45	25.57		
113.306	4500	0.31445	1.11563		92.43	43.55	43.81	1469.16	14.15	0.32	172.95	25.33		
113.074	4550	0.3171	1.10953		92.24	43.95	44.21	1466.16	14.27	0.32	174.41	25.35		
112.195	4600	0.3194	1.10569		91.53	44.09	44.35	1454.76	14.37	0.32	175.67	25.24		
111.061	4650	0.32055	1.09782		90.60	44.11	44.38	1440.05	14.42	0.33	176.30	25.17		
109.973	4700	0.3207	1.09558		89.71	44.15	44.41	1425.95	14.43	0.32	176.39	25.18		
108.654	4750	0.32485	1.08827		88.64	44.09	44.35	1408.84	14.62	0.33	178.67	24.82		
107.076	4800	0.32455	1.08396		87.35	43.90	44.16	1388.38	14.60	0.33	178.50	24.74		
105.24	4850	0.3257	1.08221		85.85	43.60	43.86	1364.58	14.66	0.33	179.14	24.48		
103.632	4900	0.3277	1.0846		84.54	43.38	43.63	1343.73	14.75	0.34	180.24	24.21		
102.335	4950	0.32845	1.08823		83.48	43.27	43.53	1326.91	14.78	0.34	180.65	24.10		
101.106	5000	0.3287	1.08687		82.48	43.18	43.44	1310.97	14.79	0.34	180.79	24.03		
99.3149	5050	0.32985	1.0891		81.02	42.84	43.10	1287.75	14.84	0.34	181.42	23.76		
97.5815	5100	0.3297	1.09185		79.60	42.51	42.76	1265.28	14.84	0.35	181.34	23.58		

On the spreadsheet data. The standard atmospheric pressure and temperature were obtained from the DIN Standard 70020 provided by the lecturer. These figures are used to calculate the corrected power. The stroke and bore figures were obtained from the engine's workshop manual provided by the lecturer and are used to calculate the Brake Mean Effective Pressure. The fuel density and calorific fuel value were obtained from the PowerPoint of the lecturer. These figures were used to calculate the fuel flow rate, specific fuel consumption, total energy input and overall thermal efficiency of the engine (Harrison, 2025).

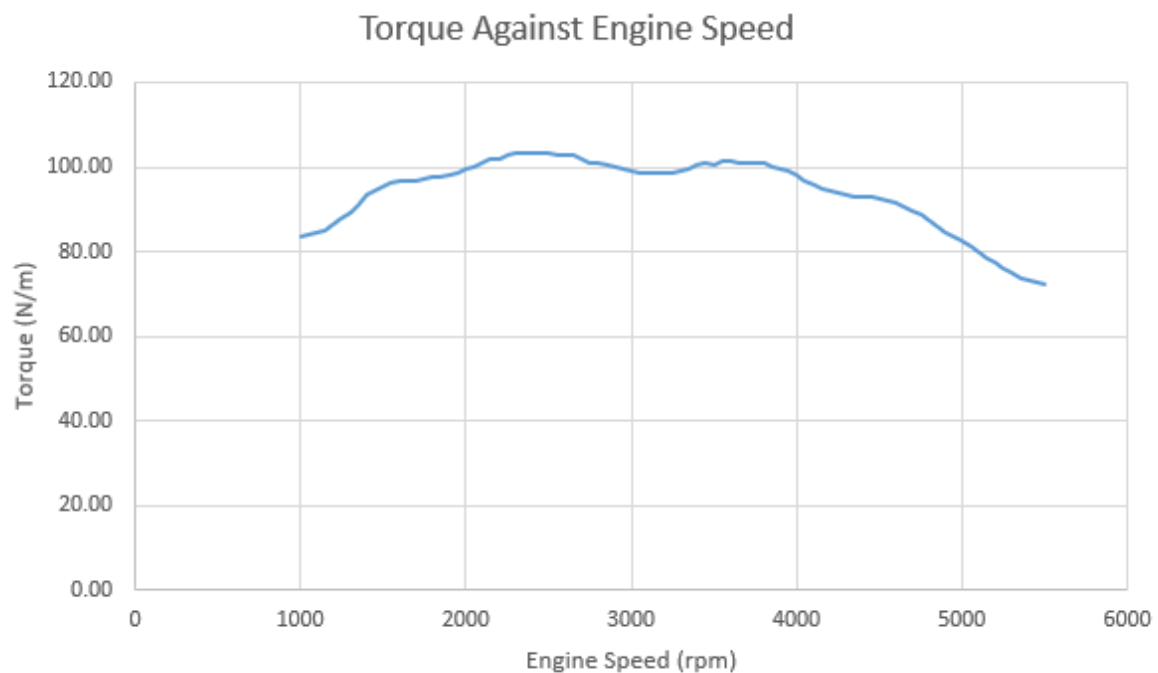
4 Result Graphs

4.1 SFC Against Engine Speed



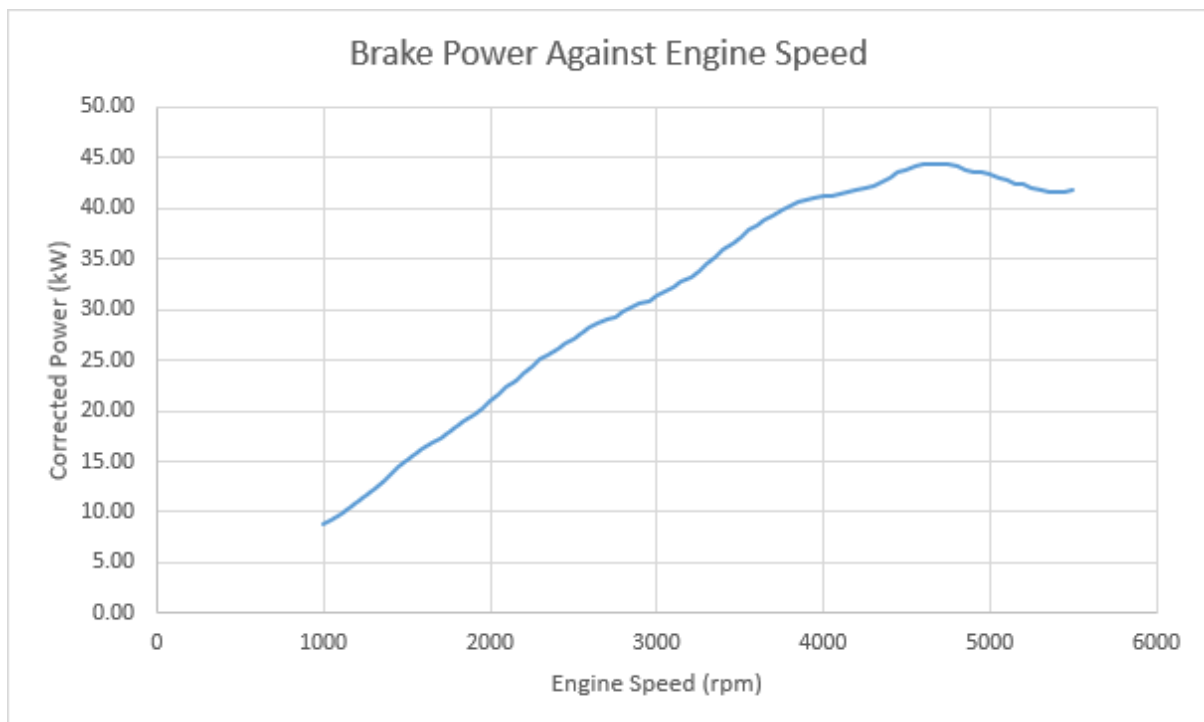
This graph portrays the SFC against the engine speed. The graph shows an exponential descending slope and a gradual increase as the engine speed increases. SFC is a measurement of engine efficiency in producing power (Harrison, 2025). At low revs, the SFC is high due to the engine consuming fuel to keep it at idle, but not producing useful power and the throttle is closed; therefore, not much air is going into the cylinder, leading to a fuel-to-air ratio that is not optimal, running rich. Between 1500-2500 rpm, where the throttle has partially opened, the SFC is at its lowest, meaning the engine is in optimal operation, producing more useful power. This suggests that the fuel-to-air ratio is close to the stoichiometric ratio, 14.7:1, for gasoline (Harrison, 2025). As the throttle gradually opens, more air goes into the chambers. The lambda sensor notices the changes in the exhaust gas, therefore altering the mixture and increasing more fuel to be injected. Hence the increase of SFC in the high rpm range.

4.2 Torque against Engine Speed



The graph shows the relationship between the torque and the engine speed. The torque follows a rise, peak, and fall as the engine speed increases (Driving 4 Answers, 2022). The torque rises as the engine reaches its optimal operation, as suggested by the previous graph with SFC. Allows more air to be pulled, providing an increased fuel-to-air ratio, which produces more pressure in the cylinder per combustion. At the peak of torque, the engine is working at peak conditions, allowing more air to reach a stoichiometric ratio, providing the highest pressure for each cylinder after combustion. As the engine rpm further increases, the torque starts to fall off. This is due to less time for the air to fill the vacuum, which reduces the volumetric efficiency of each cylinder, producing less pressure from the combustion.

4.3 Brake Power Against Engine Speed



This graph shows the correlation between the brake power and engine speed. The power increases gradually with the engine speed until flattening out around 4500 rpm where it then starts to decrease. Power is the product of engine speed and torque. Once the torque starts to decrease, it's not enough to outweigh the engine speed; therefore, power still increases. As the torque further decreases, the power is then affected too, resulting in a decline. Therefore, the peak power is always after the peak torque (Largiadier, 2025).

5 Conclusion

These graphs provide an understanding of the principles of the engine, how engine speed can affect different aspects of the engine and how it behaves with changes. It reinforces that the graphs correlate with each other. When SFC is at its lowest, the engine reaches its optimal condition. The fuel-to-air ratio mixture reaches the stoichiometric ratio, and volumetric efficiency is maximised per cylinder. This provides extreme pressure per combustion, which leads to a high torque output as portrayed on the graph for torque. As the engine speed further increases, the efficiency of the engine decreases. SFC gradually rises as more fuel is consumed, and torque starts to decline as the volumetric efficiency of the cylinders decreases, less time for air to fill the vacuum. Brake power is the product of the torque and engine speed; therefore, it connects with the torque graph. Power will gradually rise with the rpm even if the torque has declined. When torque outweighs the engine speed, power also starts to decline.

It shows that manufacturers analyse the behaviours of engines and how they can be tuned and optimised for different applications, such as motorsport and automotive. Understanding the characteristics provides a principle for gear selection to enable the engine to stay in its optimal range.

6 Evaluation

Throughout this report, the tasks set were straightforward but somewhat challenging. Due to the dynamometer not being able to be operated, I didn't get to see how it works, hindering my understanding of the dynamometer. During this report, Research was done on a dynamometer, such as videos and diagrams, to understand the mechanical functions. The spreadsheet data given for the dynamometer wasn't our simulation of the dynamometer, and we didn't get to experience real-life data of the engine from the dynamometer. What I could have done to improve is to further research the principles of the engine to deepen my knowledge and understanding.

7 Bibliography

Driving 4 Answers (2022) *WHY are HORSEPOWER and TORQUE CURVED?* - *YouTube*. Available at: https://www.youtube.com/watch?v=Nbev14oIH6I&ab_channel=driving4answers (Accessed: 29 March 2025).

Harrison, A. (2025) *Powertrain_25*. Available at: https://uowtsd-my.sharepoint.com/personal/andrew_harrison_uowtsd_ac_uk/_layouts/15/Doc.aspx?sourcedoc={c9dd2410-c111-4550-b00f-0a3dc3baa55d}&action=view&wd=target%28Lecture%20Notes.one%7Cab796523-684d-4952-84b9-95a1ebd8661c%2FWeek%204%7C15038c3a-407b-4404-bd84-701e93e9c677%2F%29&wdorigin=NavigationUrl (Accessed: 28 March 2025).

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