Theory of Machines and Automatic Control - project class

The Faculty of Automotive and Construction Machinery Engineering

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http://myinventions.pl/lectures/

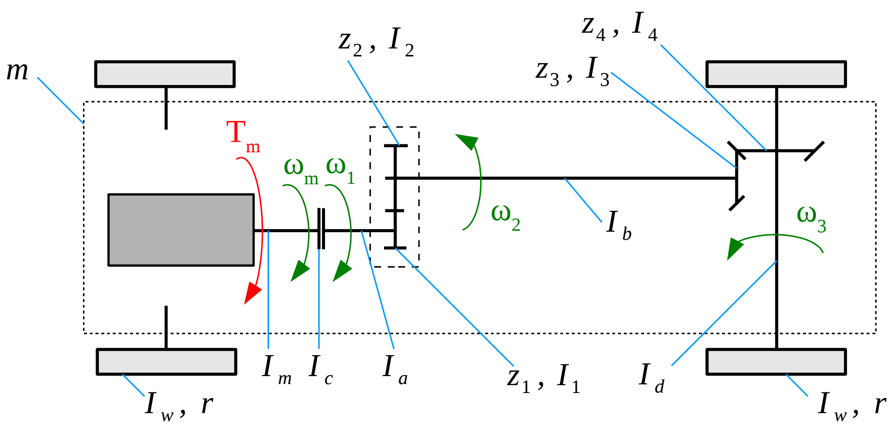
Project no. 2 (teacher: Sebastian Korczak)

In this project model of a car is analyzed (see picture below). It consist of:

- an electric motor (permanent magnet DC), which generates torque related to it's angular velocity: $T_m = A - B\omega_m$, where A and B are given constants. Motor's output shaft has moment of inertia equal to I_m;
- a clutch of inertia I_c; assume that the clutch is closed $(\omega_m = \omega_1)$;
- a gearbox (reducer) with given: input shaft inertia I_a, input gear inertia I_1, output gear inertia I_2, and gear ratio $z_2/z_1 = i_1$ (z_2 and z_1 are the numbers of teethes);
- main drive shaft with inertia I_b;
- rear gearbox (reducer) with given: input gear inertia I_3, output gear inertia I_4, and gear ratio $z_4/z_3 = i_2$ (z_4 and z_3 are the numbers of teethes);
- rear axis of inertia I_d;
- four wheels of inertia I_w and radius r;

Total car's mass is equal to *m*. Assume that there is no slip between tires and ground. Assume air resistance force as a proportional to the velocity with a parameter *c*. Car is moving on an inclined plane of angle α (gravity acceleration $g \approx 9.81\, m/s^2$).

Make reduction of the whole system with respect to linear velocity of the car (masses and forces reduction). Write down machine equation of motion. Calculate acceleration at start. Solve the equation of machine motion to obtain velocity of the car during the machine start-up. Draw a plot of the velocity in time. Find out object's maximum velocity. Calculate a time needed to achieve the steady velocity (assume it is time when velocity reach 95% of maximum).



I_m	0,01	[kgm²]
I_c	0,04	[kgm²]
I_a	0,01	[kgm²]
I_b	0,04	[kgm²]
I_d	0,05	[kgm²]
c	30	[Ns/m]

Lp.	Student number	A	B	I_1	I_2	I_3	I_4	i_1	i_2	r	I_w	α	m
		[Nm]	[Nms/rad]	[kgm²]	[kgm²]	[kgm²]	[kgm²]	[-]	[-]	[m]	[kgm²]	[°]	[kg]
1	287572	80	0,0637	0,0015	0,0025	0,0016	0,0064	3,3	4	0,29	0,1232	15	1010
2	267664	90	0,0716	0,0015	0,0014	0,0016	0,0066	1,8	4,1	0,30	0,124	8	1050
3	287270	90	0,0716	0,0016	0,0026	0,0016	0,0067	3,3	4,2	0,31	0,1248	16	1090
4	K-4669	95	0,0756	0,0016	0,0014	0,0016	0,0069	1,8	4,3	0,32	0,1256	10	1130
5	257695	100	0,0796	0,0017	0,0026	0,0016	0,0070	3,1	4,4	0,33	0,1264	15	1170
6	282650	105	0,0836	0,0017	0,0015	0,0016	0,0072	1,8	4,5	0,34	0,1272	10	1210
7	286783	110	0,0875	0,0016	0,0025	0,0017	0,0078	3,1	4,6	0,35	0,128	15	1250
8	282633	115	0,0915	0,0016	0,0014	0,0017	0,0077	1,8	4,5	0,36	0,1288	9	1290
9	282634	120	0,0955	0,0015	0,0025	0,0017	0,0075	3,3	4,4	0,37	0,1296	15	1330
10	286495	125	0,0995	0,0015	0,0014	0,0017	0,0073	1,8	4,3	0,38	0,1304	8	1370
11	288611	130	0,1035	0,0016	0,0026	0,0017	0,0071	3,3	4,2	0,39	0,1312	15	1410
12	282654	135	0,1074	0,0016	0,0014	0,0017	0,0070	1,8	4,1	0,40	0,132	7	1450
13	288639	140	0,1114	0,0017	0,0026	0,0017	0,0068	3,1	4	0,41	0,1328	11	1490
14	288475	145	0,1154	0,0017	0,0015	0,0018	0,0070	1,8	3,9	0,42	0,1336	5	1530
15	282642	150	0,1194	0,0017	0,0026	0,0018	0,0068	3,1	3,8	0,43	0,1344	10	1570
16	267450	80	0,0637	0,0015	0,0025	0,0018	0,0072	3,3	4	0,29	0,1232	15	1010
17	288517	90	0,0716	0,0015	0,0014	0,0018	0,0074	1,8	4,1	0,30	0,124	8	1050
18	282649	90	0,0716	0,0016	0,0026	0,0018	0,0076	3,3	4,2	0,31	0,1248	16	1090
19	282638	95	0,0756	0,0016	0,0014	0,0018	0,0077	1,8	4,3	0,32	0,1256	10	1130
20	288574	100	0,0796	0,0017	0,0027	0,0018	0,0079	3,2	4,4	0,33	0,1264	15	1170
21	K-4661	105	0,0836	0,0017	0,0015	0,0190	0,0855	1,8	4,5	0,34	0,1272	10	1210
22	K-4667	110	0,0875	0,0016	0,0025	0,0190	0,0874	3,1	4,6	0,35	0,128	15	1250
23	K-4674	115	0,0915	0,0016	0,0014	0,0190	0,0855	1,8	4,5	0,36	0,1288	9	1290
24	K-4671	120	0,0955	0,0015	0,0025	0,0190	0,0836	3,3	4,4	0,37	0,1296	15	1330
25	287272	125	0,0995	0,0015	0,0014	0,0190	0,0817	1,8	4,3	0,38	0,1304	8	1370