

# AA 236: Spacecraft Design

## Problem Set 1

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### Problem 1

- (a) – code –
- (b) – code –
- (c) – code –
- (d) – code –
- (e) – code –

### Problem 2

- (a) – done –
- (b) – done –

### Problem 3

- (a) Two Line Elements (TLEs) were originally developed as a way to predict the location of Earth orbiting satellites with minimal amount of data elements. The original model was developed by Max Lane in the 1960s and an improved version became TLE format in the 1970s. It was originally developed for use on punch cards but is now formatted into a text file. TLEs are still used and useful today for describing the trajectories and locations of Earth orbiting items.
- (b) Beginings of a TLE reader
  - (i) My TLE file:

```
ISS (ZARYA)
1 25544U 98067A 21020.73928083 -.000000437 00000-0 21336-6 0 9991
2 25544 51.6446 352.0168 0000410 314.0614 106.8284 15.49300430265749
KESTREL EYE IIM (KE2M)
1 42982U 98067NE 21020.34479427 .00027274 00000-0 14742-3 0 9993
2 42982 51.6324 247.7774 0003818 193.2461 166.8441 15.79895238185238
DELLINGR (RBLE)
1 43021U 98067NJ 21020.31781189 .00035075 00000-0 17032-3 0 9999
2 43021 51.6303 244.6421 0003355 158.9585 201.1556 15.82092661181044
TEMPEST-D
1 43547U 98067NV 21020.46056417 .00017990 00000-0 14022-3 0 9999
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2 43547 51.6344 291.5848 0006267 141.2688 218.8761 15.71767240143513
RADSAT-G
1 43553U 98067PB 21019.70651218 .00063592 00000-0 25764-3 0 9995
2 43553 51.6356 264.8415 0005745 174.3942 185.7127 15.85640382144236
AEROCUBE 12A
1 43556U 18046C 21020.52077132 .00002004 00000-0 78317-4 0 9990
2 43556 51.6410 141.9221 0007821 356.3931 3.6992 15.30838287140616
AEROCUBE 12B
1 43557U 18046D 21020.49947023 .00001173 00000-0 51525-4 0 9990
2 43557 51.6419 143.2581 0007880 355.9702 4.1213 15.30385996140544
LEMUR-2-VU
1 43558U 18046E 21020.60423100 .00003555 00000-0 12299-3 0 9999
2 43558 51.6403 135.8770 0006873 1.2966 358.8032 15.32551271140696
LEMUR-2-ALEXANDER
1 43559U 18046F 21020.61167735 .00003052 00000-0 10662-3 0 9994
2 43559 51.6403 135.1947 0006854 1.1781 358.9215 15.32744782140481
LEMUR-2-YUASA
1 43560U 18046G 21020.50184291 .00002461 00000-0 88887-4 0 9998
2 43560 51.6409 136.6877 0007169 13.9236 346.1942 15.32501158140678
LEMUR-2-TOMHENDERSON
1 43561U 18046H 21020.48717115 .00001847 00000-0 70313-4 0 9995
2 43561 51.6406 137.3289 0007364 13.9347 346.1837 15.32179814140225
1998-067PN
1 43638U 98067PN 21020.46299597 .00019854 00000-0 15307-3 0 9996
2 43638 51.6337 288.5566 0003417 129.4294 230.7007 15.71962071130717
1998-067PP
1 43639U 98067PP 21020.56468460 .00109790 00000-0 37799-3 0 9993
2 43639 51.6273 265.7779 0005729 162.0634 198.0574 15.88744100131028
STARS-ME
1 43640U 98067PQ 21019.96420598 .00035760 00000-0 22746-3 0 9998
2 43640 51.6308 283.6183 0005054 134.4845 225.6569 15.76079075130732
ISS DEB (SEDA-AP)
1 43870U 98067PU 21020.11522524 .00005078 00000-0 67479-4 0 9996
2 43870 51.6372 318.6278 0004599 128.8248 231.3157 15.60143765118452
CATSAT-2
1 44029U 98067PV 21019.96507292 .00071544 00000-0 35992-3 0 9994
2 44029 51.6388 289.8325 0004244 162.8595 197.2551 15.81010896112552
DELPHINI
1 44030U 98067PW 21020.13748814 .00094368 00000-0 36829-3 0 9993
2 44030 51.6285 283.9315 0005667 158.6825 201.4416 15.86260516112619
UNITE
1 44031U 98067PX 21020.49382834 .00020031 00000-0 17957-3 0 9996
2 44031 51.6374 303.8816 0003494 144.6628 215.4601 15.68299211112388
CATSAT-1
1 44033U 98067PZ 21020.02832685 .00067643 00000-0 34027-3 0 9998
2 44033 51.6387 289.5145 0003879 163.4629 196.6500 15.81036507112476
ISS DEB
1 44303U 98067QA 21020.57338348 .00006807 00000-0 99374-4 0 9997
2 44303 51.6412 334.5874 0005968 61.3700 298.7891 15.56937260 93554
ISS DEB
1 44304U 98067QB 21020.50478864 .00093013 00000-0 46060-3 0 9997
2 44304 51.6345 305.4834 0005777 108.0601 252.1031 15.81239845 93945
ISS DEB
1 44305U 98067QC 21017.99978115 .07702457 12184-4 93942-3 0 9998

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2	44305	51.6090	302.5059	0006259	207.7361	152.3330	16.35437524	93752	
ISS DEB									
1	44306U	98067QD	21020.57536360	.00008034	00000-0	11487-3	0	9996	
2	44306	51.6398	334.5170	0007095	57.5604	302.6073	15.57207924	93568	
RAAVANA-1									
1	44329U	98067QE	21020.25196836	.00022921	00000-0	22946-3	0	9999	
2	44329	51.6376	322.6169	0006596	95.2715	264.9033	15.65436194	90860	
UGUISU									
1	44330U	98067QF	21020.21770325	.00021019	00000-0	21262-3	0	9995	
2	44330	51.6353	323.0809	0006573	94.4164	265.7582	15.65234548	90831	
NEPALISAT-1									
1	44331U	98067QG	21020.24323934	.00021861	00000-0	21928-3	0	9993	
2	44331	51.6352	322.5030	0006588	96.9206	263.2539	15.65419290	90857	
SPOOQY-1									
1	44332U	98067QH	21020.52578715	.00024723	00000-0	25022-3	0	9993	
2	44332	51.6362	321.4091	0005843	100.0269	260.1386	15.65115919	90850	
RED-EYE 1 (PINOT)									
1	44364U	98067QJ	21020.59007413	.00008133	00000-0	11796-3	0	9997	
2	44364	51.6412	335.4328	0007361	56.9054	303.2643	15.56796855	89135	
IOD-1 GEMS									
1	44385U	98067QK	21020.52074404	.00081159	00000-0	49771-3	0	9990	
2	44385	51.6357	311.6620	0004974	104.4200	255.7352	15.76559516	88507	
SWIATOWID									
1	44426U	98067QL	21020.53892361	.00103053	00000-0	50184-3	0	9995	
2	44426	51.6373	307.6022	0006219	122.4693	47.9850	15.81557616	88567	
KRAKSAT									
1	44427U	98067QM	21020.29540057	.00012483	00000-0	15109-3	0	9995	
2	44427	51.6435	330.1611	0004164	63.2003	90.1888	15.61088781	88286	
VCC A									
1	44428U	98067QN	21020.54592452	.00024181	00000-0	25214-3	0	9996	
2	44428	51.6387	323.8888	0003947	80.4962	279.6479	15.64384651	88391	
ENTRYSAT									
1	44429U	98067QP	21020.53600797	.00034268	00000-0	31371-3	0	9996	
2	44429	51.6350	319.9920	0003951	84.8917	275.2531	15.67448215	88445	
VCC C									
1	44430U	98067QQ	21020.51679231	.00049083	00000-0	36739-3	0	9999	
2	44430	51.6344	315.3550	0004309	99.1439	261.0047	15.72149526	87336	
VCC B									
1	44431U	98067QR	21020.14980700	.00020257	00000-0	21089-3	0	9999	
2	44431	51.6363	325.6929	0004110	78.1062	282.0394	15.64545855	88279	
ISS DEB									
1	44788U	98067QT	21020.57600927	.00056531	00000-0	48628-3	0	9993	
2	44788	51.6379	329.2900	0006537	92.2060	267.9685	15.68733278	67296	
ISS DEB									
1	44789U	98067QU	21020.14696255	.00041436	00000-0	38830-3	0	9998	
2	44789	51.6375	333.2014	0007228	89.2563	270.9261	15.66755860	67198	
RWASAT-1									
1	44790U	98067QV	21020.31957553	.00010611	00000-0	15478-3	0	9994	
2	44790	51.6438	342.2854	0008710	101.7714	49.0428	15.56250295	66355	
AQT-D									
1	44791U	98067QW	21020.59040147	.00010518	00000-0	15342-3	0	9993	
2	44791	51.6424	341.4677	0007497	77.2794	282.9035	15.56271231	66390	
NARSSCUBE-1									
1	44792U	98067QX	21020.16641120	.00015593	00000-0	20061-3	0	9997	

2	44792	51.6397	340.0730	0006056	92.5695	267.5991	15.59242779	66371
STPSAT-4								
1	45043U	98067QY	21020.34051366	.00004689	00000-0	83688-4	0	9993
2	45043	51.6423	350.9739	0006277	87.1309	273.0400	15.52134464	55488
HARP								
1	45256U	98067QZ	21020.29625832	.00010266	00000-0	15794-3	0	9998
2	45256	51.6428	347.7171	0007897	81.9486	278.2401	15.54832969	52190
1998-067RA								
1	45257U	98067RA	21020.32495599	.00007929	00000-0	12602-3	0	9995
2	45257	51.6419	347.8835	0008463	83.4698	276.7256	15.54302323	52198
PHOENIX								
1	45258U	98067RB	21020.31372129	.00006949	00000-0	11383-3	0	9994
2	45258	51.6416	348.5455	0006756	67.1368	293.0335	15.53696731	52152
1998-067RC								
1	45259U	98067RC	21020.19050464	.00012623	00000-0	18382-3	0	9998
2	45259	51.6408	346.9849	0007811	81.5648	278.6229	15.56099486	52199
CRYOCUBE								
1	45260U	98067RD	21020.29755155	.00015006	00000-0	21712-3	0	9999
2	45260	51.6407	346.2020	0008470	82.3706	277.8247	15.56097411	52221
AZTECHSAT-1								
1	45261U	98067RE	21020.17891750	.00016306	00000-0	22218-3	0	9995
2	45261	51.6403	345.4071	0008222	81.8639	278.3286	15.57652047	52210
RADSAT-U								
1	45262U	98067RF	21020.17661766	.00008406	00000-0	13221-3	0	9994
2	45262	51.6431	348.4162	0007172	111.7800	248.3954	15.54507618	52187
QARMAN								
1	45263U	98067RG	21020.16664863	.00013027	00000-0	19069-3	0	9996
2	45263	51.6409	347.5727	0007827	78.5084	281.6785	15.55924775	52215
SORTIE								
1	45264U	98067RH	21020.60603538	.00006059	00000-0	10358-3	0	9997
2	45264	51.6430	348.2694	0008115	88.8818	271.3101	15.52752141	52212
ICS-EF (ISS DEB)								
1	45265U	98067RJ	21020.29376109	.00002823	00000-0	55263-4	0	9994
2	45265	51.6428	352.1547	0006110	87.6937	272.4752	15.51143175	51812
PROGRESS-MS 14								
1	45595U	20026A	21019.40295723	.00000872	00000-0	23712-4	0	9999
2	45595	51.6468	358.6249	0000255	279.1625	243.4938	15.49302954265537	
G-SAT								
1	45597U	98067RK	21020.18229811	.00008488	00000-0	13529-3	0	9998
2	45597	51.6421	349.9388	0005122	129.6015	230.5429	15.54131356	41520
QUETZAL-1								
1	45598U	98067RL	21020.18806342	.00011832	00000-0	18213-3	0	9991
2	45598	51.6425	349.9742	0002701	137.0479	223.0723	15.54666718	41457
RED-EYE 2 (MERLOT)								
1	45800U	98067RM	21020.37105148	.00004321	00000-0	79240-4	0	9997
2	45800	51.6430	351.9362	0001992	99.2169	260.9046	15.51570261	33684
RED-EYE 3 (CABERNET)								
1	45809U	98067RN	21020.37163286	.00004351	00000-0	79743-4	0	9994
2	45809	51.6430	351.9404	0002228	91.0917	269.0328	15.51568025	32669
DEMI								
1	45916U	98067RP	21020.17521634	.00011496	00000-0	18198-3	0	9990
2	45916	51.6427	351.3888	0003062	46.3480	313.7764	15.53921426	29644
TECHDSAT 10								
1	45917U	98067RQ	21020.59076000	.00129187	00000-0	10075-2	0	9991

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2 45917 51.6354 341.3805 0007980 88.1853 272.0059 15.70735801 29769
PROGRESS-MS 15
1 45937U 20050A 21019.40295723 .00000872 00000-0 23712-4 0 9996
2 45937 51.6468 358.6249 0000255 279.1625 243.4938 15.49302954265537
CYGNUS NG-14
1 46530U 20069A 21020.73929850 .00002253 00000-0 94558-4 0 9990
2 46530 51.6416 354.2275 0010644 337.0536 82.7912 15.27811863 16977
SOYUZ-MS 17
1 46613U 20072A 21019.40295723 .00000872 00000-0 23712-4 0 9992
2 46613 51.6468 358.6249 0000255 279.1625 243.4938 15.49302954265539
CREW DRAGON 1
1 46920U 20084A 21019.40295723 .00000872 00000-0 23712-4 0 9996
2 46920 51.6468 358.6249 0000255 279.1625 243.4938 15.49302954265530
SPOC
1 46921U 98067RR 21020.32345052 .00006955 00000-0 12289-3 0 9991
2 46921 51.6441 353.1239 0001159 231.6847 128.4039 15.51549976 11841
BOBCAT-1
1 46922U 98067RS 21020.31191849 .00009221 00000-0 15765-3 0 9995
2 46922 51.6442 353.0493 0000680 231.3485 128.7444 15.52038045 11807
NEUTRON-1
1 46923U 98067RT 21020.19912651 .00006475 00000-0 11536-3 0 9994
2 46923 51.6441 353.7926 0000993 260.3518 99.7359 15.51447767 11852
1998-067RU
1 46924U 98067RU 21020.16509533 .00014286 00000-0 23289-3 0 9990
2 46924 51.6436 353.5652 0001056 356.8432 3.2551 15.52876122 11821
LEMUR-2-BAXTER-OLIVER
1 46925U 98067RV 21020.22268771 .00015016 00000-0 24234-3 0 9997
2 46925 51.6441 353.2046 0001160 345.8670 14.2287 15.53111457 11798
LEMUR-2-DJARA
1 46926U 98067RW 21020.29182299 .00013883 00000-0 22587-3 0 9994
2 46926 51.6440 352.9156 0000270 4.2141 355.8852 15.52958214 11821
DESCENT
1 46927U 98067RX 21020.33052309 .00006839 00000-0 12156-3 0 9992
2 46927 51.6439 353.1694 0001268 303.6383 56.4485 15.51414996 11786

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(vi)

(vii)

(viii)

(ix) (BONUS)

## Problem 4

(a)

(b)