

**Question 1:** (a) Convert geodetic position 290 deg Long 42 deg latitude ellipsoidal height 0 m into Cartesian and geocentric coordinates.

(b) How far apart on the surface of the Earth (approximate radius 6371km) would be locations that have geocentric latitude 42 deg and geodetic latitude 42 deg.

Give answer in km.

(c) Using the conversion between XYZ and Geodetic coordinates, determine if ellipsoid heights are measured along a straight line. (Orthometric heights are measured along a curved path that is always along the local direction of gravity).

(30 pts)

**Question 2:** A broadcast ephemeris file for March 31 2010 is given below. All of the GPS satellites are given. For the set of PRN's 2 5 8 10 15 18 21 24 27 29 compute

(1) A 3-D plot of the trajectories of the motions of the satellites in

(a) Inertial space. Produce plots for 2 orbits of the satellites. Comment on the how closely the satellite tracks overlap.

(b) Earth fixed frame. Plots for 2 orbits of the satellites.

(2) A ground track plot (i.e., the track of the satellite position radially projected to the surface of the sphere). OPTIONAL: show projection onto an ellipsoid (Projection of ground normal to the satellite).

(3) A sky map for geocentric location 288.90 deg longitude, 42.36 deg latitude for the period 2010 03 31 14 00 to 2010 04 01 14 00 GPST (i.e., 24-hours) . A sky map shows azimuth and zenith distance (90-elevation angle) as a radial plot with zenith distance scaled to a convenient distance unit. At the 15:15 GPST all satellites in the list should be visible.

(70 pts).

The full definition of the RINEX standard can be found at:

<http://igscb.jpl.nasa.gov/igscb/data/format/rinex2.txt>

The following Matlab function can be used to read the broadcast ephemeris file and return a structure array containing the elements ReadNav.m

RINEX Navigation message file:

The following is a RINEX format dump of the Ephemeris subframes. The messages from all satellites are merged into the one file. The format of the data entries is:

The first three lines are comments. The rest of the file is made up of groups of seven lines per satellite. The format of these lines is:

prn	yy	mm	dd	hh	mm	sec	af0	af1	af2	
							aode	crs	dn	MO
							cuc	ecc	cus	art
							toe	cic	om0	cis
							i0	crc	w	omd
							idt	cflg12	weekno	pflg12
							svaccuracy	svhealth	tgdc	aodc
							transmit	spare	spare	spare

where prn is the PRN number of satellite

yy mm dd hh mm sec is the epoch to which the clock parameters follow apply

af0, af1, af2 are the clock offset (sec), rate (sec/sec) and acceleration (sec/sec<sup>2</sup>).

aode age of ephemeris entry (sec) i.e, how long ago was it uploaded

crs,crc radius corrections (m)

dn correction to mean motion (radian/sec)

MO Mean anomaly (radians)

cuc,cus correction to argument in latitude (rad)

ecc eccentricity

art square root of semi-major axis (m<sup>.5</sup>)

toe time of ephemeris

cic,cis corrections to inclination

om0 longitude of the ascending node (rad) (Capital omega)

i0 inclination (rads)

w argument of perigee (rad) (lower case omega)

omd time derivative of longitude of the ascending node (rad/sec)

idt time derivative of inclination (rads/sec)

cflg12, pflg12 Flags (whose meaning is not clear)

weekno GPS Week Number

svaccuracy range accuracy (m)

svhealth satellite health flag

tgdc Group delay L2 bias (word 7 subframe 1)

aodc age of clock parameter upload (sec)

transmit Transmission time seconds of GPS week

spare Un-used positions.

The navigation file is linked as mit0090s.10n and is list below. The full broadcast ephemeris for all satellites at 14:00 GPST is mit00900.10n.

```

2                NAVIGATION DATA                RINEX VERSION / TYPE
CCRNEXN V1.6.0 UX CDDIS                01-APR-10 02:51    PGM / RUN BY / DATE
IGS BROADCAST EPHEMERIS FILE                COMMENT
0.1118E-07  0.7451E-08  -0.5960E-07  -0.5960E-07    ION ALPHA
0.9011E+05  0.1638E+05  -0.1966E+06  -0.6554E+05    ION BETA
-0.279396772385E-08-0.266453525910E-14  503808    1577 DELTA-UTC: A0,A1,T,W
15                                            LEAP SECONDS
                                            END OF HEADER
2 10  3 31 14  0  0.0  0.241860281676E-03  0.375166564481E-11  0.000000000000E+00
0.830000000000E+02  0.640937500000E+02  0.482841540860E-08-0.528571306808E+00
0.333040952682E-05  0.945384649094E-02  0.120550394058E-04  0.515380251694E+04
0.309600000000E+06  0.152736902237E-06  0.355615492310E+00-0.100582838059E-06
0.940584516172E+00  0.139031250000E+03  0.300686089308E+01-0.813748181592E-08
-0.592881838765E-10  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.172294676304E-07  0.830000000000E+02
0.302418000000E+06  0.400000000000E+01  0.000000000000E+00  0.000000000000E+00
5 10  3 31 14  0  0.0-0.234134495258E-05  0.682121026330E-12  0.000000000000E+00
0.490000000000E+02  0.906875000000E+02  0.492484799683E-08  0.981922154302E+00
0.496208667755E-05  0.190063484479E-02  0.249035656452E-05  0.515367579460E+04
0.309600000000E+06  0.372529029846E-07  0.141499088172E+01  0.409781932831E-07
0.958755788827E+00  0.328187500000E+03  0.346174834291E+00-0.852856953487E-08
0.189293599124E-09  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.884756445885E-08  0.490000000000E+02
0.302418000000E+06  0.400000000000E+01  0.000000000000E+00  0.000000000000E+00
8 10  3 31 14  0  0.0  0.453647226095E-05  0.227373675443E-12  0.000000000000E+00
0.540000000000E+02-0.275937500000E+02  0.336371154066E-08-0.276359092174E+01
-0.141747295856E-05  0.109816654585E-01  0.128392130136E-04  0.515371162033E+04
0.309600000000E+06-0.143423676491E-06-0.270126764916E+01-0.204890966415E-07
0.992647530885E+00  0.149500000000E+03  0.309416938304E+01-0.728994651268E-08
0.342157109360E-09  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.419095158577E-08  0.540000000000E+02
0.302400000000E+06  0.000000000000E+00  0.000000000000E+00  0.000000000000E+00
10 10  3 31 14  0  0.0-0.391835346818E-04-0.102318153950E-11  0.000000000000E+00
0.320000000000E+02  0.873125000000E+02  0.505056751927E-08  0.102630628130E+01
0.484474003315E-05  0.918266270310E-02  0.285170972347E-05  0.515347989654E+04
0.309600000000E+06-0.372529029846E-07  0.144108969574E+01  0.137835741043E-06
0.953779311640E+00  0.320718750000E+03  0.663085038393E+00-0.870071956275E-08
0.102861427449E-09  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.279396772385E-08  0.320000000000E+02
0.309330000000E+06  0.000000000000E+00  0.000000000000E+00  0.000000000000E+00
15 10  3 31 14  0  0.0-0.292238313705E-03  0.432009983342E-11  0.000000000000E+00
0.640000000000E+02-0.111843750000E+03  0.482877256633E-08  0.121346127376E+00
-0.594742596149E-05  0.245567061938E-02  0.448897480965E-05  0.515373927879E+04
0.309600000000E+06  0.745058059692E-08  0.244957096832E+01-0.223517417908E-07
0.954156273444E+00  0.288062500000E+03-0.203284961898E+00-0.846856703552E-08
-0.496092092798E-09  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.977888703346E-08  0.640000000000E+02
0.306678000000E+06  0.400000000000E+01  0.000000000000E+00  0.000000000000E+00
18 10  3 31 14  0  0.0  0.588074326515E-04  0.250111042988E-11  0.000000000000E+00
0.870000000000E+02  0.984375000000E+02  0.537808116152E-08  0.209718550550E+01
0.488758087158E-05  0.110832470236E-01  0.213272869587E-05  0.515368040466E+04
0.309600000000E+06-0.197440385819E-06  0.144188014256E+01-0.238418579102E-06
0.937771292521E+00  0.328531250000E+03-0.234724053039E+01-0.877143679412E-08
0.272868508926E-09  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.107102096081E-07  0.870000000000E+02
0.308778000000E+06  0.400000000000E+01  0.000000000000E+00  0.000000000000E+00
21 10  3 31 14  0  0.0-0.503379851580E-04-0.250111042988E-11  0.000000000000E+00
0.810000000000E+02  0.957500000000E+02  0.470412464537E-08-0.306877989704E+01
0.468641519546E+05  0.162279284559E-01  0.135526061058E-04  0.515370728683E+04
0.309600000000E+06-0.819563865662E-07  0.384677822873E+00-0.266358256340E-06
0.933277436397E+00  0.103500000000E+03-0.250657696232E+01-0.784532705467E-08
-0.717887069235E-10  0.100000000000E+01  0.157700000000E+04  0.000000000000E+00
0.200000000000E+01  0.000000000000E+00-0.121071934700E-07  0.810000000000E+02

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0.302802000000E+06 0.400000000000E+01 0.000000000000E+00 0.000000000000E+00
24 10 3 31 14 0 0.0 0.275202561170E-03 0.329691829393E-11 0.000000000000E+00
0.750000000000E+02 0.941250000000E+02 0.450161596888E-08 0.116266182236E+01
0.487267971039E-05 0.576282490511E-02 0.128224492073E-04 0.515489965630E+04
0.309600000000E+06 0.147148966789E-06 0.422116667288E+00 0.242143869400E-07
0.949866528039E+00 0.127375000000E+03-0.476840678785E+00-0.792640175718E-08
-0.582167092311E-10 0.100000000000E+01 0.157700000000E+04 0.000000000000E+00
0.200000000000E+01 0.000000000000E+00-0.139698386192E-08 0.750000000000E+02
0.303138000000E+06 0.400000000000E+01 0.000000000000E+00 0.000000000000E+00
27 10 3 31 14 0 0.0 0.138952862471E-03 0.341060513165E-11 0.000000000000E+00
0.128000000000E+03-0.454687500000E+02 0.381694470535E-08 0.218574669221E+00
-0.243633985519E-05 0.215982137015E-01 0.129416584969E-04 0.515365018272E+04
0.309600000000E+06-0.355765223503E-06-0.282440778223E+01-0.260770320892E-06
0.978150634460E+00 0.148406250000E+03-0.144045627416E+01-0.792604443728E-08
0.903609067516E-10 0.100000000000E+01 0.157700000000E+04 0.000000000000E+00
0.200000000000E+01 0.000000000000E+00-0.419095158577E-08 0.128000000000E+03
0.302400000000E+06 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
29 10 3 31 14 0 0.0 0.109048094600E-03 0.284217094304E-11 0.000000000000E+00
0.610000000000E+02-0.492500000000E+02 0.479948569776E-08-0.286705479348E+01
-0.267289578915E-05 0.301809690427E-02 0.751577317715E-05 0.515376345635E+04
0.309600000000E+06 0.521540641785E-07-0.645449173275E+00 0.128522515297E-06
0.960517958503E+00 0.230437500000E+03-0.130983641503E+01-0.811283751290E-08
-0.500735120035E-09 0.100000000000E+01 0.157700000000E+04 0.000000000000E+00
0.200000000000E+01 0.000000000000E+00-0.884756445885E-08 0.610000000000E+02
0.302418000000E+06 0.400000000000E+01 0.000000000000E+00 0.000000000000E+00

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