## Contents



## proficiency check

```
we = 7.292115e-5; % rad/s

% JD time (1999-01-21 20:43:47 UTC)
JD1 = 2500000;

D = @(JD) JD - 2451545.0;
theta1 = 18.697374458 + 24.06570982 * D(JD1);

JD2 = JD1 + 1;
theta2 = 18.697374458 + 24.06570982 * D(JD2);

dtheta = theta2 - theta1; % hours
dtheta_deg = dtheta * 15;
we_deg = we * 60 * 60 * 24 * 180/pi;

sprintf('Proficiency check: accurate to %.9g', dtheta_deg - we_deg)
sprintf('Confirmed Earth rotation rate is %.9g rad/s', we)
```

```
ans =

    'Proficiency check: accurate to 4.22746874e-05'


ans =

    'Confirmed Earth rotation rate is 7.292115e-05 rad/s'
```

## problem 1

```
% Constants
mu=3.986004415e14;
ae=6378136.3;
we=7.292115e-5;
g=9.81;
J2=1.082e-3;
ws=1.99096871e-7;

missions = {'Lageos', 'Topex', 'GRACE', 'ERS-1'};

for i = 1:numel(missions)
```

```
    mission = missions{i};

    if isequal(mission,'Topex')
    a=7705;
    e=0.0010;
    I=65.99;
    end

    if isequal(mission,'GRACE')
    a=6820;
    e=0.0016;
    I=89.02;
    end

    if isequal(mission,'ERS-1')
    a=7156;
    e=0.0010;
    I=98.6;
    end

    if isequal(mission,'Lageos')
    a=12271;
    e=0.0040;
    I=109.83;
    end

    a=a*1000;

    % Orbital Rates
    nb=sqrt(mu/a^3);

    dOb=-3/2*nb*(ae/a)^2*J2*cosd(I)/(1-e^2)^(1/2);
    dwb=-3/4*nb*(ae/a)^2*J2*(1-5*cosd(I)^2)/(1-e^2)^2;
    dMb=nb*(1-3/4*(ae/a)^2*J2*(1-3*cosd(I)^2)/(1-e^2)^(3/2));
    dub=dwb+dMb;

    % Periods
    Tp=2*pi/nb;
    Ta=2*pi/dMb;
    Tn=2*pi/dub;
    TD=2*pi/(we+dOb);
    TS=2*pi/(ws+dOb);

    sprintf('Mission: %s', mission)
    sprintf('Keplerian period = %.5g', Tp)
    sprintf('Anomalistic period = %.5g', Ta)
    sprintf('Draconitic period = %.5g', Tn)
    sprintf('Nodal day = %.5g', TD)
    sprintf('Sun cycle = %.5g', TS)

end
```

```
ans =

    'Mission: Lageos'
```

```
ans =

    'Keplerian period = 13528'


ans =

    'Anomalistic period = 13530'


ans =

    'Draconitic period = 13531'


ans =

    'Nodal day = 86083'


ans =

    'Sun cycle = 2.3429e+07'


ans =

    'Mission: Topex'


ans =

    'Keplerian period = 6730.9'


ans =

    'Anomalistic period = 6732.7'


ans =

    'Draconitic period = 6733.4'


ans =

    'Nodal day = 86666'


ans =

    'Sun cycle = -2.8134e+07'


ans =

    'Mission: GRACE'
```

```
ans =

    'Keplerian period = 5605.2'


ans =

    'Anomalistic period = 5609.1'


ans =

    'Draconitic period = 5613.1'


ans =

    'Nodal day = 86196'


ans =

    'Sun cycle = 3.6555e+07'


ans =

    'Mission: ERS-1'


ans =

    'Keplerian period = 6024.4'


ans =

    'Anomalistic period = 6028.1'


ans =

    'Draconitic period = 6031.5'


ans =

    'Nodal day = 85927'


ans =

    'Sun cycle = 1.5701e+07'
```

## PROB 3

```
clear
clc

% Constants
mu=3.986004415e14;
ae=6378136.3;
we=7.292115e-5;
g=9.81;
J2=1.082e-3;
ws=2*pi/365.2422/24/60/60;

% orbit
alt=350000;
a=alt+ae;
e=0;
I=35;
Long=+5.157;
n=sqrt(mu/a^3);

% O Precession Calcs
sprintf('O precession:')
Odot = -(3/2)*n*(ae/a)^2*J2*(1/(1-e^2)^(1/2))*cosd(I) % O precession

sprintf('O precession for day:')
Odotday = Odot*3600*24 % for day

sprintf('Sun Precession for day:')
wsd = ws*3600*24 % Sun Precession for day

sprintf('Sun cycle period days:')
Cs = 2*pi/(Odotday-wsd) % Sun Cycle period days

sprintf('Clock time to decimal:')
tc = 20+43/60+47/3600 % clock time to decimal

sprintf('Local time at crossing TRMM:')
LMTT = tc+(Long/15) % Local time at crossing TRMM

sprintf('Local time Resurs')
LMTR = 22+20/60 % Local time Resurs

sprintf('Difference time between LMTT and LMTR:')
time_diff = (LMTT-LMTR) % Difference time

sprintf('Initial difference in time:')
O_diff_change_day= 24/Cs %initial difference in time

sprintf('Days since last cross: ')
Offset = time_diff/(O_diff_change_day) % Days since last cross

sprintf('Amount of crosses in 1 year:')
k=0:round(abs(365.2425/Cs))-1 % amount of crosses in one year

sprintf('offset by initial cross beforehand and set to cycle every Solar cycle:')
Jk=round(21-Offset)+fix(k*abs(Cs)) % offset by initial cross beforehand and set to cycle every Solar cycle
```

```
ans =

    'O precession:'


Odot =

    -1.366808860265681e-06


ans =

    'O precession for day:'


Odotday =

  -0.118092285526955


ans =

    'Sun Precession for day:'


wsd =

   0.017202791208627


ans =

    'Sun cycle period days:'


Cs =

 -46.440605665639453


ans =

    'Clock time to decimal:'


tc =

  20.729722222222222


ans =

    'Local time at crossing TRMM:'


LMTT =
```

```
  21.073522222222223


ans =

    'Local time Resurs'


LMTR =

  22.333333333333332


ans =

    'Difference time between LMTT and LMTR:'


time_diff =

  -1.259811111111109


ans =

    'Initial difference in time:'


O_diff_change_day =

  -0.516789125723163


ans =

    'Days since last cross: '


Offset =

   2.437766292679254


ans =

    'Amount of crosses in 1 year:'


k =

     0     1     2     3     4     5     6     7


ans =

    'offset by initial cross beforehand and set to cycle every Solar cycle:'
```

```
Jk =

    19    65   111   158   204   251   297   344
```

## prob 4

```
h = 500e3;  % m
a0 = ae + h;
e0 = 0;
I0 = 89 * pi/180;     % rad
w0 = 0;
long0 = 0;
M0 = 0;

% rv0 = oe2rv(0, [a0 e0 I0 w0 long0 nu0]);

%  Define parameters for a state lookup:
% t0      = 'Oct 20, 2020 11:00 AM CST';
t0      = 'May 22, 2018';
abcorr  = 'NONE';

%  Convert the epoch to ephemeris time (secs)
et_t0   = cspice_str2et( t0 );

% get states --> Earth to Sun
target   = 'Sun';
frame    = 'J2000';
observer = 'Earth';
abcorr   = 'NONE';

% orbit rate equations
nb = @(a) sqrt(mu/a^3);
dlongb = @(a, e, I) -3/2*nb(a)*(ae/a)^2*J2*cos(I)/(1-e^2)^(1/2);
dwb = @(a, e, I) -3/4*nb(a)*(ae/a)^2*J2*(1-5*cos(I)^2)/(1-e^2)^2;
dMb = @(a, e, I) nb(a)*(1-3/4*(ae/a)^2*J2*(1-3*cos(I)^2)/(1-e^2)^(3/2));
dub = @(dwb, dMb) dwb+dMb;

for k = 1 : 1 : 12*365

    % delta time
    dt = k * 60 * 60 * 24;

    % rest of OEs
    w(k,:)      = w0 + dwb(a0, e0, I0) * dt;
    long(k,:)   = long0 + dlongb(a0, e0, I0) * dt;
    M(k,:)      = M0 + dMb(a0, e0, I0) * dt;

    % convert to cartesian
    rv = oe2rv([a0, e0, I0, w(k,:), long(k,:), M(k,:)]);
%     rv = fn.orb2rv([a0, e0, I0, w(k,:), long(k,:), M(k,:)]);

    % orbit plane
    h = cross(rv(1:3), rv(4:6));
    h = h / norm(h);

    % get sun position
```

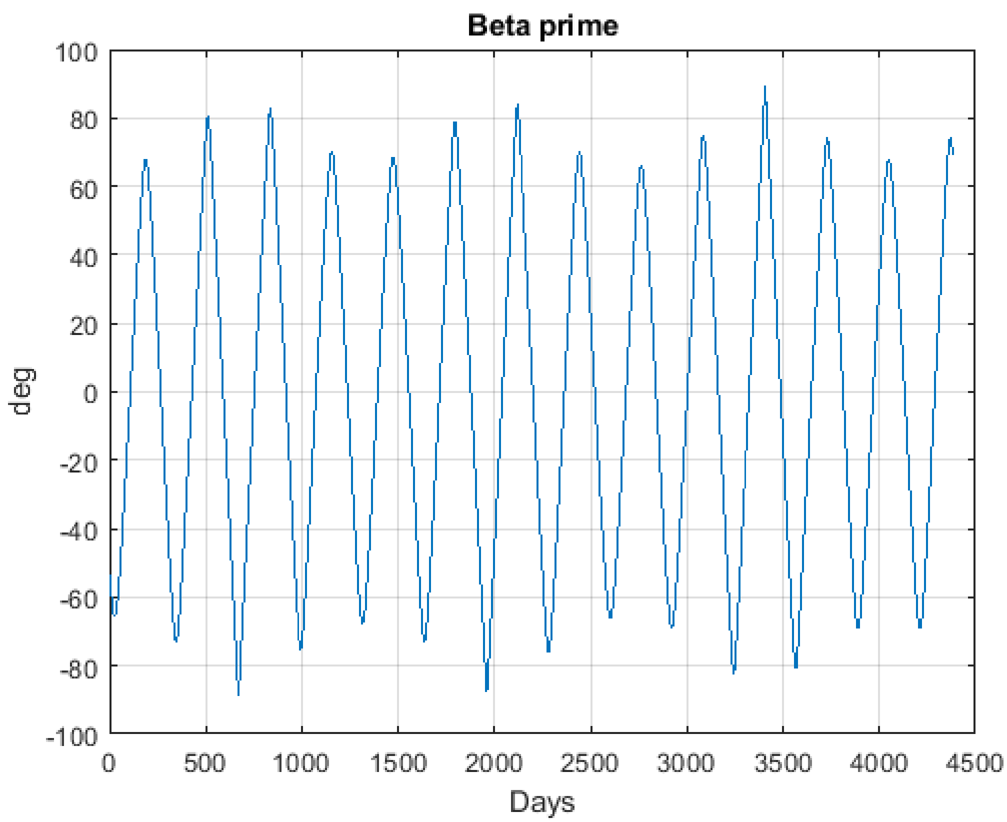
```
    et = et_t0 + dt;    % propagate ephemeris time by 1 day in secs
    X_Esun  = spice_state(et, target, frame, abcorr, observer);
    X_Esun  = X_Esun';
    r_sun   = X_Esun(1:3);
    r_sun   = r_sun / norm(r_sun);

    % get projection
    sun_proj = dot(h, r_sun);

    % Jonathan's method beta prime
    b_prime(k,:) = 90 - acosd(sun_proj);

end

fname = 'beta prime';
figure('name', fname);
    plot(b_prime);
    xlabel('Days')
    ylabel('deg')
    title('Beta prime')

sprintf('a. Q: Is the variation of the beta prime angle periodic?')
sprintf('a. A: Yes')

sprintf('b. Q: Is the variation of the beta prime angle sinusoidal?')
sprintf('b. A: Yes')

sprintf('c. Q: Why doesn’t beta prime angle in each cycle reach the same maximum value?')
sprintf('c. A: Because of orbital precession and other perturbing forces (like J2).')
```

## subfunctions

```
function rv = spice_state(epoch, target, frame, abcorr, observer)

    rv = zeros(length(epoch), 6);

    for i = 1:length(epoch)

        %  Look-up the state for the defined parameters.
        starg   = mice_spkezr( target, epoch(i), frame, abcorr, observer);
        rv(i,:) = starg.state(1:6);

    end

end
```

```
ans =

    'a. Q: Is the variation of the beta prime angle periodic?'


ans =

    'a. A: Yes'
```

```
ans =

    'b. Q: Is the variation of the beta prime angle sinusoidal?'


ans =

    'b. A: Yes'


ans =

    'c. Q: Why doesn’t beta prime angle in each cycle reach the same maximum value?'


ans =

    'c. A: Because of orbital precession and other perturbing forces (like J2).'
```

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