Assignment 1: Date, time, and time transformations

Task1:

Function used is R_i = rot3d(angle,axis)

Two imput arguments are required to for the function rot3d. For more information use 'doc rot3d'.

```
for axis = 1:3

    R_2pi = rot3d(rad2deg(2*pi),axis);
    R_0 = rot3d(rad2deg(0),axis);
    R_pi = rot3d(rad2deg(pi),axis);
    Eye_3 = eye(3);

    if (sum(sum(R_2pi == R_0))==9 && ...
    sum(sum(R_2pi == R_pi*R_pi))==9 && ...
    sum(sum(R_2pi == Eye_3))==9 && ...
    sum(sum(R_0 == R_pi*R_pi))==9 && ...
    sum(sum(R_0 == Eye_3))==9 && ...
    sum(sum(R_pi*R_pi == Eye_3))==9)

        disp(append("rot3d seems to be correct for axis: ",num2str(axis)))
    else
        error("rot3d works NOT like intended.")
    end
end
```

```
rot3d seems to be correct for axis: 1
rot3d seems to be correct for axis: 2
rot3d seems to be correct for axis: 3
```

Check function rot3d with a test vector:

```
x = [1,0,0]'
```

```
x = 3×1
     1
     0
     0
```

```
e1 = rot3d(90,2)*x
```

```
e1 = 3×1
     0
     0
     1
```

```
e2 = rot3d(90,3)*x
```

```
e2 = 3×1
     0
    -1
     0
```

```
e3 = rot3d(90,1)*x
```

```
e3 = 3×1
     1
     0
     0
```

From perspective at the origin the matrices are roatating counterclockwise when using positive angles.

Task2:

Function used is [R_ref] = ref3d(axis)

Checking the results with the Identity matrix:

```
for axis = 1:3
    if (sum(sum(ref3d(axis)*ref3d(axis) == eye(3)))==9)
        disp(append("ref3d seems to be correct for axis: ",num2str(axis)))
    else
        error("ref3d works NOT like intended.")
    end
end
```

```
ref3d seems to be correct for axis: 1
ref3d seems to be correct for axis: 2
ref3d seems to be correct for axis: 3
```

Checking the results with mutltiplication of reflection matrixes:

```
if (sum(sum(ref3d(1)*ref3d(2)*ref3d(3) == -eye(3)))==9)
        disp("ref3d works like intended.")
else
        error("ref3d works NOT like intended.")
end
```

```
ref3d works like intended.
```

=> Because M1*M2 == M2*M1 this works for all combinations

Task3:

Function used is [E,it] = kepler_ecc_ano(M,e)

For the kepler_ecc_ano function an extra paramtermeter could be introduced to define the starting value.

```
[E,iterations] = kepler_ecc_ano(10,0.5) %Some test values
```

```
E = 9.8114
iterations = 18
```

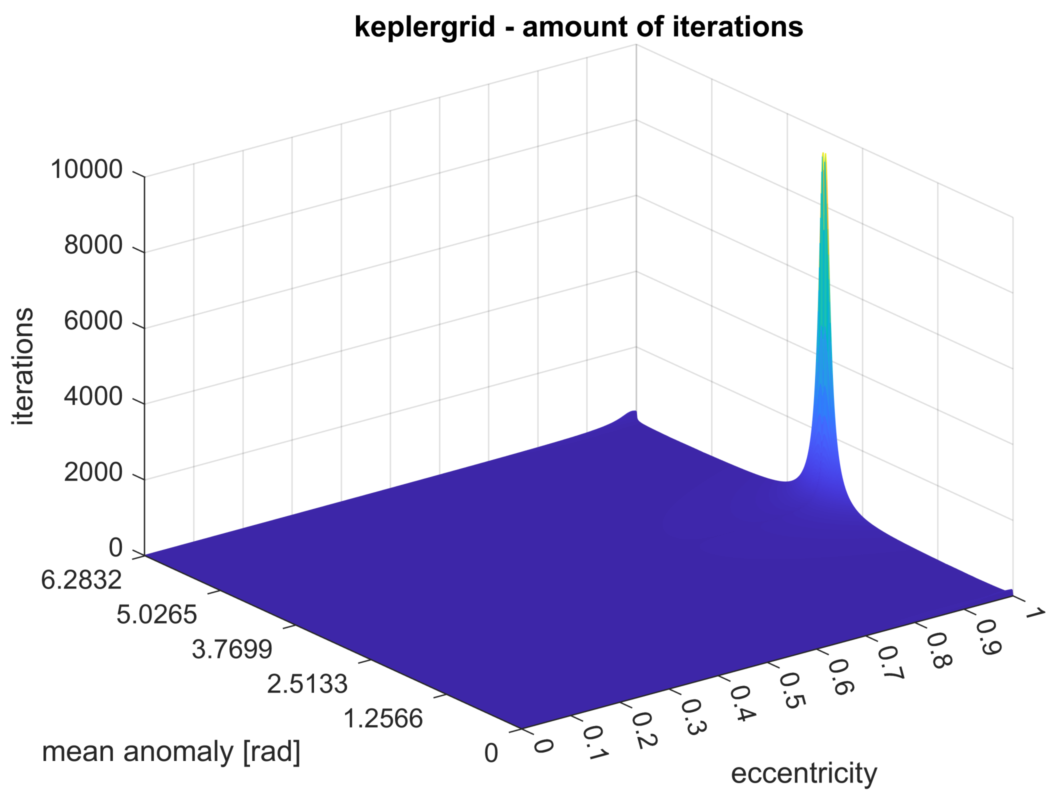
The Grid

```
M_an=0:0.01:2*pi;
ecc=0:0.001:(1-0.001);

keplergrid_E =  zeros(length(M_an),length(ecc));
keplergrid_it =  zeros(length(M_an),length(ecc));
keplergrid_diff =  zeros(length(M_an),length(ecc));
```

```
for i_M_an = 1:length(M_an)
    for i_ecc = 1:length(ecc)

        [keplergrid_E(i_M_an,i_ecc), keplergrid_it(i_M_an,i_ecc)] = ...
            kepler_ecc_ano(M_an(i_M_an),ecc(i_ecc));
        keplergrid_diff(i_M_an,i_ecc) = keplergrid_E(i_M_an,i_ecc)-M_an(i_M_an);
    end
end
```

Plot iterations

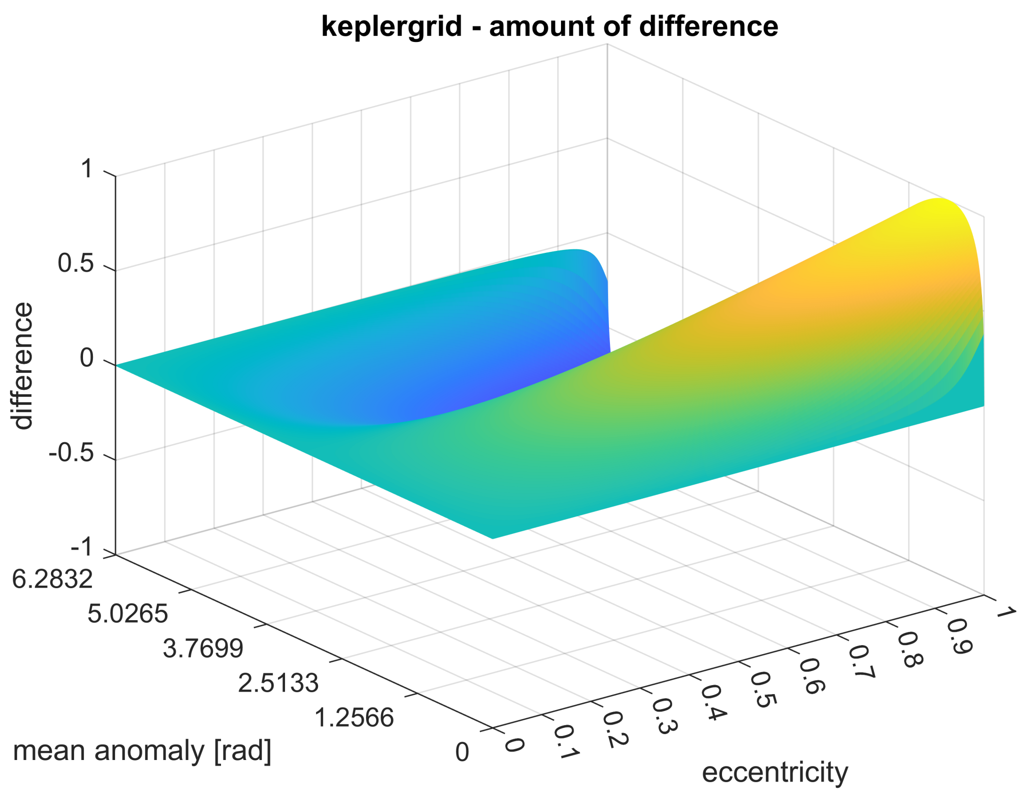
```
figure;
mesh(keplergrid_it)
title('keplergrid - amount of iterations');
xlabel('eccentricity');
ylabel('mean anomaly [rad]');
zlabel('iterations');
xticks([0,100,200,300,400,500,600,700,800,900,1000])
xticklabels({'0','0.1','0.2','0.3','0.4','0.5','0.6','0.7','0.8','0.9','1'})
yticks([0,pi*40,pi*80,pi*120,pi*160,pi*200])
yticklabels({'0',num2str((pi/100)*40),num2str((pi/100)*80), ...
    num2str((pi/100)*120),num2str((pi/100)*160),num2str((pi/100)*200)})
```



Plot difference

```
figure;
mesh(keplergrid_diff)
```

```
title('keplergrid - amount of difference');
xlabel('eccentricity');
ylabel('mean anomaly [rad]');
zlabel('difference');
xticks([0,100,200,300,400,500,600,700,800,900,1000])
xticklabels({'0','0.1','0.2','0.3','0.4','0.5','0.6','0.7','0.8','0.9','1'})
yticks([0,pi*40,pi*80,pi*120,pi*160,pi*200])
yticklabels({'0',num2str((pi/100)*40),num2str((pi/100)*80), ...
    num2str((pi/100)*120),num2str((pi/100)*160),num2str((pi/100)*200)})
```



Task4:

For the question what the difference is between the two functions:

There is no a really big difference. By converting to degrees,minutes and seconds, the seperated values get multiplyed bei 60 or 3600 and by converting to decimal degrees they are getting divided by 60 or 3600.

Just a lilte note to the two functions:

The task was to convert a vector of angles with unit decimal degree into vectors of degree, minute and decimal second.

We instead convertet the decimal degree vector into a matrix of degree, minute and decimal seconds. The reason behind this change is

that is way more clear where every coordinate starts and ends.

Becuase of this change is also way more easy to use in further functions.

```
TestDecimalDegrees = [-31.2342,12.425,93.2334,-178.23]
```

```
TestDecimalDegrees = 1×4
  -31.2342   12.4250   93.2334 -178.2300
```

```
De_Mi_Se_Matrix = DecDeg_To_De_Mi_Se(TestDecimalDegrees)
```

```
De_Mi_Se_Matrix = 4×3
  -31.0000   14.0000    3.1200
   12.0000   25.0000   30.0000
   93.0000   14.0000    0.2400
 -178.0000   13.0000   48.0000
```

```
DecDegVector = De_Mi_Se_To_DecDeg(De_Mi_Se_Matrix)
```

```
DecDegVector = 1×4
  -31.2342   12.4250   93.2334 -178.2300
```

```
if (sum(TestDecimalDegrees == DecDegVector)==length(TestDecimalDegrees))
        disp("The Decimal Degrees got transferd between the two functions " + ...
            "without correctly.")
else
        error("DecDeg_To_De_Mi_Se and De_Mi_Se_To_DecDeg arent inverse " + ...
            "to each other.")
end
```

```
The Decimal Degrees got transferd between the two functions without correctly.
```

Task5:

```
year = 2021;
month = 11;
day = 22;
hour = 01; %CET
minute = 0;
second = 0;
```

Change time zone

```
[year,month,day,hour] = CET_hour_To_UTC_hour(year,month,day,hour);
```

Corrected Time

```
[year,month,day,hour,minute,second] = Get_UT1_sec(year,month,day,hour,minute,second)
```

```
year = 2021
month = 11
day = 21
hour = 23
minute = 59
```

```
second = 59.8927
```

```
[jd_UT1,~] = gre2jd(year,month,day,hour,minute,second);
```

Calculate Earth roation angle / Calculate T_UT1

```
T_UT1 = jd_UT1 - 2451545.0;

ERA = 2 * pi * ...
    (0.7790572732640 + 1.00273781191135448 * T_UT1);

Ra_ERA = Get_Radius_From_Cycles_of_Radius(ERA);
```

Convert radiant to degree

```
Randiant_to_Degree_value = 360/(2*pi);

deg = Randiant_to_Degree_value*Ra_ERA;
```

Calculate the Decimal hours, minutes and seconds

```
De_Mi_Se_ERA = DecDeg_To_De_Mi_Se(deg);

De_Mi_Se_ERA(3) = round(De_Mi_Se_ERA(3));
```

Earth roation angle:

```
De_Mi_Se_ERA
```

```
De_Mi_Se_ERA = 1×3
    60    55    24
```

Greenwich Apparent Sidereal Time

```
t = (jd_UT1 -2451545.0)/36525;

GMST = (F(jd_UT1)*86400 + 24110.54841 -86400/2 + ...
8640184.812866 * t + 0.093104 * t * t -...
6.2e-6 * t * t * t)/3600; % hour

equinox = get_equinox(year,month,day,jd_UT1)
```

```
equinox = -1.8733e-06
```

```
GAST = GMST + equinox;

GAST = Get_Hours_From_HourCycles(GAST);

DecDeg_To_De_Mi_Se(GAST)
```

```
ans = 1×3
    4.0000    4.0000   48.8826
```

Task6:

```
VLBI_Group_Delay_TT = 0.02 %sconds in TT
```

```
VLBI_Group_Delay_TT = 0.0200
```

```
VLBI_Group_Delay_TCG = TTdiv_To_TCGdiv(VLBI_Group_Delay_TT)
```

```
VLBI_Group_Delay_TCG = 0.0200
```

```
VLBI_Group_Delay_TCB = TCGdiv_To_TCBdiv(VLBI_Group_Delay_TCG)
```

```
VLBI_Group_Delay_TCB = 0.0200
```

Difference in meter

```
c = 299792458; %m/s

VLBI_Group_Delay_In_Meter = ((c * VLBI_Group_Delay_TCB) / c) - ...
    ((c * VLBI_Group_Delay_TT) / c);

disp(append("The difference is: ", ...
    num2str(VLBI_Group_Delay_In_Meter * 10^6), " micro meter"))
```

```
The difference is: 0.19759 micro meter
```

Ratio between gravitational relativistic term and special relativistic term

```
% Values from the calculations as in the function TCGdiv_To_TCBdiv
gravitantional_potential = 887384185629.236;
Special_relativistic_term = 450000000;

GS_ratio = gravitantional_potential / Special_relativistic_term;
disp(append("gravitantional_potential is ", ...
    num2str(GS_ratio), " times as large as the Special_relativistic_term"))
```

```
gravitantional_potential is 1971.9649 times as large as the Special_relativistic_term
```

We can't see that the gravitational relativistic term is about twice as large as the special relativistic term.