Table of Contents

..... 1
Constants 1
Calculate temperature of the balloon at day and night 2
Calculate atmospheric conditions based on the 1976 standard atmosphere at 25km 2
Calculate the density of helium at 25km conditions 2
Calculate radius of balloon at night (launch time) 3
Calculate mass of balloon material 3
Calculate # of moles and mass of helium present at night 3
Calculate how much helium we need to vent 3
Calculate the volume of the daytime balloon 4


```
% ASEN 2002 Thermodynamics Design Laboratory Assignment: Atmospheric
% Satellites
clc
clear
close all
```

Constants

```
% Flight properties
mass_payload = 500; % [kg]
altitude = 25000; %[m]

% Balloon Material Properties
% (average of values given on matweb for polyester film)
density_material = 1255; % [kg/m^3]
FS = 1.5; % Factor of Safety
YS = 27.6*10^6; % [Pa]

% Gas properties
gage_pressure = 10;      % [Pa]
R = 8.314;               % [Nm/kmol] Universal gas constant
molar_mass_helium = 4.0026e-03; % [kg/mol]
R_helium = 2077.1;       % [J/kgK] Specific gas constant of helium

% Radiation Constants
sigmaSB = 5.670*(10^-8); % [J/(K^4m^2s)] - Stephan Boltzman constant
alphasb = .6;            % Absortivity of the sun-balloon system
epsilonb = .8;           % Emissivity of the balloon
alphaeb = epsilonb;      % Absortivity of the earth-balloon system
qsun = 1353;             % [W/m^2] - Solar irradiance
qearth = 237;            % [W/m^2] - Earth irradiance
```

Calculate temperature of the balloon at day and night

```
temp_day = (((alphasb*qsun)+(alphaeb*qearth))/
(epsilonb*sigmaSB*4))^.25; % [K]
temp_night = ((alphaeb*qearth)/(epsilonb*sigmaSB*4))^.25; % [K]
fprintf(['Calculated temperatures using stefan boltzmann
 equations:',...
    '\ntemp_day: %.3f K, temp_night: %.3f K\n\n'], temp_day,
 temp_night);
```

```
Calculated temperatures using stefan boltzmann equations:
temp_day: 272.564 K, temp_night: 179.794 K
```

Calculate atmospheric conditions based on the 1976 standard atmosphere at 25km

```
[temp_25km, speed_of_sound_25km, pressure_25km, density_25km] = ...
    atmoscoesa(altitude, 'None'); % [k, m/s, Pa, kg/m^3]
fprintf(['Atmospheric conditions found using 1976 standard
 atmosphere:'...
    '\ntemp_25km: %.3f K, speed_of_sound_25km: %.3f m/s,
 pressure_25km: '...
    '%.3f Pa, density_25km: %.3f kg/m^3\n\n'],...
    temp_25km, speed_of_sound_25km, pressure_25km, density_25km);
```

```
Atmospheric conditions found using 1976 standard atmosphere:
temp_25km: 221.650 K, speed_of_sound_25km: 298.455 m/s, pressure_25km:
 2511.023 Pa, density_25km: 0.039 kg/m^3
```

Calculate the density of helium at 25km conditions

```
density_helium_day = (pressure_25km + 10)/(R_helium * temp_day); %
 [kg/m^3]
density_helium_night = (pressure_25km + 10)/(R_helium * temp_night); %
 [kg/m^3]
fprintf(['Calculated density of helium using the ideal gas law\n'...
    'density_helium_day: %.6f kg/m^3, density_helium_night: '...
    '%.6f kg/m^3\n\n'], density_helium_day, density_helium_night);
```

```
Calculated density of helium using the ideal gas law
density_helium_day: 0.004453 kg/m^3, density_helium_night: 0.006751
 kg/m^3
```

Calculate radius of balloon at night (launch time)

```
radius_night = nthroot((mass_payload/((((4*pi)/3)*density_25km)-
(((4*pi)/3)...
    *density_helium_night)-((4*pi*density_material*gage_pressure*FS)/
(2*YS)))), 3); % [m]
fprintf(['Radius at night calculated using the formula derrived in
 design specifications:\n'...
    'radius_night: %.3f m\n\n'], radius_night);
```

```
Radius at night calculated using the formula derrived in design
 specifications:
radius_night: 15.559 m
```

Calculate mass of balloon material

```
mass_material =
 (4*pi*density_material*gage_pressure*FS*(radius_night^3))/(2*YS); %
 [kg]
fprintf('Mass of the balloon material:\nmass_material: %.3f kg\n\n',
 mass_material);
```

```
Mass of the balloon material:
mass_material: 16.141 kg
```

Calculate # of moles and mass of helium present at night

```
volume_helium_night = (4/3)*pi*radius_night^3; % [m^3]
moles_helium_night = ((pressure_25km +
 gage_pressure)*volume_helium_night)/(R*temp_night); % [mol]
mass_helium_night = moles_helium_night * molar_mass_helium; % [kg]
fprintf(['Extent of the helium gas at night:\n',...
    'volume_helium_night: %.3f m^3, moles_helium_night: %.3f mol,
 mass_helium_night %.3f kg\n\n'],...
    volume_helium_night, moles_helium_night, mass_helium_night);
```

```
Extent of the helium gas at night:
volume_helium_night: 15776.811 m^3, moles_helium_night: 26607.849 mol,
 mass_helium_night 106.501 kg
```

Calculate how much helium we need to vent

```
mass_helium_day = (mass_payload+mass_material)/((density_25km/
density_helium_day)-1);
```

```
mass_delta = mass_helium_day - mass_helium_night;
fprintf(['Venting requirements:\n',...
    'mass_helium_day: %.3f kg, mass_delta: %.3f kg\n\n'],...
    mass_helium_day, mass_delta);
```

```
Venting requirements:
mass_helium_day: 65.644 kg, mass_delta: -40.857 kg
```

Calculate the volume of the daytime balloon

```
volume_helium_day = mass_helium_day/density_helium_day;
volume_delta = volume_helium_day - volume_helium_night;
radius_day = (3*(volume_helium_day/(4*pi)))^(1/3);
fprintf(['Extent of the balloon system durring the day:\n',...
    'volume_helium_day: %.3f m^3, volume_delta: %.3f kg, radius_day
 %.3f \n\n'],...
    volume_helium_day, volume_delta, radius_day);
```

```
Extent of the balloon system durring the day:
volume_helium_day: 14741.496 m^3, volume_delta: -1035.315 kg,
 radius_day 15.211
```

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