# Execution

- Problem 4: Executing the algorithm made in the previous problem for 4 types of aircrafts: general aviation-single engine, general aviation-twin engine, jet transport, and military cargo.
- (Assumption) No loitering

The aircrafts are listed below

General Aviation-Single Engine

1. Cessna TTX: Range 1250 nmi, payload 578 lb, 0.312 Mach, piston-prop fixed pitch
2. Cirrus Vision SF50: 796 nmi, payload 1328 lb, 0.45 Mach, high-bypass turbofan
3. Valcanair V1.0: 575 nmi, payload 970 lb, 0.192 Mach, piston-prop fixed pitch

General Aviation-Twin Engine

1. Piper Seneca: 828 nmi, payload 1331 lb, 0.300 Mach, piston-prop fixed pitch
2. Beechcraft B55 Baron: 933 nmi, payload 900 lb, 0.300 Mach, piston-prop fixed pitch
3. Honda Jet HA-420: 1223 nmi, payload 547 lb, 0.633 Mach, high-bypass turbofan

Jet Transport

1. Boeing 737-900: Range 2950 nmi, payload 44622 lb, 0.79 Mach, high-bypass turbofan
2. Boeing 787-8: Range 7355 nmi, 90500 lb, 0.90 Mach, high-bypass turbofan
3. Airbus A380: Range 8000 nmi, 185000 lb, 0.89 Mach, high-bypass turbofan

Military Cargo

1. Kawasaki C-1: Range 1810 nmi, payload 34128 lb, 0.53 Mach, high-bypass turbofan
2. Boeing C-17 Globemaster 3: Range 2420 nmi, 170900 lb, 0.74 Mach, high-bypass turbofan
3. Lockheed C-5 Galaxy: Range 5500 nmi, payload 285000 lb, 0.79 Mach, high-bypass turbofan

Now, callout function created in problem three for each of the aircrafts above. Entering each specification as the inputs.

```
%Cessna TTX
[W_gross1, T1, Wempty_W01, W0_new1, We_W0_final1] = takeoff_weight_sizing(578, 0, 1250, 0.312,
    "general aviation single engine", 11, 0, 0);
```

```
W3_W2 = 0.8193
Wf_W0 = 0.3835
T = 19×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0014 | 1.3580e+15 | 2.2402e+03 |
| 2 | 2.2402e+03 | 0.5887 | 1.3187e+03 | 4.9525e+04 |
| 3 | 4.9525e+04 | 0.3372 | 1.6698e+04 | 4.9335e+03 |
| 4 | 4.9335e+03 | 0.5107 | 2.5194e+03 | 1.3024e+04 |

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 5 | 1.3024e+04 | 0.4288 | 5.5847e+03 | 7.3425e+03 |
| 6 | 7.3425e+03 | 0.4754 | 3.4906e+03 | 9.7677e+03 |
| 7 | 9.7677e+03 | 0.4516 | 4.4111e+03 | 8.3574e+03 |
| 8 | 8.3574e+03 | 0.4644 | 3.8816e+03 | 9.0641e+03 |
| 9 | 9.0641e+03 | 0.4577 | 4.1488e+03 | 8.6795e+03 |
| 10 | 8.6795e+03 | 0.4613 | 4.0039e+03 | 8.8801e+03 |
| 11 | 8.8801e+03 | 0.4594 | 4.0796e+03 | 8.7731e+03 |
| 12 | 8.7731e+03 | 0.4604 | 4.0392e+03 | 8.8295e+03 |
| 13 | 8.8295e+03 | 0.4599 | 4.0605e+03 | 8.7995e+03 |
| 14 | 8.7995e+03 | 0.4602 | 4.0492e+03 | 8.8154e+03 |
| 15 | 8.8154e+03 | 0.4600 | 4.0552e+03 | 8.8070e+03 |
| 16 | 8.8070e+03 | 0.4601 | 4.0520e+03 | 8.8114e+03 |
| 17 | 8.8114e+03 | 0.4600 | 4.0537e+03 | 8.8091e+03 |
| 18 | 8.8091e+03 | 0.4601 | 4.0528e+03 | 8.8103e+03 |
| 19 | 8.8103e+03 | 0.4601 | 4.0533e+03 | 8.8097e+03 |

```
%Cirrus Vision SF50
[W_gross2, T2, Wempty_W02, W0_new2, We_W0_final2] = takeoff_weight_sizing(1328, 0, 796, 0.45, "
    "general aviation single engine", 12, 0, 0);
```

```
W3_W2 = 0.8655
Wf_W0 = 0.3051
T = 12×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0014 | 1.3580e+15 | 3.0681e+03 |
| 2 | 3.0681e+03 | 0.5563 | 1.7067e+03 | 1.5344e+04 |
| 3 | 1.5344e+04 | 0.4163 | 6.3882e+03 | 7.6380e+03 |
| 4 | 7.6380e+03 | 0.4720 | 3.6054e+03 | 9.5466e+03 |
| 5 | 9.5466e+03 | 0.4535 | 4.3290e+03 | 8.8122e+03 |
| 6 | 8.8122e+03 | 0.4600 | 4.0540e+03 | 9.0591e+03 |
| 7 | 9.0591e+03 | 0.4578 | 4.1469e+03 | 8.9719e+03 |
| 8 | 8.9719e+03 | 0.4586 | 4.1141e+03 | 9.0022e+03 |
| 9 | 9.0022e+03 | 0.4583 | 4.1255e+03 | 8.9916e+03 |
| 10 | 8.9916e+03 | 0.4584 | 4.1215e+03 | 8.9953e+03 |
| 11 | 8.9953e+03 | 0.4583 | 4.1229e+03 | 8.9940e+03 |

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 12 | 8.9940e+03 | 0.4584 | 4.1224e+03 | 8.9944e+03 |

```
%Valcanair V1.0
[W_gross3, T3, Wempty_W03, W0_new3, We_W0_final3] = takeoff_weight_sizing(970, 0, 575, 0.192, '
    "general aviation single engine", 10.5, 0, 0);
```

```
W3_W2 = 0.9084
Wf_W0 = 0.2284
T = 11×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0014 | 1.3580e+15 | 2.2979e+03 |
| 2 | 2.2979e+03 | 0.5860 | 1.3465e+03 | 9.5336e+03 |
| 3 | 9.5336e+03 | 0.4536 | 4.3242e+03 | 5.5651e+03 |
| 4 | 5.5651e+03 | 0.4997 | 2.7810e+03 | 6.5096e+03 |
| 5 | 6.5096e+03 | 0.4858 | 3.1625e+03 | 6.1930e+03 |
| 6 | 6.1930e+03 | 0.4902 | 3.0358e+03 | 6.2894e+03 |
| 7 | 6.2894e+03 | 0.4888 | 3.0745e+03 | 6.2591e+03 |
| 8 | 6.2591e+03 | 0.4893 | 3.0623e+03 | 6.2685e+03 |
| 9 | 6.2685e+03 | 0.4891 | 3.0661e+03 | 6.2656e+03 |
| 10 | 6.2656e+03 | 0.4892 | 3.0649e+03 | 6.2665e+03 |
| 11 | 6.2665e+03 | 0.4892 | 3.0653e+03 | 6.2662e+03 |

```
%Piper Seneca
[W_gross4, T4, Wempty_W04, W0_new4, We_W0_final4] = takeoff_weight_sizing(828, 0, 828, 0.300, '
    "general aviation twin engine", 13, 0,0);
```

```
W3_W2 = 0.8943
Wf_W0 = 0.2540
T = 14×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0241 | 2.4090e+16 | 2.2552e+03 |
| 2 | 2.2552e+03 | 0.7023 | 1.5838e+03 | 3.7273e+04 |
| 3 | 3.7273e+04 | 0.5305 | 1.9774e+04 | 7.5560e+03 |
| 4 | 7.5560e+03 | 0.6223 | 4.7022e+03 | 1.3165e+04 |
| 5 | 1.3165e+04 | 0.5887 | 7.7504e+03 | 1.0351e+04 |
| 6 | 1.0351e+04 | 0.6030 | 6.2423e+03 | 1.1389e+04 |
| 7 | 1.1389e+04 | 0.5973 | 6.8027e+03 | 1.0950e+04 |
| 8 | 1.0950e+04 | 0.5997 | 6.5661e+03 | 1.1126e+04 |
| 9 | 1.1126e+04 | 0.5987 | 6.6611e+03 | 1.1054e+04 |

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 10 | 1.1054e+04 | 0.5991 | 6.6222e+03 | 1.1083e+04 |
| 11 | 1.1083e+04 | 0.5989 | 6.6380e+03 | 1.1071e+04 |
| 12 | 1.1071e+04 | 0.5990 | 6.6316e+03 | 1.1076e+04 |
| 13 | 1.1076e+04 | 0.5990 | 6.6342e+03 | 1.1074e+04 |
| 14 | 1.1074e+04 | 0.5990 | 6.6331e+03 | 1.1075e+04 |

```
%Beechcraft B55 Baron
[W_gross5, T5, Wempty_W05, W0_new5, We_W0_final5] = takeoff_weight_sizing(900, 0, 933, 0.300, '
    "general aviation twin engine", 13, 0,0);
```

```
W3_W2 = 0.8817
Wf_W0 = 0.2765
T = 16×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0241 | 2.4090e+16 | 2.4307e+03 |
| 2 | 2.4307e+03 | 0.6971 | 1.6944e+03 | 6.4367e+04 |
| 3 | 6.4367e+04 | 0.5023 | 3.2332e+04 | 7.6869e+03 |
| 4 | 7.6869e+03 | 0.6213 | 4.7755e+03 | 1.6631e+04 |
| 5 | 1.6631e+04 | 0.5751 | 9.5647e+03 | 1.1459e+04 |
| 6 | 1.1459e+04 | 0.5969 | 6.8401e+03 | 1.3435e+04 |
| 7 | 1.3435e+04 | 0.5875 | 7.8935e+03 | 1.2504e+04 |
| 8 | 1.2504e+04 | 0.5918 | 7.3992e+03 | 1.2906e+04 |
| 9 | 1.2906e+04 | 0.5899 | 7.6131e+03 | 1.2725e+04 |
| 10 | 1.2725e+04 | 0.5907 | 7.5171e+03 | 1.2805e+04 |
| 11 | 1.2805e+04 | 0.5903 | 7.5595e+03 | 1.2770e+04 |
| 12 | 1.2770e+04 | 0.5905 | 7.5406e+03 | 1.2785e+04 |
| 13 | 1.2785e+04 | 0.5904 | 7.5490e+03 | 1.2778e+04 |
| 14 | 1.2778e+04 | 0.5905 | 7.5453e+03 | 1.2782e+04 |
| 15 | 1.2782e+04 | 0.5905 | 7.5469e+03 | 1.2780e+04 |
| 16 | 1.2780e+04 | 0.5905 | 7.5462e+03 | 1.2781e+04 |

```
%Honda Jet HA-420
[W_gross6, T6, Wempty_W06, W0_new6, We_W0_final6] = takeoff_weight_sizing(547, 0, 1223, 0.633,
    "general aviation twin engine", 15, 0, 0);
```

```
W3_W2 = 0.8815
Wf_W0 = 0.2770
T = 18×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0241 | 2.4090e+16 | 1.9274e+03 |
| 2 | 1.9274e+03 | 0.7134 | 1.3750e+03 | 1.4114e+05 |
| 3 | 1.4114e+05 | 0.4644 | 6.5543e+04 | 5.2092e+03 |
| 4 | 5.2092e+03 | 0.6459 | 3.3646e+03 | 1.7479e+04 |
| 5 | 1.7479e+04 | 0.5723 | 1.0002e+04 | 8.9378e+03 |
| 6 | 8.9378e+03 | 0.6120 | 5.4696e+03 | 1.2134e+04 |
| 7 | 1.2134e+04 | 0.5935 | 7.2019e+03 | 1.0407e+04 |
| 8 | 1.0407e+04 | 0.6027 | 6.2723e+03 | 1.1202e+04 |
| 9 | 1.1202e+04 | 0.5983 | 6.7018e+03 | 1.0804e+04 |
| 10 | 1.0804e+04 | 0.6005 | 6.4876e+03 | 1.0995e+04 |
| 11 | 1.0995e+04 | 0.5994 | 6.5907e+03 | 1.0902e+04 |
| 12 | 1.0902e+04 | 0.5999 | 6.5402e+03 | 1.0947e+04 |
| 13 | 1.0947e+04 | 0.5997 | 6.5647e+03 | 1.0925e+04 |
| 14 | 1.0925e+04 | 0.5998 | 6.5528e+03 | 1.0936e+04 |
| 15 | 1.0936e+04 | 0.5997 | 6.5586e+03 | 1.0931e+04 |
| 16 | 1.0931e+04 | 0.5998 | 6.5557e+03 | 1.0933e+04 |
| 17 | 1.0933e+04 | 0.5997 | 6.5571e+03 | 1.0932e+04 |
| 18 | 1.0932e+04 | 0.5998 | 6.5564e+03 | 1.0932e+04 |

```
%Boeing 737-900
[W_gross7, T7, Wempty_W07, W0_new7, We_W0_final7] = takeoff_weight_sizing(44622, 0, 2950, 0.79
    "jet transport", 17, 0,0);
```

```
W3_W2 = 0.8064
Wf_W0 = 0.4047
T = 10×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0882 | 8.8234e+16 | 8.9578e+04 |
| 2 | 8.9578e+04 | 0.5352 | 4.7940e+04 | 7.5554e+05 |
| 3 | 7.5554e+05 | 0.4709 | 3.5579e+05 | 3.6516e+05 |
| 4 | 3.6516e+05 | 0.4919 | 1.7962e+05 | 4.3932e+05 |
| 5 | 4.3932e+05 | 0.4865 | 2.1372e+05 | 4.1741e+05 |
| 6 | 4.1741e+05 | 0.4880 | 2.0369e+05 | 4.2323e+05 |
| 7 | 4.2323e+05 | 0.4876 | 2.0635e+05 | 4.2163e+05 |
| 8 | 4.2163e+05 | 0.4877 | 2.0562e+05 | 4.2207e+05 |

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 9 | 4.2207e+05 | 0.4877 | 2.0582e+05 | 4.2195e+05 |
| 10 | 4.2195e+05 | 0.4877 | 2.0577e+05 | 4.2198e+05 |

```
%These two aircrafts have too high range that the algorithm returns error
%So I will use values on the internet
%Boeing 787-8
% [W_gross8, T8, Wempty_W08, W0_new8, We_W0_final8] = takeoff_weight_sizing(90500, 0, 7355, 0.9
%     "jet transport", 18, 0,0);
W_gross8 = 502,500;
```

```
W_gross8 = 502
```

```
We_W0_final8 = 0.5264;
% %Airbus A380
% [W_gross9, T9, Wempty_W09, W0_new9, We_W0_final9] = takeoff_weight_sizing(185000, 0, 8000, 0
%     "jet transport", 18.5, 0, 0);
W_gross9 = 1234600;
We_W0_final9 = 0.4947;

%Kawasaki C-1
[W_gross10, T10, Wempty_W010, W0_new10, We_W0_final10] = takeoff_weight_sizing(34128, 0, 1810,
    "military cargo", 16,0,0);
```

```
W3_W2 = 0.8113
Wf_W0 = 0.3967
T = 7×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0511 | 5.1107e+16 | 6.3250e+04 |
| 2 | 6.3250e+04 | 0.4290 | 2.7131e+04 | 2.0030e+05 |
| 3 | 2.0030e+05 | 0.3957 | 7.9260e+04 | 1.6822e+05 |
| 4 | 1.6822e+05 | 0.4006 | 6.7384e+04 | 1.7226e+05 |
| 5 | 1.7226e+05 | 0.3999 | 6.8886e+04 | 1.7170e+05 |
| 6 | 1.7170e+05 | 0.4000 | 6.8677e+04 | 1.7177e+05 |
| 7 | 1.7177e+05 | 0.4000 | 6.8706e+04 | 1.7176e+05 |

```
%Boeing C-17
[W_gross11, T11, Wempty_W011, W0_new11, We_W0_final11] = takeoff_weight_sizing(170900, 0, 2420,
    "military cargo", 18, 0,0);
```

```
W3_W2 = 0.8370
Wf_W0 = 0.3541
T = 6×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0511 | 5.1107e+16 | 2.8866e+05 |
| 2 | 2.8866e+05 | 0.3857 | 1.1134e+05 | 6.5985e+05 |

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 3 | 6.5985e+05 | 0.3640 | 2.4020e+05 | 6.0909e+05 |
| 4 | 6.0909e+05 | 0.3661 | 2.2296e+05 | 6.1354e+05 |
| 5 | 6.1354e+05 | 0.3659 | 2.2448e+05 | 6.1313e+05 |
| 6 | 6.1313e+05 | 0.3659 | 2.2434e+05 | 6.1317e+05 |

```
%Lockheed C-5
[W_gross12, T12, Wempty_W012, W0_new12, We_W0_final12] = takeoff_weight_sizing(285000, 0, 5500
    "military cargo", 18, 0, 0);
```

```
W3_W2 = 0.6846
Wf_W0 = 0.5877
T = 10×4 table
```

| | W0_guess | Wempty_W0 | Wempty | W0_new |
|---|---|---|---|---|
| 1 | 1.0000e+18 | 0.0511 | 5.1107e+16 | 7.9120e+05 |
| 2 | 7.9120e+05 | 0.3594 | 2.8437e+05 | 5.4018e+06 |
| 3 | 5.4018e+06 | 0.3142 | 1.6972e+06 | 2.9125e+06 |
| 4 | 2.9125e+06 | 0.3281 | 9.5554e+05 | 3.3925e+06 |
| 5 | 3.3925e+06 | 0.3246 | 1.1012e+06 | 3.2577e+06 |
| 6 | 3.2577e+06 | 0.3255 | 1.0605e+06 | 3.2923e+06 |
| 7 | 3.2923e+06 | 0.3253 | 1.0709e+06 | 3.2832e+06 |
| 8 | 3.2832e+06 | 0.3253 | 1.0682e+06 | 3.2856e+06 |
| 9 | 3.2856e+06 | 0.3253 | 1.0689e+06 | 3.2850e+06 |
| 10 | 3.2850e+06 | 0.3253 | 1.0687e+06 | 3.2851e+06 |

Polyfit the best-fit line for each type of aircraft as W0_new# on x-axis and We_W0_final# as y-axis

```
%First create vector from the given data to plot
%Single Engine
W0_singEng = [W_gross1 W_gross2 W_gross3]; %x-values
WeFrac_singEng = [We_W0_final1 We_W0_final2 We_W0_final3]; %y-values

%Twin Engines
W0_twinEng = [W_gross4 W_gross5 W_gross6];
WeFrac_twinEng = [We_W0_final4 We_W0_final5 We_W0_final6];

%Jet Transport
W0_JT = [W_gross7 W_gross8 W_gross9];
WeFrac_JT = [We_W0_final7 We_W0_final8 We_W0_final9];

%Military Cargo
W0_MC = [W_gross10 W_gross11 W_gross12];
WeFrac_MC = [We_W0_final10 We_W0_final11 We_W0_final12];
```

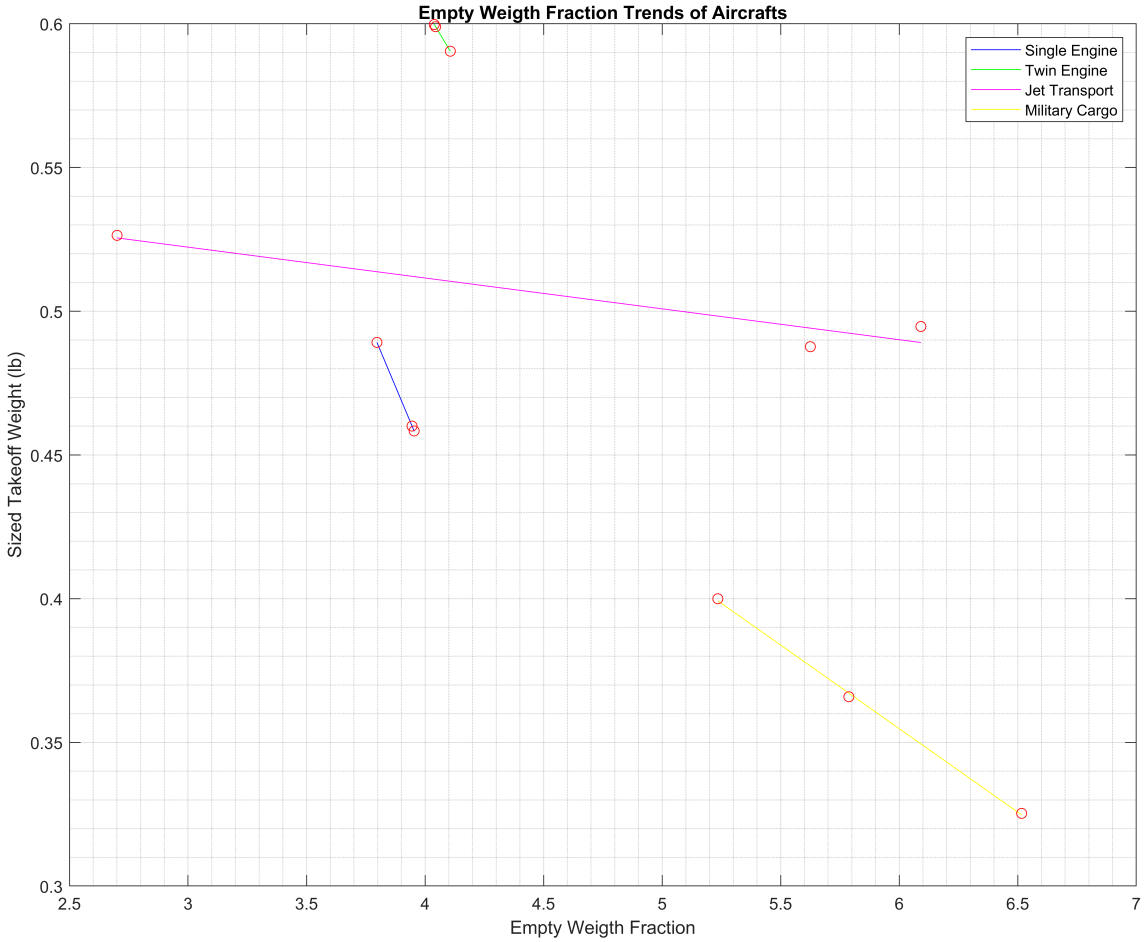
```
%Calibrate the data by semilogX which gives a clean linear
%graph (better than normal plot). Take log10 for all x-values.
%Then polyfit each of them
%Single Engine
W0_singEng = log10(W0_singEng);
p1 = polyfit(W0_singEng, WeFrac_singEng, 1);
fit1 = polyval(p1, W0_singEng);

%Twin Engine
W0_twinEng = log10(W0_twinEng);
p2 = polyfit(W0_twinEng, WeFrac_twinEng,1);
fit2 = polyval(p2, W0_twinEng);

%Jet Transport
W0_JT = log10(W0_JT);
p3 = polyfit(W0_JT, WeFrac_JT,1);
fit3 = polyval(p3, W0_JT);

%Military Cargo
W0_MC = log10(W0_MC);
p4 = polyfit(W0_MC, WeFrac_MC,1);
fit4 = polyval(p4, W0_MC);

%Plotting
figure(1)
plot(W0_singEng, fit1, "-b")
title("Empty Weigth Fraction Trends of Aircrafts")
ylabel("Empty Weigth Fraction")
xlabel("Sized Takeoff Weight (log10(lb))")
grid on
grid minor
box on
hold on
plot(W0_twinEng, fit2, "-g")
plot(W0_JT, fit3, "-m")
plot(W0_MC, fit4, "-y")
plot(W0_singEng, WeFrac_singEng, "or")
plot(W0_twinEng, WeFrac_twinEng, "or")
plot(W0_JT, WeFrac_JT, "or")
plot(W0_MC, WeFrac_MC, "or")
hold off
legend("Single Engine", "Twin Engine", "Jet Transport", "Military Cargo");
set(gcf,'PaperPositionMode','auto','Position',[0 0 1100 850]) % Control where plots are positio
```




## Analysis

- Do the different types of aircraft occupy different parts of your plot, and why/why not?

ANS:

Yes, they do. For the jet transport the high values of the range and payload giver larger results for the takeoff weight; but, lower empty weight fractions.

And vice versa for the light single engine and twin engine aircrafts.

- Within a given type of aircraft, does the empty weight fraction vary, and why/why not?

ANS:

Yes, they vary. As stated above the takeoff weight is dependent of the payload and the range, and within a category of aircrafts there are aircrafts with different payloads and ranges even though the flight mission might be alike. With such change of parameters, the empty weight fraction can vary. Such trend can be observed in the graph above for all aircraft categories.

- Are your results similar to Raymer's table, and why/why not?

ANS:

Yes, my graph and the graph on Raymer is somewhat alike. For example, the general aviation-twin engine category range in the empty weight fraction of around 6 with a negative slope. This is the very close to the example in Raymer. Jet transport and military cargo appear at the right hand side and low empty weight ratio (where military cargo ranges lower than jet transport). These trends are similar which makes it reasonable to conclude that the example graph and my graph are similar to each other.