AIRCRAFT DYNAMICS
AIRCRAFT SIMULATION

1) Relationship between Acceleration, Velocity and Distance

Velocity (m/s) is the Integral of Acceleration (ft/s^2)
Distance (m) is the Integral of Velocity (ft/s)

Model the Acceleration, Velocity and Distance of an aircraft moving on the surface of an airport for 30 seconds.

The aircraft is stationary at t= 0, the accelerates to 1 ft/s^2 for 4 seconds. Holds constant velocity for 15 seconds (i.e. a(t) = 0), then decelerates at -1 ft/s^2 for 4 seconds.

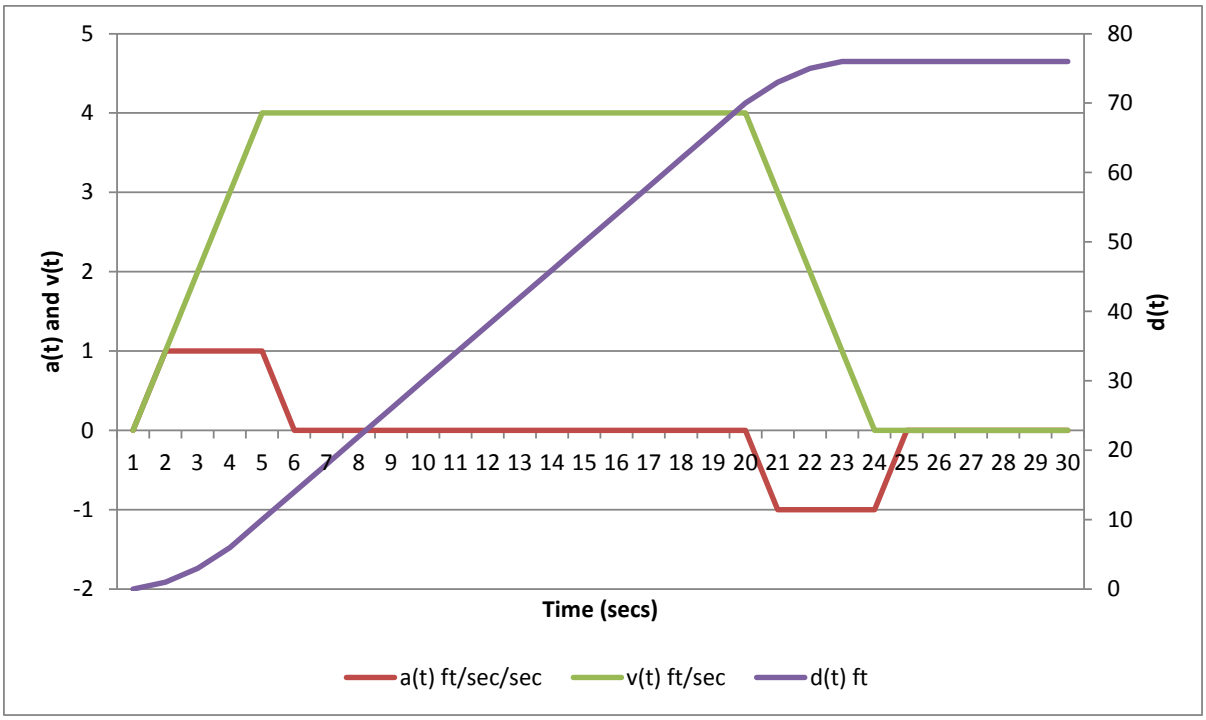
Velocity = v(t) = v(t-1) + (a(t) * Δt)
Distance= d(t) = d(t-1) + (v(t) * Δt)

Plot Time on x-axis and a(t), v(t) and d(t) on the y-axis.

Hint: Here is a sample spreadsheet implementation.

A	B	C	D
T (secs)	**a(t) ft/sec/sec**	**v(t) ft/sec**	**d(t) ft**
1	0	0	0
=A2+1	1	=C2+(B3*(A3-A2))	=D2+(C3*(A3-A2))
=A3+1	1	=C3+(B4*(A4-A3))	=D3+(C4*(A4-A3))
=A4+1	1	=C4+(B5*(A5-A4))	=D4+(C5*(A5-A4))
=A5+1	1	=C5+(B6*(A6-A5))	=D5+(C6*(A6-A5))
=A6+1	0	=C6+(B7*(A7-A6))	=D6+(C7*(A7-A6))
=A7+1	0	=C7+(B8*(A8-A7))	=D7+(C8*(A8-A7))
=A8+1	0	=C8+(B9*(A9-A8))	=D8+(C9*(A9-A8))
=A9+1	0	=C9+(B10*(A10-A9))	=D9+(C10*(A10-A9))

Hint: Here is what the plot should look like.



2) Aircraft Dynamics on the Surface of the Airport

When the aircraft is on the surface of the airport, the acceleration on the body axis = flight path axis = horizontal axis = a(t) = 1/m (T – D – μ – Wsin(φ))
Where:
T = Thrust
D = Drag
μ=Rolling Friction
W = weight = mass * gravitational constant
Φ = slope (or incline of airport surface)
Model the dynamics of the aircraft on the surface of the airport for 56 seconds with the Thrust and Braking profile shown below.
Plot time (x-axis) and Thrust, Braking, a(t), v(t) and d(t)

	INPUT	
T (secs)	**Brakes**	**Thrust**
0	0	0
1	0	6,904
2	0	20,000
3	0	20,000
4	0	20,000
5	0	20,000
6	0	20,000
7	0	20,000

8	0	20,000
9	0	20,000
10	0	20,000
11	0	20,000
12	0	6904
13	0	6904
14	0	6904
15	0	6904
16	0	6904
17	0	6904
18	0	6904
19	0	6904
20	0	6904
21	0	6904
22	0	6904
23	0	6904
24	0	6904
25	0	6904
26	0	6904
27	0	6904
28	0	6904
29	0	6904
30	0	6904
31	0	6904
32	0	6904
33	0	6904
34	0	6904
35	0	6904
36	7000	6904
37	7000	6904
38	7000	6904
39	7000	6904
40	7000	6904
41	7000	6904
42	7000	6904
43	7000	6904
44	7000	6904
45	7000	6904
46	7000	6904
47	7000	6904
48	7000	6904

49	7000	6904
50	7000	6904
51	7000	6904
52	7000	6904
53	0	6904
54	0	6904
55	0	6904
56	0	6904

Thrust (lbs)	Input
Braking Force (lbs)	Input
Drag (lbs)	6404
Lift (lbs)	0
Rolling Friction (lbs)	500
Mass (lbs)	6000
Gravitational Constant (ft/sec/sec)	32.2
Surface Incline	0

Hint: Here is a sample spreadsheet implementation.

H	I	J	K	L	M	N	O	P
	INPUT		OUTPUTS					
T (secs)	**Brakes**	**Thrust**	**a(t) ft/sec/sec**	**a(t) g's**	**v(t) ft/sec**	**v(t) knots**	**d(t) ft**	**d(t) Nm**
0	0	0	0	=K3/$B$7	0	=M3*0.592484	0	=O3*0.000164579
=H3+1	0	6904	=(1/$B$6)*(J4-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I4)	=K4/$B$7	=M3+(K4*(H4-H3))	=M4*0.592484	=O3+(M4*(H4-H3))	=O4*0.000164579
=H4+1	0	20000	=(1/$B$6)*(J5-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I5)	=K5/$B$7	=M4+(K5*(H5-H4))	=M5*0.592484	=O4+(M5*(H5-H4))	=O5*0.000164579
=H5+1	0	20000	=(1/$B$6)*(J6-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I6)	=K6/$B$7	=M5+(K6*(H6-H5))	=M6*0.592484	=O5+(M6*(H6-H5))	=O6*0.000164579
=H6+1	0	20000	=(1/$B$6)*(J7-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I7)	=K7/$B$7	=M6+(K7*(H7-H6))	=M7*0.592484	=O6+(M7*(H7-H6))	=O7*0.000164579
=H7+1	0	20000	=(1/$B$6)*(J8-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I8)	=K8/$B$7	=M7+(K8*(H8-H7))	=M8*0.592484	=O7+(M8*(H8-H7))	=O8*0.000164579
=H8+1	0	20000	=(1/$B$6)*(J9-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I9)	=K9/$B$7	=M8+(K9*(H9-H8))	=M9*0.592484	=O8+(M9*(H9-H8))	=O9*0.000164579
=H9+1	0	20000	=(1/$B$6)*(J10-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I10)	=K10/$B$7	=M9+(K10*(H10-H9))	=M10*0.592484	=O9+(M10*(H10-H9))	=O10*0.000164579
=H10+1	0	20000	=(1/$B$6)*(J11-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I11)	=K11/$B$7	=M10+(K11*(H11-H10))	=M11*0.592484	=O10+(M11*(H11-H10))	=O11*0.000164579
=H11+1	0	20000	=(1/$B$6)*(J12-$B$3-	=K12/$B$7	=M11+(K12*(H12-	=M12*0.592484	=O11+(M12*(H12-	=O12*0.000164579

			$B$5-(($B$6*$B$7)*SIN($B$8))-I12)		H11))		H11))	
=H12+1	0	20000	=(1/$B$6)*(J13-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I13)	=K13/$B$7	=M12+(K13*(H13-H12))	=M13*0.592484	=O12+(M13*(H13-H12))	=O13*0.000164579
=H13+1	0	20000	=(1/$B$6)*(J14-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I14)	=K14/$B$7	=M13+(K14*(H14-H13))	=M14*0.592484	=O13+(M14*(H14-H13))	=O14*0.000164579
=H14+1	0	6904	=(1/$B$6)*(J15-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I15)	=K15/$B$7	=M14+(K15*(H15-H14))	=M15*0.592484	=O14+(M15*(H15-H14))	=O15*0.000164579
=H15+1	0	6904	=(1/$B$6)*(J16-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I16)	=K16/$B$7	=M15+(K16*(H16-H15))	=M16*0.592484	=O15+(M16*(H16-H15))	=O16*0.000164579
=H16+1	0	6904	=(1/$B$6)*(J17-$B$3-$B$5-(($B$6*$B$7)*SIN($B$8))-I17)	=K17/$B$7	=M16+(K17*(H17-H16))	=M17*0.592484	=O16+(M17*(H17-H16))	=O17*0.000164579

Hint: Here is what the plot should look like.