Analysis of Forces and Acceleration

In this assignment, you must carry out an investigation into forces and the acceleration that result from unbalanced forces. You will collect data using the Acceleration and Forces on a Jet simulation and then use that data to record observations and answer the following analysis questions.

Qualitative Pre-lab Activity: The simulation begins with jets in various types of motion. In what situations would a jet airplane have either a lot or very little of the following forces?

- Gravity force
- Thrust force
- Normal force
- Sliding friction
- Rolling friction
- Wind resistance/drag
- Lift force – from the angle of attack of the wing in the air

Purpose: To analyze the effects of forces on the acceleration and motion of a jet. Consider the effects of net force on the acceleration on the jet, the contribution of thrust, and the role of the direction of the net force to the motion.

Procedure: Follow the instructions as you progress through the Acceleration and Forces on a Jet virtual lab. Record the data in the table below.

Observations and Analysis: Data table

Jet Scenario (mass of the jet is 5 000 kg)	Initial Velocity (m/s)	Final Velocity (m/s)	Distance travelled (m)	Time (s)	Acceleration (m/s^2)	F_{net} (kN)	Coefficient of Sliding (Kinetic)	Total Frictional Forces (kN)	Thrust (kN)
Jet Breaking Sound Barrier and going to Mach 1.5							n.a.		
Jet flying straight up		n.a.	n.a.	n.a			n.a.		
Jet flying in and landing successfully									
Jet landing but ripped in half by the forces									

Diagrams:
Draw free body diagrams to show the forces acting on plane for each of the scenarios you have described in the chart above.

a) Jet Breaking Sound Barrier and going to Mach 1.5:

b) Jet flying straight up:

c) Jet flying in and landing successfully:

d) Jet landing but ripped in half by the forces:

All forces require labels and appropriate values in Newtons.

Conclusion: Make a concise statement that relates directly back to the purpose.

Assignment 2 Analysis of Forces and Acceleration SOLUTIONS

In this assignment, you must carry out an investigation into forces and the acceleration which results from unbalanced forces. You will collect data using the Acceleration and Forces on a Jet simulation and then use that data to record observations and answer the following analysis questions.

Qualitative Pre-lab Activity: The simulation begins with jets in various types of motion. In what situations would a jet airplane have either a lot or very little of the following forces?

- **Gravity force (constant unless the plane is at very high altitude or has additional mass)**
- **Thrust force (varies with throttle, required to accelerate or to climb vertically)**
- **Normal force (equal to the weight when taxiing, also in effect during takeoff/landing)**
- **Sliding friction (only if landing without landing gear deployed)**
- **Rolling friction (only if wheels are turning and the plane is taxiing or during takeoff/landing)**
- **Wind resistance/drag (none at rest, very little when taxiing, increases dramatically with speed)**
- **Lift force—from the angle of attack of the wing in the air (when moving rapidly and with wings trimmed properly)**

Purpose: to analyze the effects of forces on the acceleration and motion of a jet. Consider the effects of net force on the acceleration on the jet, the contribution of thrust, and the role of the direction of the net force to the motion.

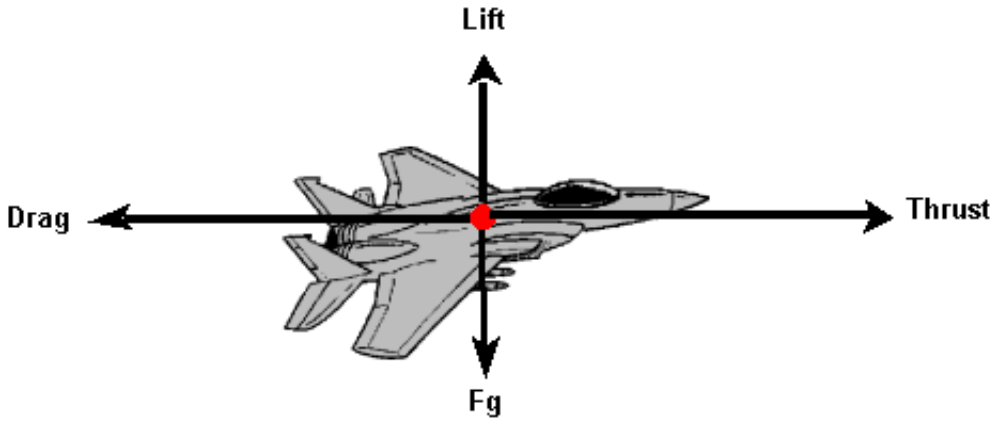
Procedure: Follow the instructions as you progress through the Acceleration and Forces on a Jet virtual lab. Record the data in the table below.

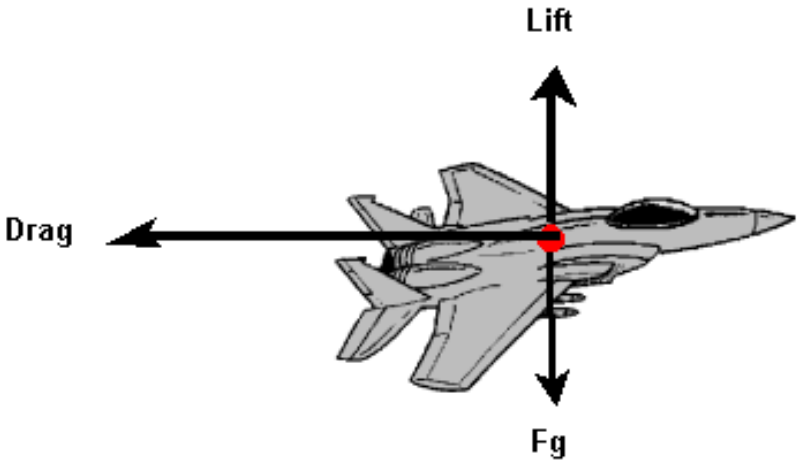
Observations and Analysis: Data and Calculations

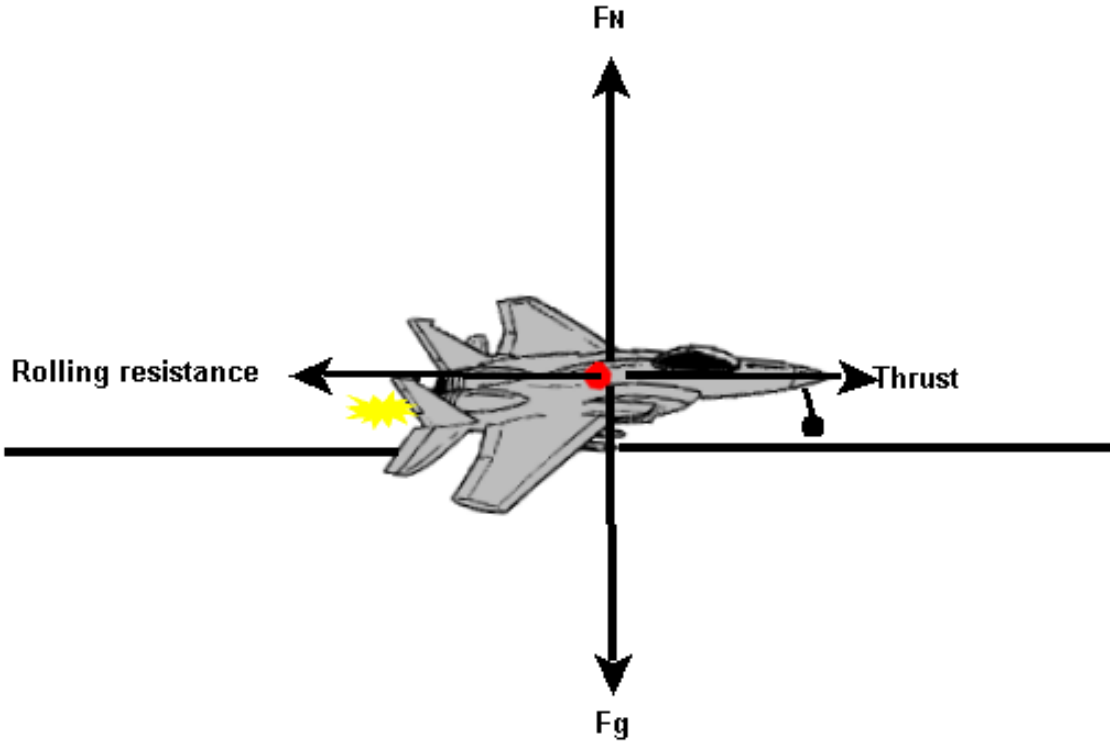
Jet Scenario (mass of the jet is 5000 kg)	Initial Velocity (m/s)	Final Velocity (m/s)	Distance travelled (m)	Time (s)	Acceleration (m/s^2)	F_{net} (kN)	Coefficient of Sliding (Kinetic)	Total Frictional Forces (kN)	Thrust (kN)
Jet Breaking Sound Barrier and going to Mach 1.5	332	498	2343	$\Delta t = d/v_{avg}$ = 2343/415 =5.65	$a=\Delta v/\Delta t$ = (498 – 332)/5.65 = 29.4 (3g)	$F_{net} = ma$ = (5000) (29..4) =147	n.a.	49 (drag)	$F_{net} = F_f + _{thrust}$ 147=-49+ F_{thrust} F_{thrust} = 196
Jet flying straight up	0	n.a.	n.a.	n.a	$a = F_{net}/m$ =147000/5000 =29.4 (pilot will feel 3g + g)	$F_{net} = F_g + F_{thrust}$ =(-49) + (196) =147	n.a.	0	196
Jet flying in and landing successfully	150	0	$\Delta d = v_{avg}\ \Delta t$ = 75(4.5) =338	$\Delta t = \Delta v / a$ = 150/33.3 =4.5	$a = F_{net}/m$ =166600/5000 =33.3 (> 3g)	$F_{net} = F_f + _{thrust}$ =29.4+137.2 =166.6	0.6	29.4	70% of Thrust or 137.2
Jet flying in ripped in half by the forces	150	0	$\Delta d = v_{avg}\ \Delta t$ = 75(3.64) =273	$\Delta t = \Delta v / a$ = 150/41.2 =3.64	$a = F_{net}/m$ =196000/5000 =41.2 (>4g)	$F_{net} = F_f + _{thrust}$ =29.4+176.4 =205.8	0.6	29.4	90% of Thrust or 176.4

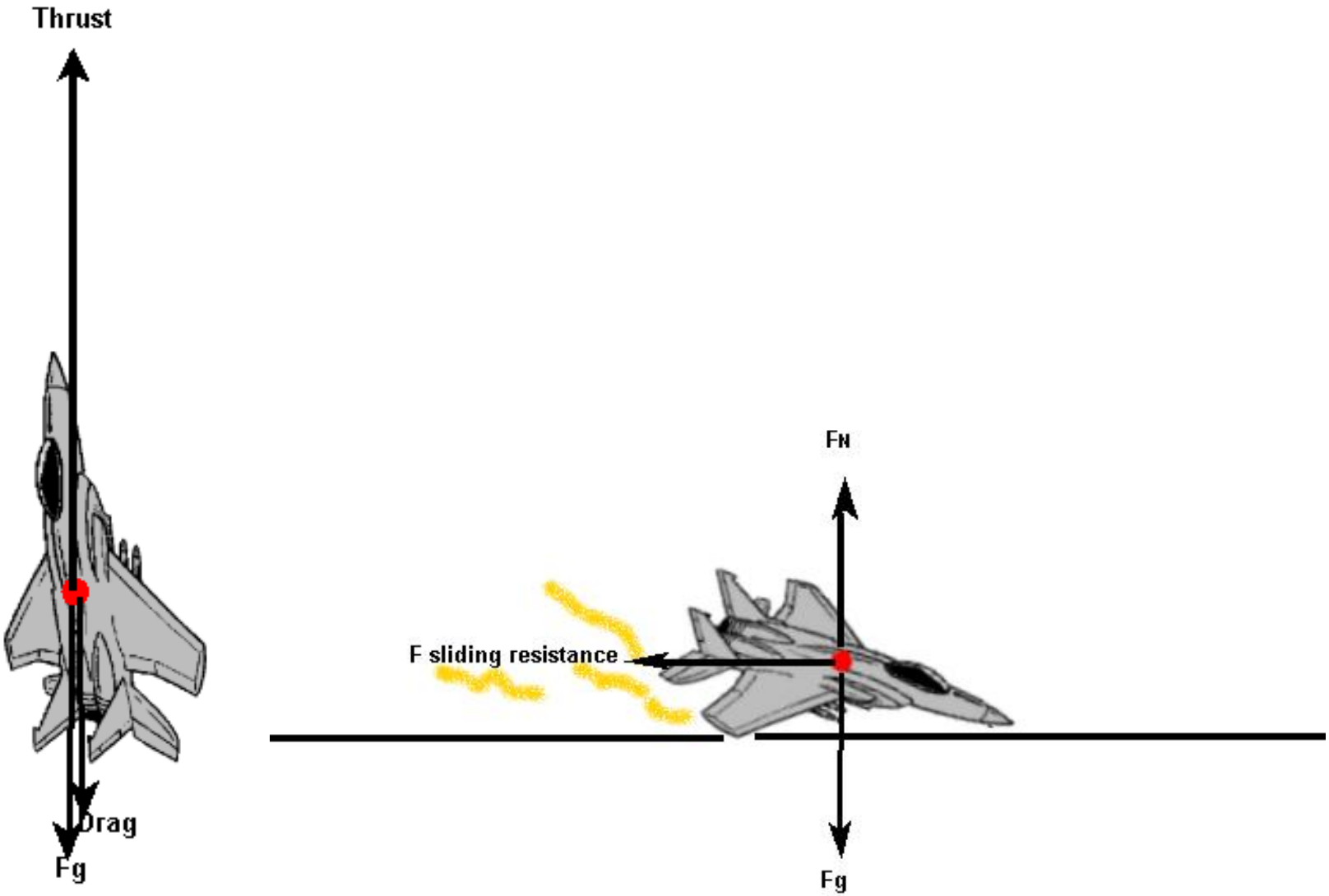
Diagrams:
Draw free body diagrams to show the forces acting on plane for each of the scenarios you have described in the chart above.

The following diagrams show the forces but the actual values are found below the diagrams.




Lift
Drag
Fg


FN
Rolling resistance
Thrust
Fg


Thrust
Drag
Fg
FN
F sliding resistance
Fg

Consider right and up as positive and these are values of the force vectors in the diagrams.

e) Jet Breaking Sound Barrier and going to Mach 1.5:

F_g = -49 000 N, F_{lift} = 49 000 N F_{drag} = -49 000 N, F_{thrust} = 196 000 N

f) Jet flying straight up:

F_g = 49 000 N, F_{thrust} = 196 000 N (F_{drag} =0 until the speed becomes appreciable)

g) Jet flying in and landing successfully:

F_g = -49 000 N, F_N = 49 000 N, $F_{friction}$ = -29 400 N F_{thrust} = -137 200 N (F_{lift} = 0, F_{drag} = 0)

h) Jet landing but ripped in half by the forces:

F_g = -49 000 N, F_N = 49 000 N, $F_{friction}$ = -29 400 N F_{thrust} = -176 400 N (F_{lift} = 0, F_{drag} = 0)

All forces require labels and appropriate values in newtons.

Conclusion: The jet will accelerate proportionally to the net force. The thrust is just one of the forces which may contribute to the net force. Acceleration may slow down or speed up the jet.