

Drag

Force



DRAG OCCURS WHEN A SOLID OBJECT MOVES THROUGH A GAS OR LIQUID. WHEN YOUR DRAGSTER IS STREAKING DOWN THE TRACK, AIR FLOW CREATES PRESSURES AND FRICTION ON THE VEHICLE. LIKE SURFACE FRICTION FORCE, DRAG FORCE IS A NEGATIVE FORCE WORKING TO SLOW YOUR DRAGSTER.



IF ANY VARIABLE INCREASES, THEN DRAG FORCE WILL INCREASE. LIKEWISE, IF ANY VARIABLE DECREASES, THEN DRAG FORCE WILL DECREASE. SO IF YOU WANT TO REDUCE DRAG FORCE, YOU CAN DO SO BY REDUCING ANY OF THESE VARIABLES. AS YOU WILL SEE, HOWEVER, SOME VARIABLES ARE OUT OF YOUR CONTROL (LIKE AIR DENSITY) AND SOME YOU WOULD NOT WANT TO REDUCE FOR THE PURPOSE OF REDUCING DRAG (VELOCITY).

VARIABLES THAT CONTRIBUTE TO DRAG

- ✓ **AIR DENSITY, WHICH DEPENDS ON TEMPERATURE AND ALTITUDE;**
- ✓ **VELOCITY OF THE VEHICLE: AS THE DRAGSTER ACCELERATES, DRAG INCREASES;**
- ✓ **COEFFICIENT OF DRAG, WHICH DEPENDS ON BODY SHAPE;**
- ✓ **FRONTAL AREA OF THE BODY**

AIR DENSITY

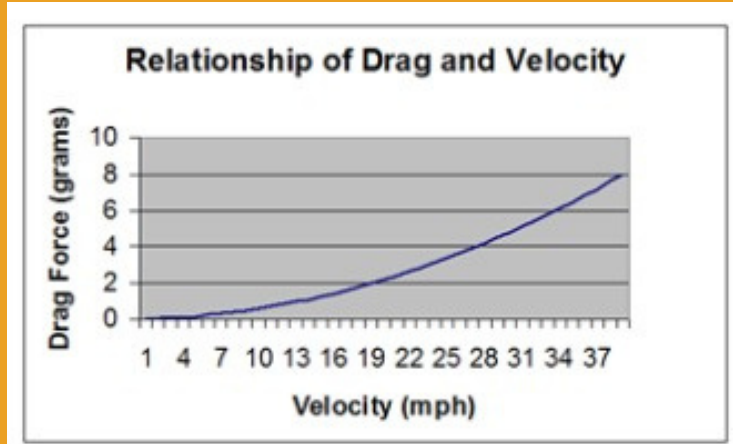
ALL MATERIALS HAVE A UNIQUE DENSITY. WE DON'T THINK OF AIR AS HAVING MASS AND DENSITY, BUT IT DOES. FURTHERMORE, THE DENSITY OF AIR CHANGES WITH TEMPERATURE AND ALTITUDE. COLD AIR IS MORE DENSE THAN HOT AIR. AIR AT SEA LEVEL IS MORE DENSE THAN AIR AT HIGHER ELEVATIONS. AND SINCE **DRAG FORCE INCREASES WITH HIGHER AIR DENSITY, THIS MEANS THAT YOUR CAR (OR ANYTHING ELSE) WILL GO SLOWER IN COLD WEATHER OR LOWER ELEVATIONS.**

VELOCITY

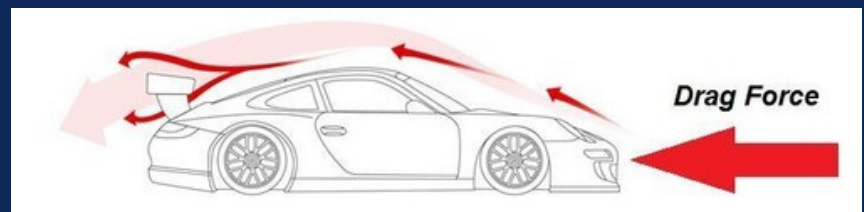
WHEN YOU ARE STANDING IN HIGH WINDS, YOU CAN FEEL THE PRESSURE OF THE WIND ON YOUR BODY. WHEN WIND SPEED INCREASES, THE PRESSURE INCREASES. A VEHICLE MOVING THROUGH THE AIR IS LIKE THE WIND PUSHING ON YOUR BODY. AS VEHICLE SPEED INCREASES, PRESSURE INCREASES THUS INCREASING DRAG FORCE. UNLIKE THE OTHER VARIABLES, DRAG INCREASES WITH THE SQUARE OF VELOCITY. THIS MEANS THAT IF YOU DOUBLE THE VEHICLE'S SPEED YOU WILL QUADRUPLE THE DRAG. THE GRAPH SHOWS THE EXPONENTIAL RELATIONSHIP OF DRAG AND VELOCITY. AT 16 MPH THE DRAG FORCE IS 1.28 GRAMS. AT 32 MPH THE DRAG FORCE 5.12 GRAMS (QUADRUPLED)



DECREASING VELOCITY OR AIR DENSITY WILL DECREASE DRAG FORCE. BUT THIS ISN'T VERY USEFUL INFORMATION. THE OVERALL OBJECTIVE OF THE CHALLENGE IS TO MINIMIZE RACE TIME WHICH MEANS THAT YOU WILL WANT TO MAKE DESIGN CHOICES THAT MAXIMIZE VELOCITY. AND, YOU CANNOT CONTROL AIR DENSITY ON RACE DAY. THUS, TO DECREASE DRAG, ENGINEERS MUST LOOK AT THE OTHER VARIABLES — THE COEFFICIENT OF DRAG AND FRONTAL AREA.



THE COEFFICIENT OF DRAG (C_D) — OR DRAG COEFFICIENT — IS A NUMBER THAT REPRESENTS HOW EASILY A CERTAIN SHAPE WILL CUT THROUGH THE AIR WHILE IN MOTION. OBJECTS WITH A LOW DRAG COEFFICIENT WILL HAVE LESS DRAG FORCE THAN OBJECTS WITH A HIGHER DRAG COEFFICIENT.



THINK AGAIN ABOUT HOW YOU FEEL WHEN STANDING IN A STRONG WIND. IF YOU ARE FACING THE WIND, THE PRESSURE YOU FEEL WILL TEND TO PUSH YOU BACKWARDS. YOU PROBABLY AREN'T THINKING ABOUT IT AT THE TIME, BUT BECAUSE THE WIND IS HAVING TO CHANGE DIRECTION SO RAPIDLY TO MAKE ITS WAY AROUND YOUR BODY, THIS ALSO CREATES AN AREA OF LOW PRESSURE ON YOUR BACK THAT TENDS TO PULL YOU BACKWARDS. A DRAG COEFFICIENT IS ESSENTIALLY AN APPROXIMATE MEASURE OF THIS DIFFERENCE BETWEEN HIGH AND LOW PRESSURE ON THE FRONT AND BACK OF AN OBJECT.



THE MOST EFFECTIVE WAY TO REDUCE THE DRAG COEFFICIENT IS THROUGH **STREAMLINING**. STREAMLINING IS THE PROCESS OF MODIFYING A SHAPE TO MAKE IT EASIER FOR AIR TO FLOW AROUND THE OBJECT. TO UNDERSTAND STREAMLINING, LET'S TAKE A LOOK AT THE THREE OBJECTS BELOW. THE FIRST OBJECT HAS A DRAG COEFFICIENT OF 2.3. THE FLAT FRONT CREATES A LARGE HIGH PRESSURE AREA AND THE SHARP EDGES CAUSE AIR SEPARATION, INCREASING DRAG. ROUNDING THE FRONT TO REDUCE AIR SEPARATION REDUCES THE DRAG COEFFICIENT TO 1.2 AS SHOWN IN THE SECOND IMAGE. FINALLY, TAPERING THE REAR TO A POINT AS SHOWN IN THE THIRD IMAGE REDUCES THE LOW PRESSURE AREA IN THE REAR, REDUCING THE DRAG COEFFICIENT TO 0.18.

FRONTAL AREA

FRONTAL AREA IS WHAT THE AIR STREAM "SEES" OR WHAT YOU SEE LOOKING AT THE FRONT OF A CAR. DRAG FORCE IS PROPORTIONAL TO FRONTAL AREA. YOU CAN MINIMIZE FRONTAL AREA BY SKETCHING YOUR PROFILES TO MINIMIZE THE HEIGHT AND WIDTH OF THE CAR. ROUNDING THE CORNERS OF THE BODY WILL ALSO CHANGE THE FRONTAL AREA.

