**STUDENT ACTIVITY SHEET** **Name _____ Period _____**

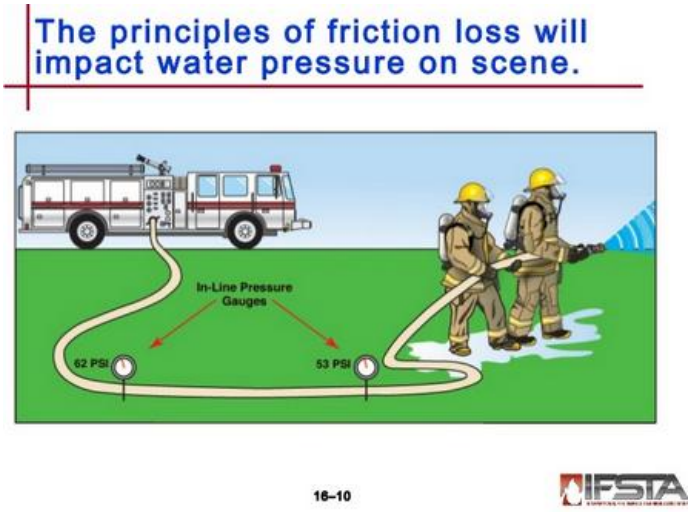
**Fire Hose Friction Loss – The Varying Variables for the One That Got Away – Part 1**

The questions:
How does Friction Loss change with the quality of the fire hose?
How does Friction Loss change with the length of the fire hose?
How does Friction Loss change with the velocity of the water in the fire hose?
How does Friction Loss change with various diameters of the fire hose?

You will need:
Activity sheet
Access to the internet to view website and YouTube video information

Assignment:

**Investigation # 1 – Direct & Inverse Variation Formulas**




In the fire service, Friction Loss is defined as the loss of energy in pressure whenever water runs through hoses, fittings, and appliances. As water runs through the hose, it rubs against the lining of the hose, the couplings, and even itself. Each time this happens, friction causes the water to slow down.

View the following video "Firefighter Gets Owned by the Hose - Rookie Mistake": https://www.youtube.com/watch?v=Ci_sfp1rGjE . Investigate the four rules of Friction Loss below and determine the rookie's mistakes.

Friction Loss in a fire hose is governed by several rules: (Use FL for Friction Loss)

- **Rule 1 – Friction loss varies with the quality of the hose.**

a. Write the variation formula for the 1st Friction Rule _____

- **Rule 2 – Friction loss varies directly with the length of the hose.**

b. Write the variation formula for the 2nd Friction Rule. _____

*c.* Given the following example,

Friction loss is calculated in 100-foot lengths; the total friction loss is figured when all lengths are added together. For example, if the friction loss in one length of 1¾-inch hose is 15 psi, then if four 100-foot lengths are added together, the total friction loss would be 60 psi.

Identify the letters for the formula and fill in the numerical values below:

- **Rule 3 – Friction Loss varies with the square of the velocity.**

  a. Write the variation formula for the 3rd Friction Rule _____

  b. What if the velocity is doubled? What will happen to the Friction Loss?

  *c.* What if the velocity is quadrupled? Will the FL double from the previous answer?

- **Rule 4 – For a given flow, the Friction Loss varies inversely as the fifth power of the diameter of the hose.**

  d. Write the variation formula for the 4thd Friction Rule _____.

  e. What if the hose size is doubled, but the flow rate is kept the same, what happens to the friction loss?

  f. How do Rules 1 – 4 affect the "rookie's" mistake?

*(Fire Hose Friction Activity written by J. Blackwell, nbct in connection w/ Wake Tech Community College)*

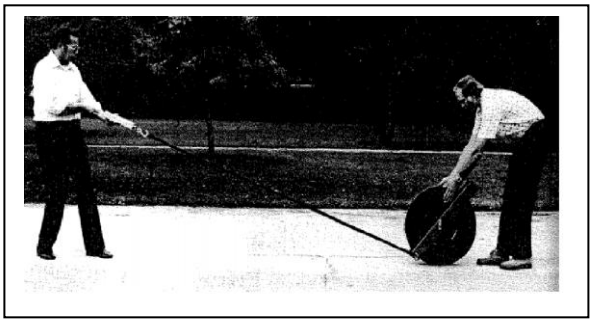
**STUDENT ACTIVITY SHEET**
**Predicting Car Speeds from Skid Marks Analysis**

The question:
Given a skid mark length and a road surface type and condition, predict the car's speed entering the skid? Such information could be used in court to prove certain aspects of a crime.

You will need:

- Excel or a calculator with regression capabilities

Assignment:



First, you will determine the coefficient of friction for two surface types. To do this, a weighted tire drag sled is used with an instrument to measure the force being applied. From Newton's second law, it can be determined that the friction $f = F/W$, where F is the force applied to pull the drag sled and W is the weight of the drag sled. Below you will find 10 samples of forces required to move a 38 pound drag sled on a certain new asphalt road. Determine the coefficient of friction of each force and then find the average f for this particular asphalt. Below you will also find 10 samples of forces required to move a 52 pound drag sled on a certain heavy traveled concrete road. Determine the coefficient of friction of each force and then find the average f for this particular concrete road.

New Asphalt (38 pound sled):

| Force | 32 | 34 | 35 | 33 | 35 | 34 | 33 | 32 | 33 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|
| Friction | | | | | | | | | | |

Now, find the friction average to be used for this certain road type later in this activity.

F = _____

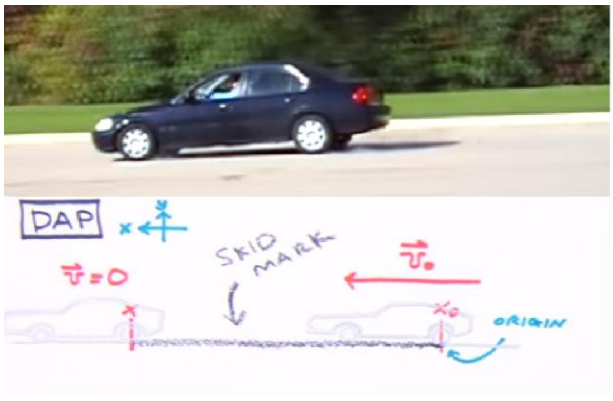
Heavy Traveled Concrete (52 pound sled):

| Force | 28 | 27 | 29 | 30 | 26 | 27 | 30 | 25 | 29 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|
| Friction | | | | | | | | | | |

Now, find the friction average to be used for this certain road type later in this activity.

F = _____

Second and after knowing the road's coefficient of friction, you can now use test skids to determine the relationship between the vehicle speed entering the skid and the skid mark length. To determine this relationship, one could create test skids recording the speed entering the skid and then measuring the skid length. Below you will find 8 samples of mph recorded and the corresponding skid length. The first set of data is for the New Asphalt and the second set of data is for the Heavy Traveled Concrete.




New Asphalt:

| Speed at breaking(mph) | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
|---|---|---|---|---|---|---|---|---|
| Skid Length (ft) | 34 | 46 | 60 | 76 | 94 | 114 | 135 | 159 |

Using regression, find the best model for this relationship: _____

Heavy Traveled Concrete:

| Speed at breaking(mph) | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
|---|---|---|---|---|---|---|---|---|
| Skid Length (ft) | 56 | 76 | 99 | 126 | 155 | 188 | 224 | 262 |

Using regression, find the best model for this relationship: _____

Third, now compare your models with the accepted standard used in the criminal field. In the field, the skid mark is measured and then the speed is determined or predicted, so what should be the independent variable and what should be the dependent variable? _____
Now, rearrange both equations above so that the input variable is the skid length and the output variable is the predicted speed.

New Asphalt Equation for Speed: _____

Heavy Traveled Concrete Equation for Speed: _____

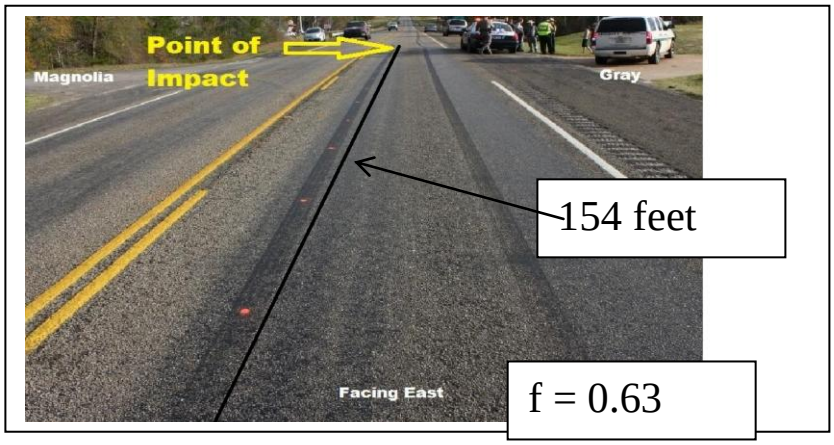
The accepted standard model used in the field is $\sqrt{30 \cdot D \cdot f}$ , where $D$ is the skid length in feet and $f$ is the road surface coefficient of friction. Is this formula consistent with your two formulas? If not, then what is different?

Fourth, predict the vehicle's speed entering the skid for each situation below.

Situation 1: A car closely strikes a child getting off a school bus in a 45 mph speed limit zone. The skid mark is measured to be 134 feet long and the asphalt coefficient of friction is estimated to be 0.8. Is the driver guilty of any crime? What crimes?


Situation 2: A car strikes another car entering the intersection in a 45 mph speed limit zone. The skid mark is measured to be 154 feet long and the older used asphalt coefficient of friction is estimated to be 0.63. Is the driver guilty of any crime? What crimes?

f = 0.8



Situation 3: A car strikes another car entering the highway in a 55 mph speed limit zone. The skid mark is measured to be 112 feet long and the concrete coefficient of friction is estimated to be 0.72. At the point of impact between the two cars, it is also estimated by analyzing the impact damage that the car traveling down the highway was still moving at 35 mph at the point of impact with the second car. The standard formula used when combining two speeds ( like one from a skid mark into another speed at an impact) is given to be $S = \sqrt{(S_1)^2 + (S_2)^2}$ , where $S_1$ and $S_2$ are the two speeds to be combined. Is the driver guilty of any crime?


f = 0.72

Situation 4: A car travels off road to avoid an accident and creates a skid mark across two different types of surfaces. The first surface is concrete and the second surface is a grassy area. If the skid mark on the concrete is 38 feet and the skid mark on the grass area is 80 feet, was the drive speeding if the area is in a 35 mph speed zone? Assume the concrete f = .75 and the grass area f = .47.

*(Skid Mark Activity written by J. Martin – Wake Tech Community College)*