

Brake Effort Distribution

Ideal Brake Effort Distribution

In addition to determining the weight transfer to find individual wheel loads the longitudinal calculation weight transfer can be used to find the optimum brake effort ratio

Maximum braking will occur when all four wheels produce their maximum retarding force at the same time with neither front nor rear wheels locking prematurely.

Looking at the simple case of a single wheel that is slipping sufficiently to give the maximum maximum grip

Maximum deceleration achievable

Brake Force $F_b = Ma_x$

Friction Force. $F_f = \mu_t R$

$$F_b = F_f$$

$$\mu_t R = Ma_x$$

$$\mu_t = \frac{Ma_x}{R}$$

but $R = Mg$

So the maximum deceleration $a_x = \mu_t g$

Braking force available

In general terms $F = \mu_t R$

Looking at the front wheels

$$F_{fb} = \mu_t W_{fb}$$

Where:

$$W_{fb} = W_{usf} + \frac{W_s \times b}{L} + \frac{W_s \times a_x \times H}{L \times g} + \frac{W_{us} \times a_x \times r}{L \times g}$$

Similarly

$$F_{rb} = \mu_t W_{rb}$$

Maximum brake force transmittable

Use the data from Example 1 to calculate Maximum Brake Force transmittable at the front and rear of a vehicle at 0g and at 1.4g decelerations.

Taking

$$W_{fb} = 5203.93$$

$$W_{rb} = 2644.08$$

Finding F_{fb} and F_{rb}

The maximum deceleration is given as $1.4g$ so, ignoring the fact that front and rear μ_t values will actually be slightly different, assume $\mu_t = 1.4$

$$\begin{aligned} F_{fb} &= \mu_t 5203.93 \\ &= 1.4 \times 5203.93 \\ &= 7285.5\text{N} \end{aligned}$$

$$\begin{aligned} F_{rb} &= \mu_t 2644.08 \\ &= 1.4 \times 2644.08 \\ &= 3701.7\text{N} \end{aligned}$$

Brake force distribution by total brake force

The brake force distribution can be expressed as a proportion of total brake force.

Front $7285.5/10987.2 = 0.66$ ie 66%

Rear $3701.7/10987.2 = 0.34$ ie 34%

The brake force distribution can also be expressed by vehicle weight which expresses the braking force at each axle as a proportion of total vehicle weight.

Braking Force distribution by vehicle weight

F_{fbp} = Maximum Brake Force transmittable at front wheels as a proportion of vehicle weight.

$$F_{fbp} = F_{fb} / W_t$$

F_{rbp} = Maximum Brake Force transmittable at rear wheels as a proportion of vehicle weight.

$$F_{rbp} = F_{rb} / W_t$$

Using Brake Force Distribution by vehicle weight

We can use the Brake Force Distribution by vehicle weight description to help understand where brake lockup and limiting deceleration will occur.

The static weight distributions in Example 1 were found to be:

$$W_{fs} = 3624.46 \text{ N}$$

$$W_{rs} = 4205.5 \text{ N}$$

Brake Force Distribution by vehicle weight at 0g

The value of F_{bpf} and F_{bpr} at zero deceleration (*remember this is the force transmittability*) when $\mu_t = 1.4$ will be in proportion to this static load distribution.

$$F_{fbp} = \mu_t W_{fs} / W_t = 0.65$$

$$F_{rbp} = \mu_t W_{rs} / W_t = 0.75$$

Now find F_{fbp} and F_{rbp} at 1.4g deceleration by using W_{fb} and W_{rb}

Brake Force Distribution by vehicle weight at 1.4 g

Giving

$$F_{fbp} = 7285.5/800g \\ = 0.93$$

$$F_{rbp} = 3701/ 800g \\ = 0.47$$

Plotting F_{fbp} and F_{rbp} against Decel

Summary of transmittable brake forces at 0g and 1.4g
ie when $\mu_t = 1.4$

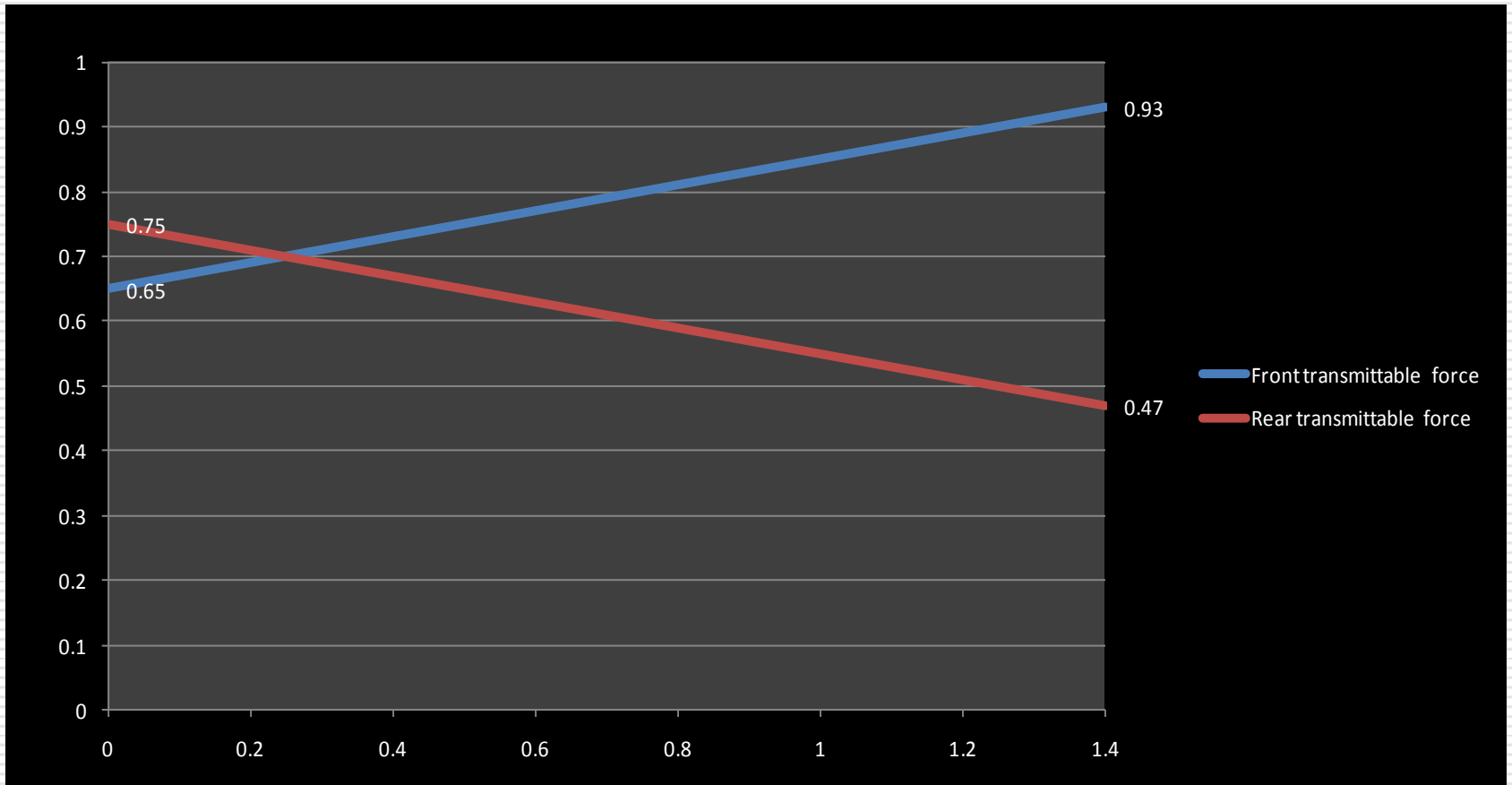
	0g	1.4g
F_{fbp}	0.65	0.93
F_{rbp}	0.75	0.47

Now repeat the exercise for Example 1 but with $\mu_t = 1.0$
Maximum deceleration will now be 1.0g

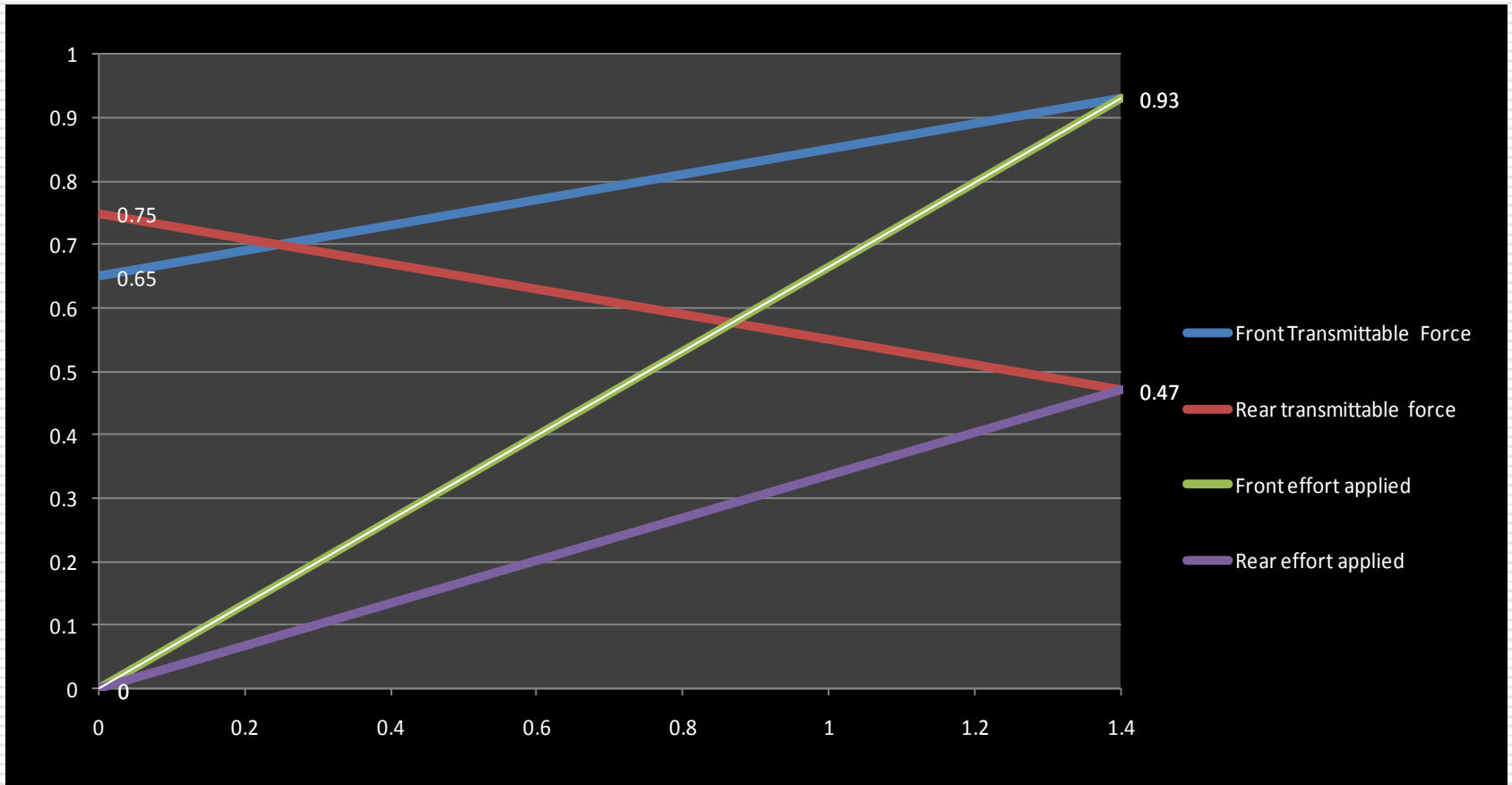
Summary of transmittable brake forces at 0g and 1g

	0g	1g
F_{fbp}	0.46	0.61
F_{rbp}	0.54	0.39

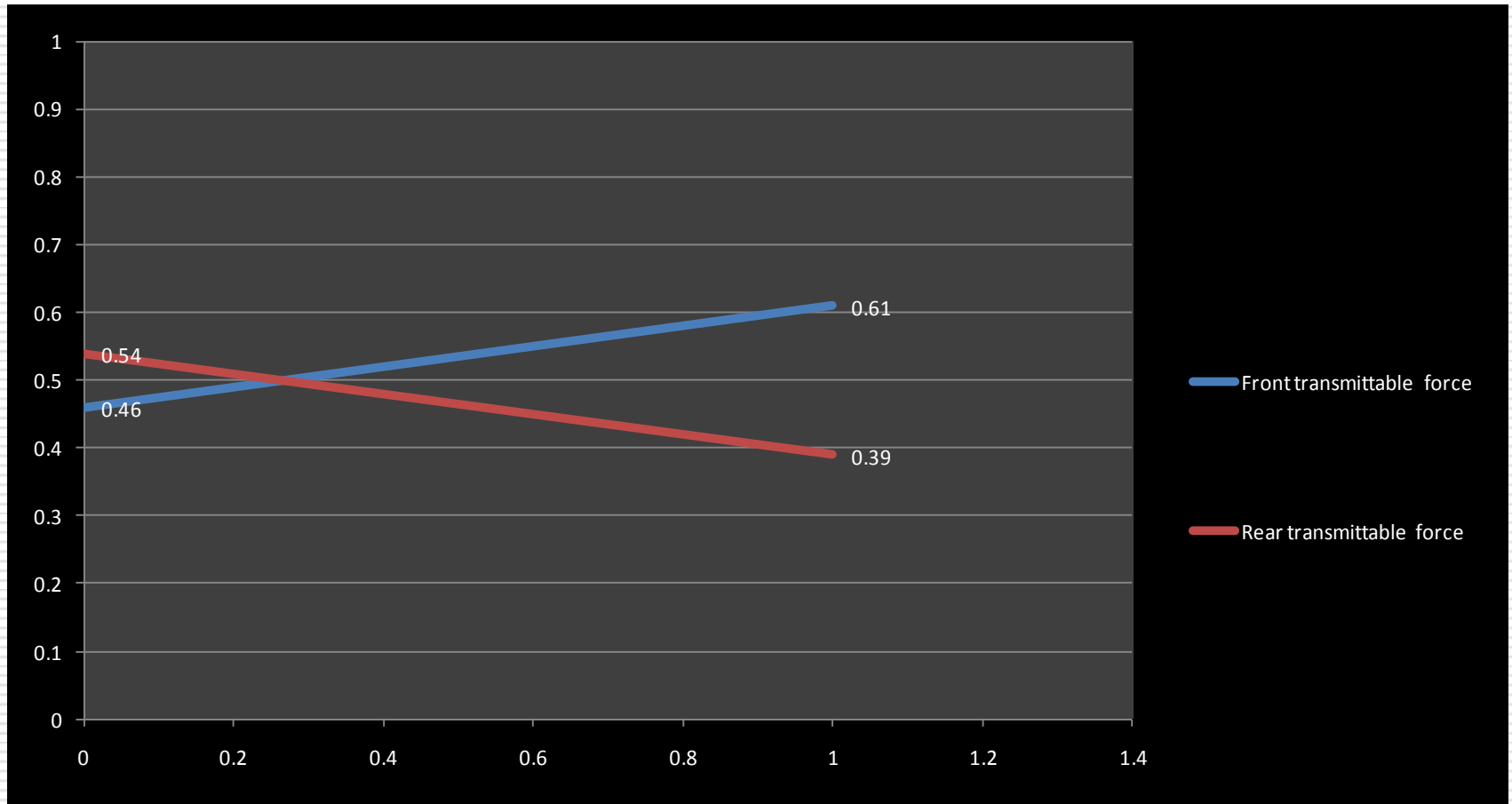
Plot of F_{fbp} and F_{rbp} against deceleration for $\mu_t = 1.4$



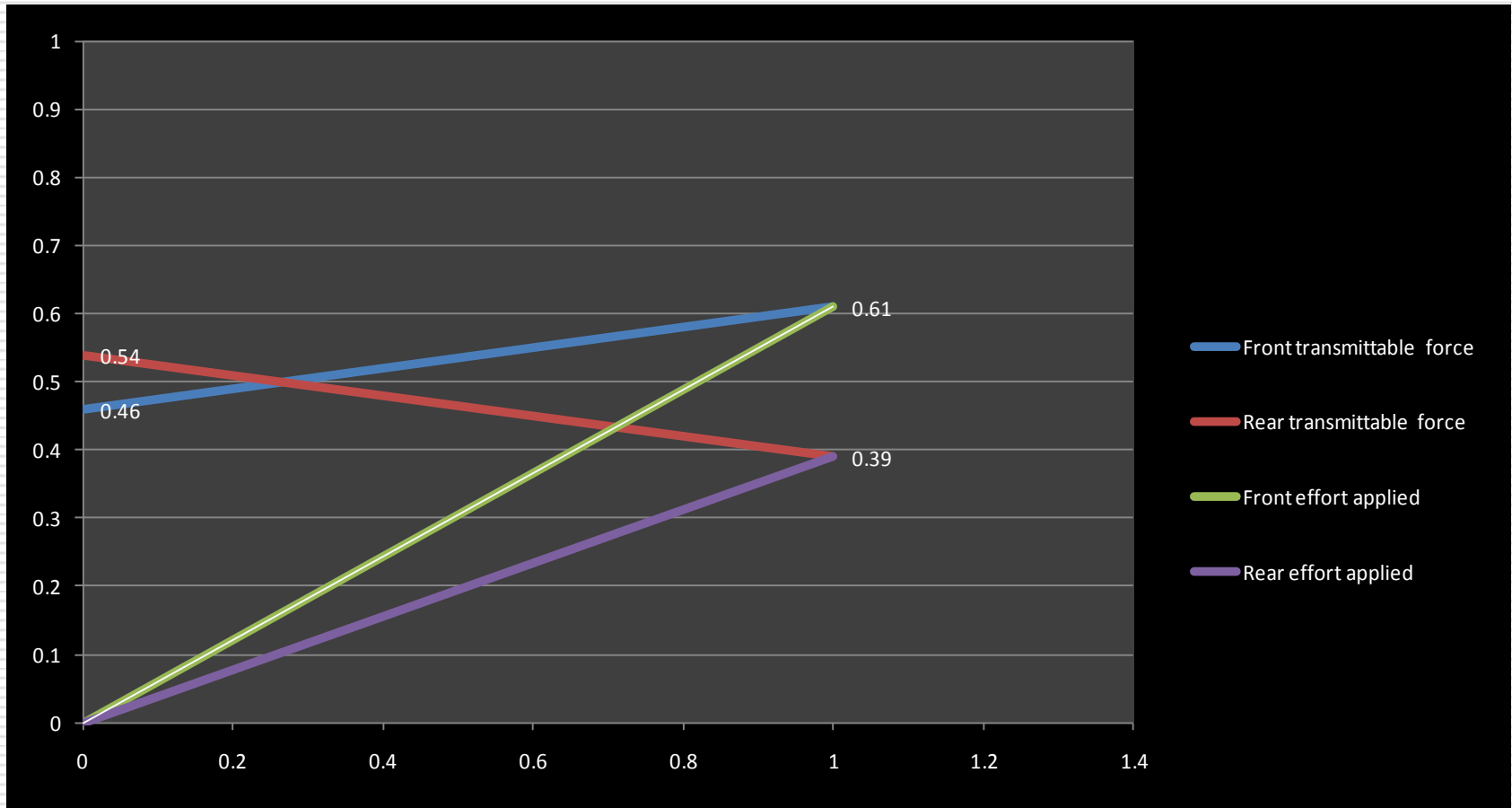
Ideal brake effort lines added for $\mu_t = 1.4$



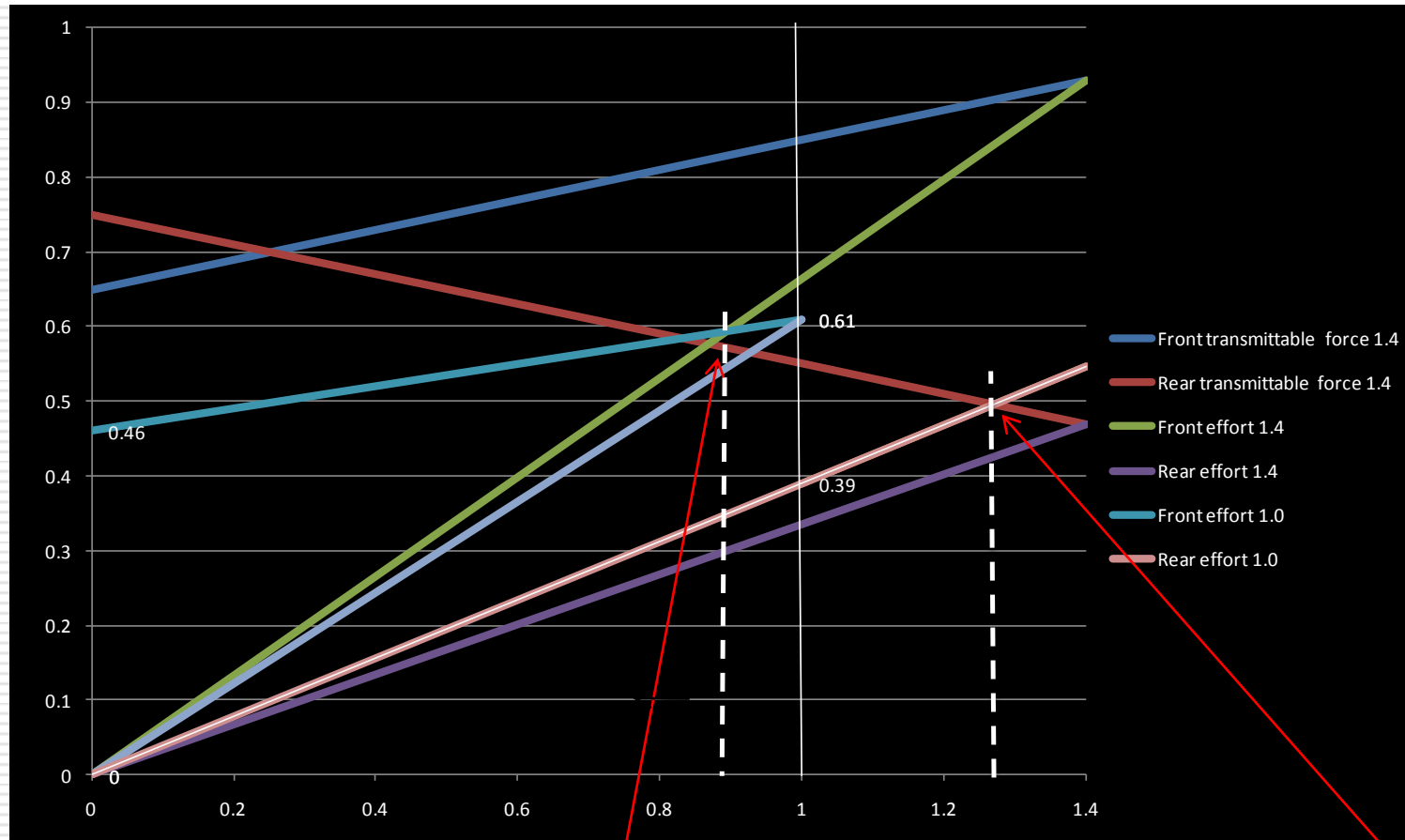
Plot of F_{fbp} and F_{rbp} against decel for $\mu_t = 1.0$



Ideal brake effort lines added for $\mu_t = 1.0$



Premature wheel lockup using setup for 'wrong' μ_t



Early front lockup due to μ_t 1.4 setup on μ_t 1.0 😊

Early rear lockup due to μ_t 1.0 setup on μ_t 1.4 ☹️