Problems and Solutions

in Mathematics, Physics and Applied Sciences

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Maximum Speed in a Quarter Mile

To determine the maximum speed possible for a wheel driven vehicle, *assume* that the coefficient of friction between the tires and the ground is unity, *i.e.*, it takes as much force to lift the vehicle as it does to drag it. Then the maximum velocity possible in a quarter mile is the same as the velocity achieved by dropping the vehicle a quarter mile under the influence of gravity.

Given these conditions the maximum available horizontal force is $F = ma = mg$, where g is the acceleration due to gravity. Thus,

$$g = \frac{dv}{dt} = \frac{dv}{ds}\frac{ds}{dt} = v\frac{dv}{ds} \tag{1}$$

and, using $g = 32.2\text{ft/sec}^2$,

$$\begin{aligned} g\int_0^{1320} ds &= \int_0^{V_{max}} v\,dv && (2)\\ gs\Big|_0^{1320} &= \frac{V^2}{2}\Big|_0^{V_{max}} && (3)\\ 2\times 1320\times 32.2 &= V_{max}^2 && (4)\\ V_{max} &= 291.56\frac{\text{ft}}{\text{sec}} = 198.8\frac{\text{mi}}{\text{hr}} && (5)\end{aligned}$$

It was long held that the assumption of unity coefficient of friction was appropriate for a wheel driven vehicle. This belief was shown to be incorrect if the tires develop significant viscous friction against the road surface. In fact, the viscous friction developed by melting rubber has a coefficient proportional to velocity — the faster the tires rotate, the greater the motive force.

With the development of dragster engines capable of spinning the wheels at high rates the maximum speed limit calculated above has been completely shattered. The current record is greater than 300 mph with no end in sight!