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Physics and Engineering of SLED, the Speed Limit Enforcement Devices

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Abstract

The need of limiting speed is based on multiple reasons related to safety.

The practice of use of speed limiting devices (e.g.: speed humps/speed bumps) is very contradicting in terms of achieving the main goals, as safety without increasing pollution.

The study also showed that selection of speed limiting devices is often intuitive, but not based on adequate physical model and accurate calculation and design.

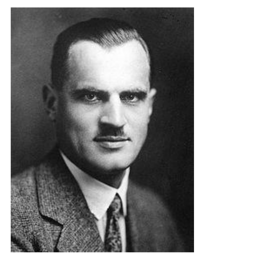
Actual practice today shows that the safe speed passing a speed hump/bump is often differs from the assigned speed limit. This leads to drivers' slowing down before the speed humps and their acceleration in the space between speed humps.

As a result, the purpose is not achieved, the safety is not improved, the environment becomes more polluted and the spent money wasted.

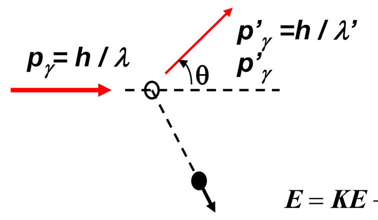
The study was made on reasoning of the shape and dimensions of speed limit enforcement devices to match the assigned speed limit

The Origins

discoveries resulting in major changes in electromagnetic theory. He is commonly known for his work on the Compton Effect with X-rays. He also invented what he called "traffic control bumps," the basic design for the speed hump, in 1953. Compton began designs on the speed bump after noticing the speed at which motorists passed Brookings Hall at Washington University in St. Louis, Missouri, where he was chancellor.[3]



1892 - 1962
Arthur Holly Compton
Nobel Prize in physics. 1927

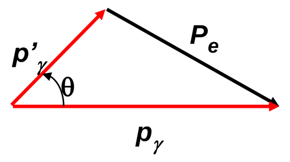


$$p_e = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\left.\begin{aligned} E &= KE + m_o c^2 \\ E^2 &= m^2c^4 + p^2c^2 \end{aligned}\right\} \Rightarrow \left(m = 0 \Rightarrow \underline{E = pc}\right)$$

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

Elastic Collision: Conservation of Momentum & Conservation of Energy:



$$\vec{p}_i = \vec{p}_s + \vec{p}_e \Rightarrow$$

$$p_e^2 = p_i^2 + p_s^2 - 2p_i p_s \cos\theta$$

$$p_e = \frac{mv}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$E_i + m_e c^2 = E_s + E_e$$

$$\Rightarrow E_e^2 = c^2 p_e^2 + m_e^2 c^4$$

$$\left(\frac{mv}{\sqrt{1-v^2/c^2}}\right)^2 = \frac{h^2}{\lambda_i^2} + \frac{h^2}{\lambda_s^2} - \frac{2h^2\cos\theta}{\lambda_i \lambda_s}$$

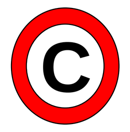
$$\frac{hc}{\lambda_i} = \frac{hc}{\lambda_s} + mc^2 \frac{1}{\sqrt{1-v^2/c^2}} - mc^2 \Rightarrow$$

$$\Delta\lambda = \lambda_s - \lambda_i = \frac{h}{mc}(1-\cos\theta)$$

Compton wavelength:

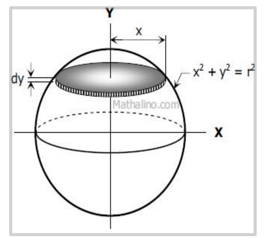
$$\lambda_c = \frac{h}{mc} = 2.426 \times 10^{-12}\, m$$

Arthur Holly Compton Originated study of SLED



METHODOLOGY
Volume of the blue rubber ball found by

Mathematician

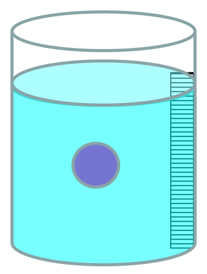


$$V = 2\cdot\int_0^r \pi x^2 dy = 2\cdot\pi\int_0^r (r^2 - y^2)dy =$$

$$= 2\pi\left[r^2 y - \frac{y^3}{3}\right]_0^r = 2\pi\left[\left(r^3 - \frac{r^3}{3}\right) - \left(0^3 - \frac{0^3}{3}\right)\right] =$$

$$= 2\pi\frac{2r^3}{3} = \frac{4\pi r^3}{3}$$

Physicist



Engineer

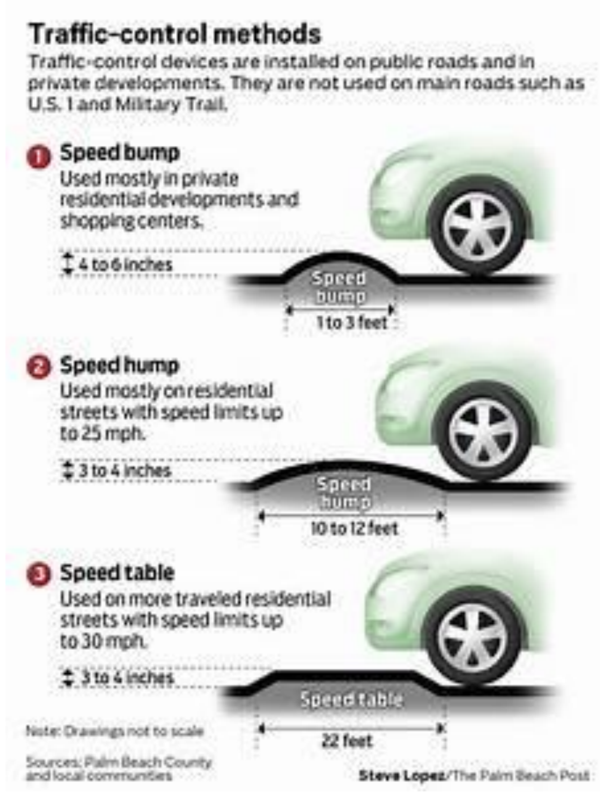
Handbook
of blue rubber balls

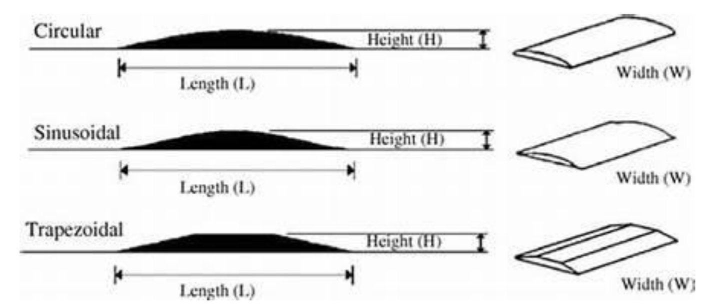
An Engineered SLED

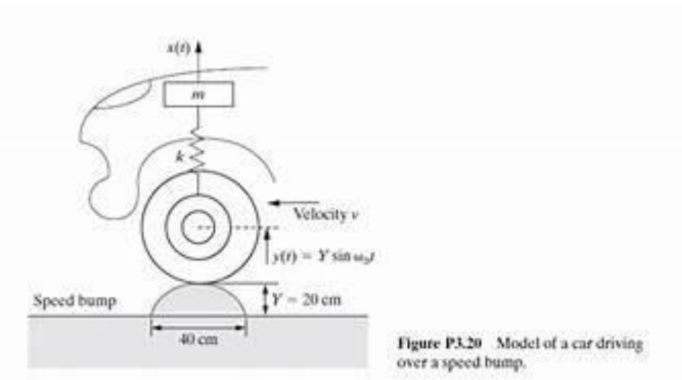
An inexpensive "organic" SLED

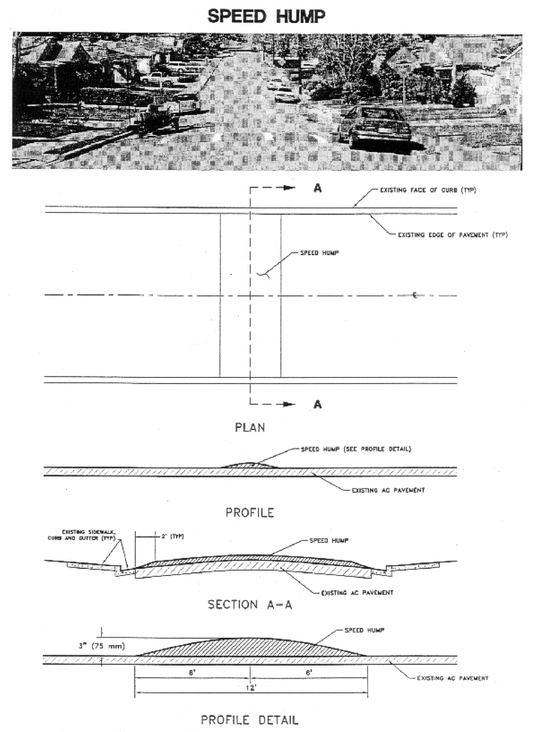
NASA Space Pen

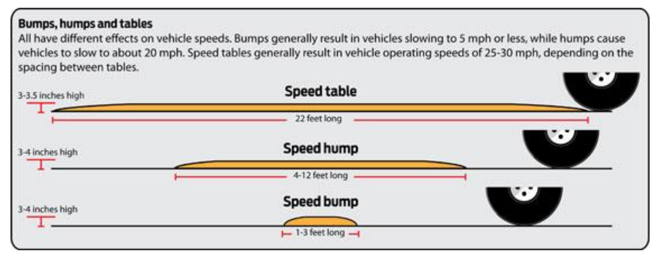
Inexpensive Russian Cosmonauts
zero gravity writing device







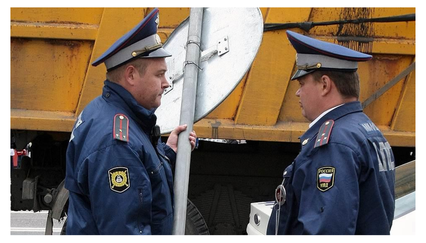




The Actibump system, successfully used in Sweden, is based on powered equipment integrated into the road surface, which operates a platform that is lowered a few centimeters when a speeding vehicle approaches. Any vehicle approaching at or under the speed limit will pass on a level road. The system measures the speed of an oncoming vehicle by using radar.[13]

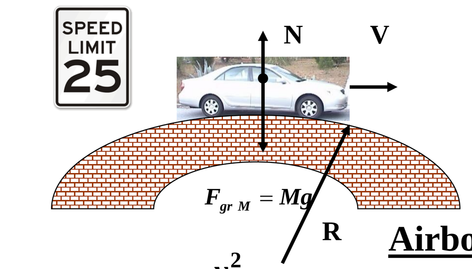
In another design, a rubber housing is fitted with a pressure relief valve that determines the speed of a vehicle. If the vehicle is traveling below the set speed, the valve opens allowing the bump to deflate as the vehicle drives over it, but it remains closed if the vehicle is traveling too fast. The valve can also be set to allow heavy vehicles, such as fire trucks, ambulances, and buses to cross at higher speeds.[14][15]

SLED International



Bose Electromagnetic car suspension

Use QR Reader to watch video on your smart electronic device



$F_{gr\,M} = Mg$

$$F_{grM} - N = M\frac{v^2}{R} \Rightarrow$$

$$N = Mg - M\frac{v^2}{R} \Rightarrow$$

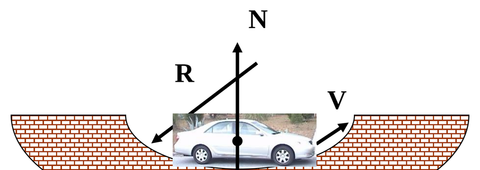
$$N = M\left(g - \frac{v^2}{R}\right) < Mg$$

Airborn

$$N = 0 \Rightarrow$$

$$Mg - M\frac{v^2}{R} = 0$$

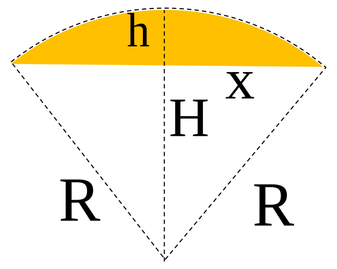
$$v = \sqrt{Rg}$$



$$N - F_{grM} = M\frac{v^2}{r}$$

$$N = M\frac{v^2}{r} + Mg$$

$$N = M\left(\frac{v^2}{r} + g\right) > Mg$$



$$N = 0 \Rightarrow$$

$$Mg - M\frac{v^2}{R} = 0$$

$$v = \sqrt{Rg}$$

$$R = \frac{v_{max}^2}{g}$$

$$(R - h)^2 + x^2 = R^2$$

$$R^2 - 2Rh + h^2 + x^2 = R^2$$

$$2Rh = h^2 + x^2$$

$$R = \frac{h^2 + x^2}{2h}$$

$$h^2 - 2Rh + x^2 = 0$$

$$h = R - \sqrt{R^2 - x^2}$$

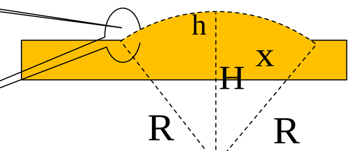
$$x[m] \subset (1.50, 2.00)$$

$$v[km/h] \subset (10.00, 20.00)$$

$$h^2 - 2Rh + x^2 = 0$$

$$x = \sqrt{2Rh - h^2}$$

v[mi/h]	v[m/s]	R[m]=v2/g	x[h=0.05]	x[h=0.10]	x[h=0.02]
10	4.469444	2.03628274	0.448473	0.630283	0.284695
12	5.363333	2.93224714	0.539189	0.759243	0.341892
15	6.704167	4.58163616	0.675029	0.952012	0.427628
18	8.045	6.59755607	0.810713	1.144339	0.513325
20	8.938889	8.14513094	0.901118	1.27241	0.570443



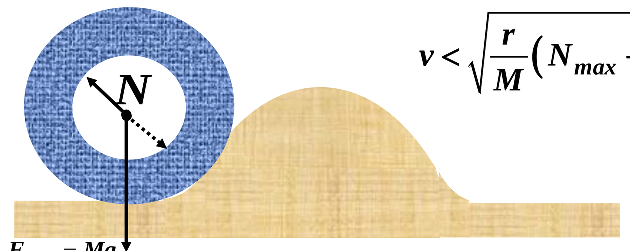
$$N - F_{grM}\cos 45 = M\frac{v^2}{r}$$

$$N = M\frac{v^2}{r} + Mg\cos 45$$

$$N = M\left(\frac{v^2}{r} + g\cos 45\right)$$

$$N - F_{grM}\cos 45 = M\frac{v^2}{r}$$

$$v < \sqrt{\frac{r}{M}\left(N_{max} - Mg\cos 45\right)}$$



$F_{gr\,M} = Mg$

Conclusion:

Studying the issues related to the SLED we learned that here are numerous groups of people involved and their interests and requirements are contradicting sometimes.

- The customers – inhabitants of the surrounding area who are interested that SLEDs to be installed and be in use of the drivers.
- The Drivers, whether bypassing, or the locals, who need fast and safe commute and they don't want to have any obstacles like SLED.
- The Department of Transportation = DoT has multiple interests: as designers and installers as well as law enforcement officers controlling obeying the speed limit.

A variety of approaches was attempted to implement design of SLED based on the goals and availability of resources.

Permanent shape and size SLEDs; Variable size SLEDs

As we can see, the SLEDs present multidimensional problems and so, multidimensional approaches are required to address them. There is no single solution to address all the aspects.

Our goal was to understand how to make an average driver without a super-designed, or super-equipped car be safe crossing a SLED, following at a speed limit velocity.

Involving the cadets of both Physics and Engineering Majors into this kind of applied Physics Undergraduate research will tune them into critical thinking approach to their projects after their graduation at their work places.

One driving ahead of you is an Idiot,
One driving behind you is a Maniac