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Co-design of roads & cars on hilly terrains

saurabh kwatra

Need to Redesign:

I very much doubt if vehicles are specifically designed for operation over hills; I haven't heard of so-called hill-car or mountainous truck? Of course we have all-terrain jeep & geared bicycle that allow operation over slopes easy. But I am talking of design with primary function as locomotion over hills. There appears a gap. Reason isn't scarcity of hills on Earth for sure. It appears scarcity of high end political and business traffic there. So the design need is low but existent.

Problems and their design solutions:

This feature is inspired by my numerous and frequent travels to several hill stations nestled in the Himalayas of northern India. Following points were obtained on basis of empirical observations. My suggested solutions are included alongside.

1) Roads with steep slopes beyond an angle overload the engines of vehicles to extreme. Trucks that have a lower power-to-mass ratio suffer most. Efficiency is low, un-burnt carbon release is high and to a common man dark dirty fumes emitted cause suffocation and cough. Proximity to such a vehicle for few seconds can mar the freshness experienced courtesy crisp mountain air in the past one hour. Well tuned engines that give complete combustion and have a high ecological rating should be encouraged.

2) If the road is resurfaced well, i.e. it is smooth, difficulties are less. Slight neglect in maintenance of roads causes enormous power loss, discomfort and undue wear and tear to vehicles. Regular inspection and resurfacing are a must.

3) The above two points get an enhancement on uphill drive. On downhill, these factors are weighted less; there is more resilience.

4) Generally speaking, better climatic conditions over hills, such as respite from hot sultry tropical conditions faced on neighboring plains, are a relieving factor. People don't mind waiting in traffic jams, road rages are infrequent and there is greater cooperation. In fact some unsaid, unwritten, informal & non-governmental rules exist. Like, the uphill vehicle is bestowed priority over its downhill counterpart. This has a technical explanation. An uphill vehicle needs to maintain his inertia of motion to climb without getting stuck. In contrast, the downhill one can change his state from rest to motion effortlessly. Gravity is in his favor. The colloquial

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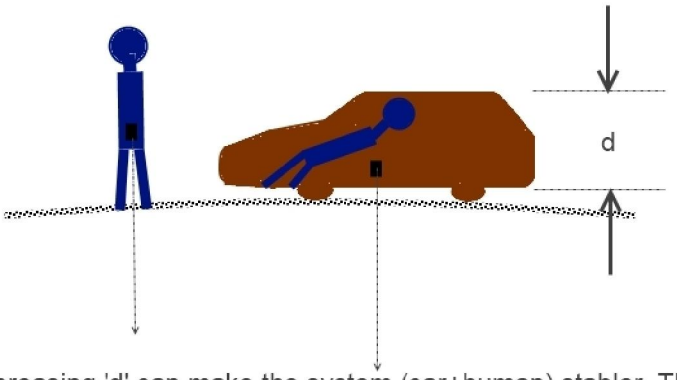
regulations designed by local hill drivers by empirical experience over years seem to implicitly echo laws of Newton contained in formal physics, automobile engineering & basics of inclined planes.

5) Prominent roads are wide allowing simultaneous two-way movement. There is ample margin for overtaking and temporary parking. Picnic spots on side-bends are not uncommon too. Still, there is no center-divider physically; a colored line painted on road geometrically divides the road. Less important roads, say those not listed as national or state highways, are often narrower, more curved and poorly maintained. Their resurfacing schedules stretch over months if not years. Vehicles are big (rather wide) enough for roads. Two-way movement is difficult not infrequently. Solutions are to restrict movement of over-wide vehicles or schedule unidirectional flow alternating. A long-termed solution would be to manufacture slim vehicles or temporarily compress ordinary vehicles on hills.

6) See figure (1). Traditionally cars that carry us are shorter than us in height. They are longer of course, to fit us obliquely in a sitting position. The center of gravity (cg) of car + human system is lower than human alone. Statically it is more stable and safe to be (rest) in a car than stand alone! For any hill-driven design, cg should be as low as possible. Low floor dwarf cars are to be preferred. Further compression should be done wherever feasible. It cannot however be done at expense of length or width, as explained in the figure (1).

The center of gravity or cg of the car+human is lower than (wo)man alone when he/she is in upright position. Statically, car (at rest) carying man is stabler and safer than wo(man) standing (at rest).



Decreasing 'd' can make the system (car+human) stabler. This is highly desired on hilly roads. How to achieve this is tricky. If the car is compressed at the expense of its width, it is problem. Hill roads are often narrow. If done at the expense of length, it is again a problem; maneuverability suffers.

Figure 1

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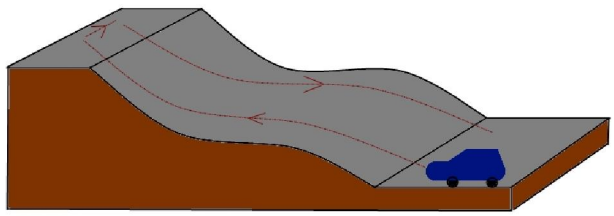
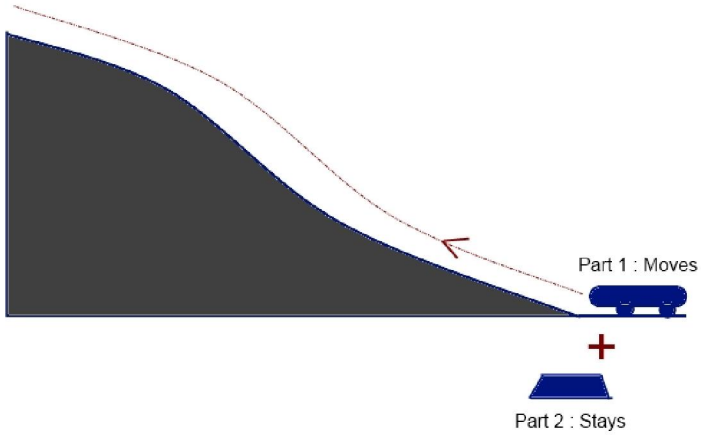
7) An innovative solution inspired from laptops with detachable DVDs has been developed by me. These machines are composed of two distinct parts. The main part (let us call it M) is portable and is a self-sufficient light machine. The other part contains the DVD writer & other non-mandatory functions which can safely be left behind at home: let us call it H. When M is brought home, it is fits to H - in few seconds the full featured complete machine is assembled. This dual-bit laptop design combines versatility & portability without loss of any function. Returning to hill transportation, weight is the single most important factor in any venture. Trekkers endeavor to travel as light as possible especially when climbing. Hilly cars that frequently undertake round trips could be made as a two-bit structure. The primary part could journey up & down while its secondary counter-part could patiently wait on the ground. See figures (2) & (3).





figures 2 & 3

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8) There is an intricate game of using gas & brake pedals in hill driving. Screeching noise of brakes during gravity-aided, happy descent; unavoidable use, misuse, overuse and even misuse of gas pedal on climb; overheating of either braking (retarding) system or engine & transmission (accelerating system) are rampant. It takes a decade to master the art of skilful hill driving; legally there is an optional hill driving license in many hilly states of India! I have developed a mechanism called 'pairing vehicle technology' (PVT). PVT was inspired by an intensive recall of the laws of conservation of energy and momentum. While it is neither desirable nor required to describe this invention here, I make use of its application to hill driving. Please see figure (4).

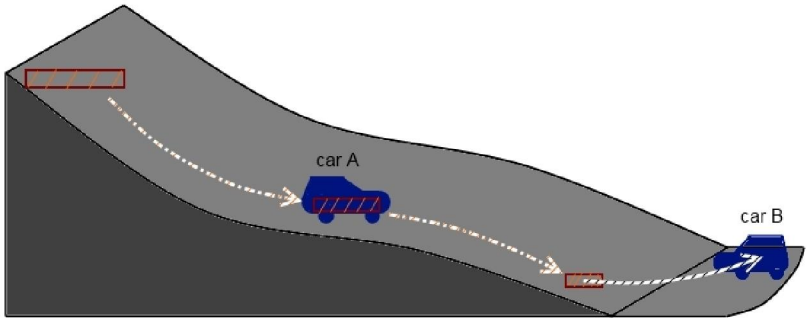

figure 4

Car 'A' coming downhill applies regenerative braking technology to compress the enclosed spring. Driving down gravity thus gets away with the dissipative energy loss in conventional braking and makes driving itself more controlled and safer. When it reaches the lower end of the hill, it 'donates' its powered spring to the eagerly awaiting car 'B'. Car 'B' uses the stored potential energy of the spring with its light, lean engine to comfortably ascend the same hill. It acts like a hybrid vehicle in a sense, saving fuel. Pollution on hill stations is also curtailed this way; hence it is also an ecologically conscious solution.

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*Paper titled