Power Requirements of A Vehicle

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ng Department

Match the Horse to the Cart ....

Animal Driven Vehicles

Cycle Work to be done by an *Engine* Directly Powering the Vehicle

The Powering Engine Torque is: $T_{PE} = F_{wheel}\ r_{wheel}$

r_{wheel} = Wheel Rolling Radius (meters)

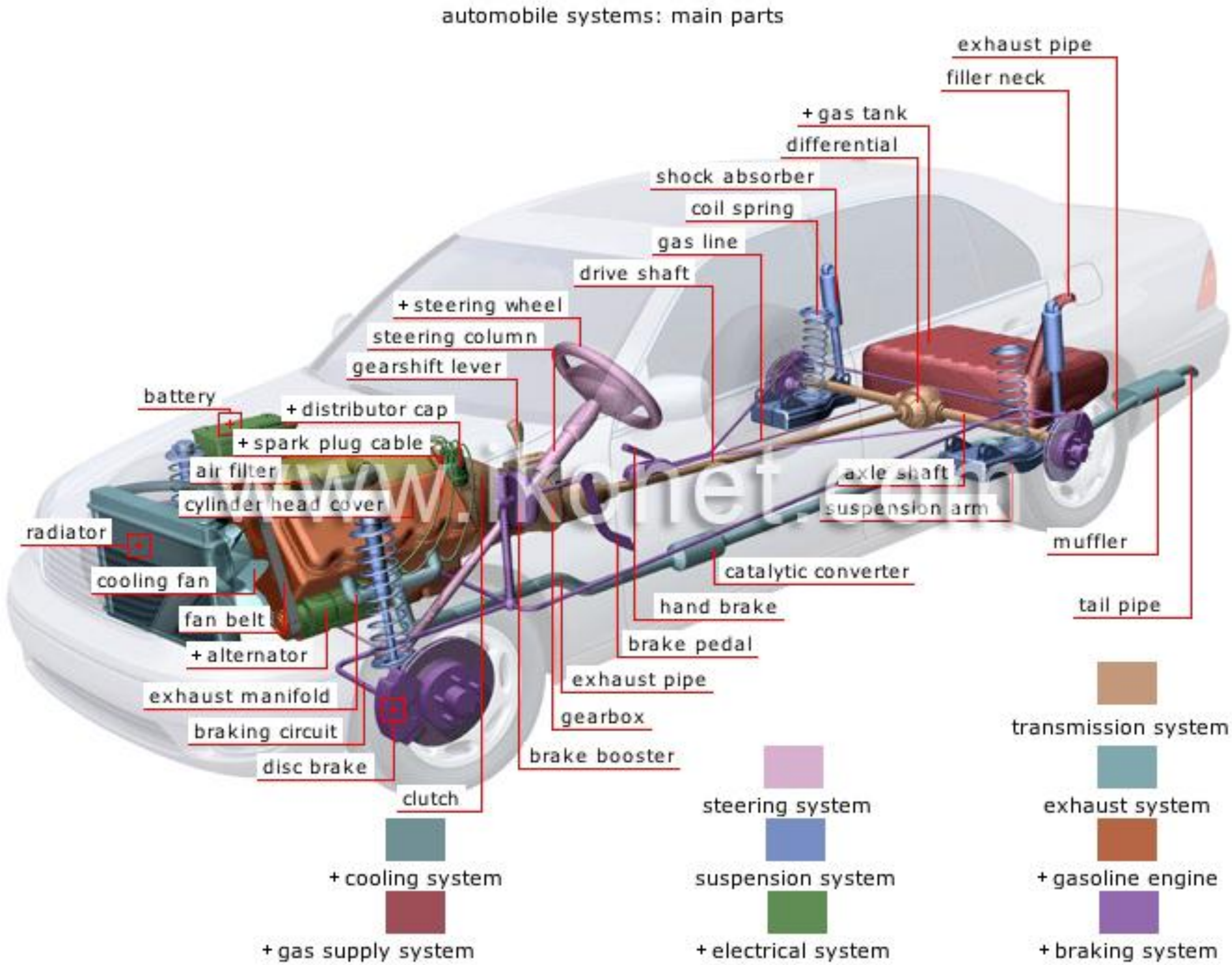
The speed of the vehicle in *km/h* is: $km/h = \frac{2\pi N_{PE}}{60}\ r_{tire}$

Ideal capacity of Powering Engine: $$P_{PE} = T_{PE} \times \left(\frac{2\pi N}{60000}\right) kW$$

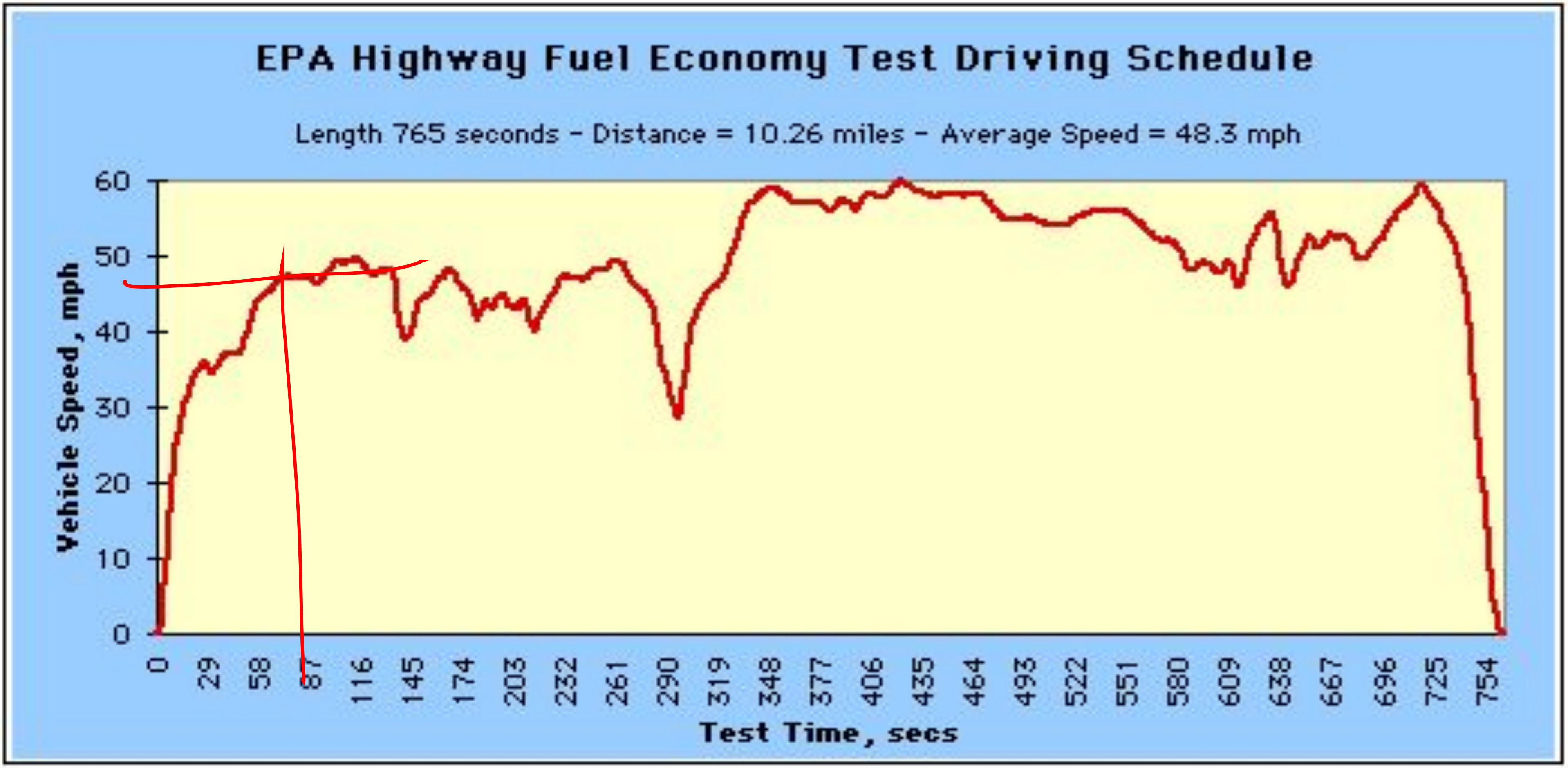
Ideal cycle work of A Powering Engine:

$$P_{PE} = T_{PE} \times \left(\frac{2\pi N}{60}\right) \Big/ \frac{N}{2\times 60}$$

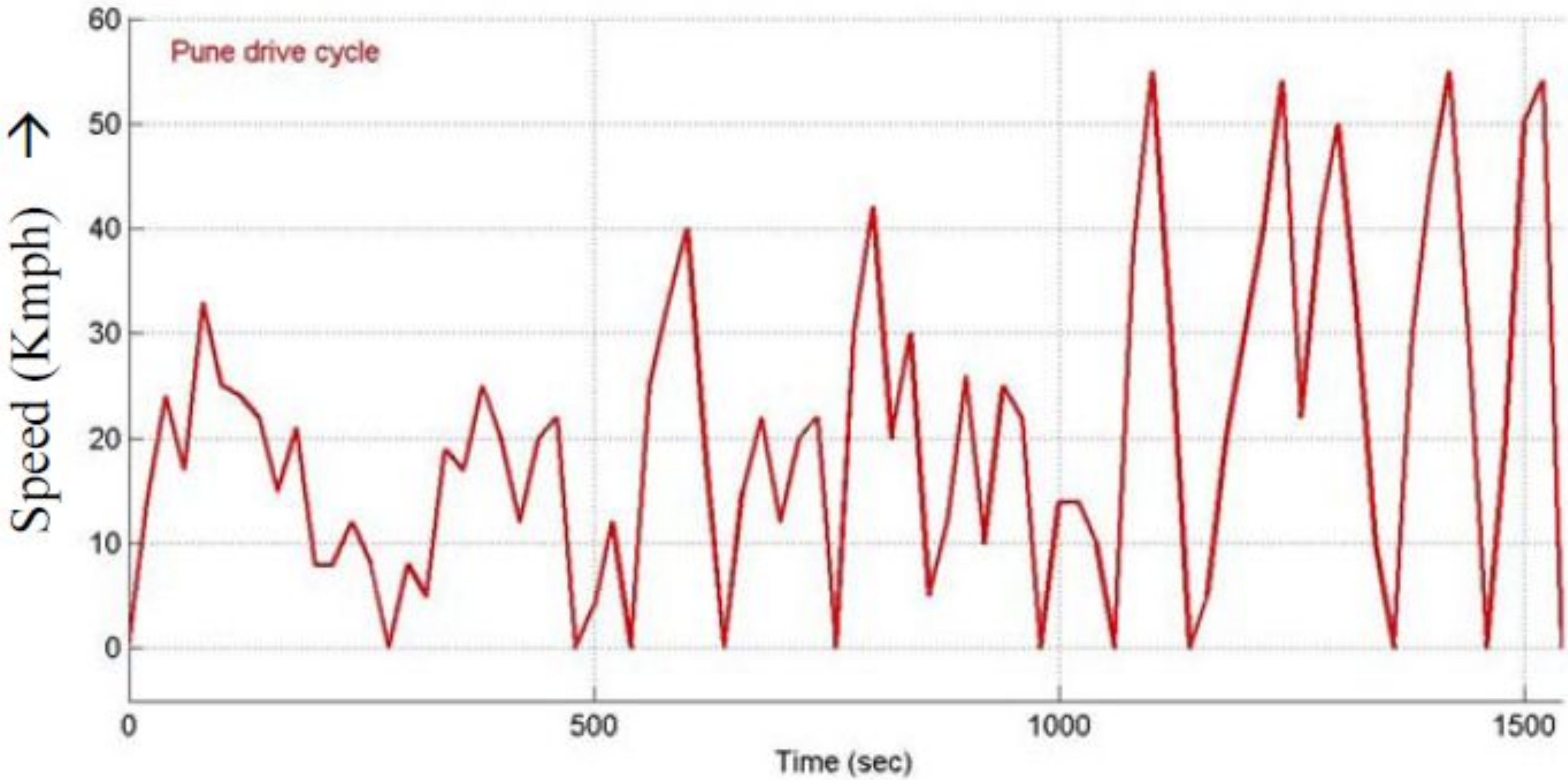
Modern Cars are not Directly Driven!?!?!



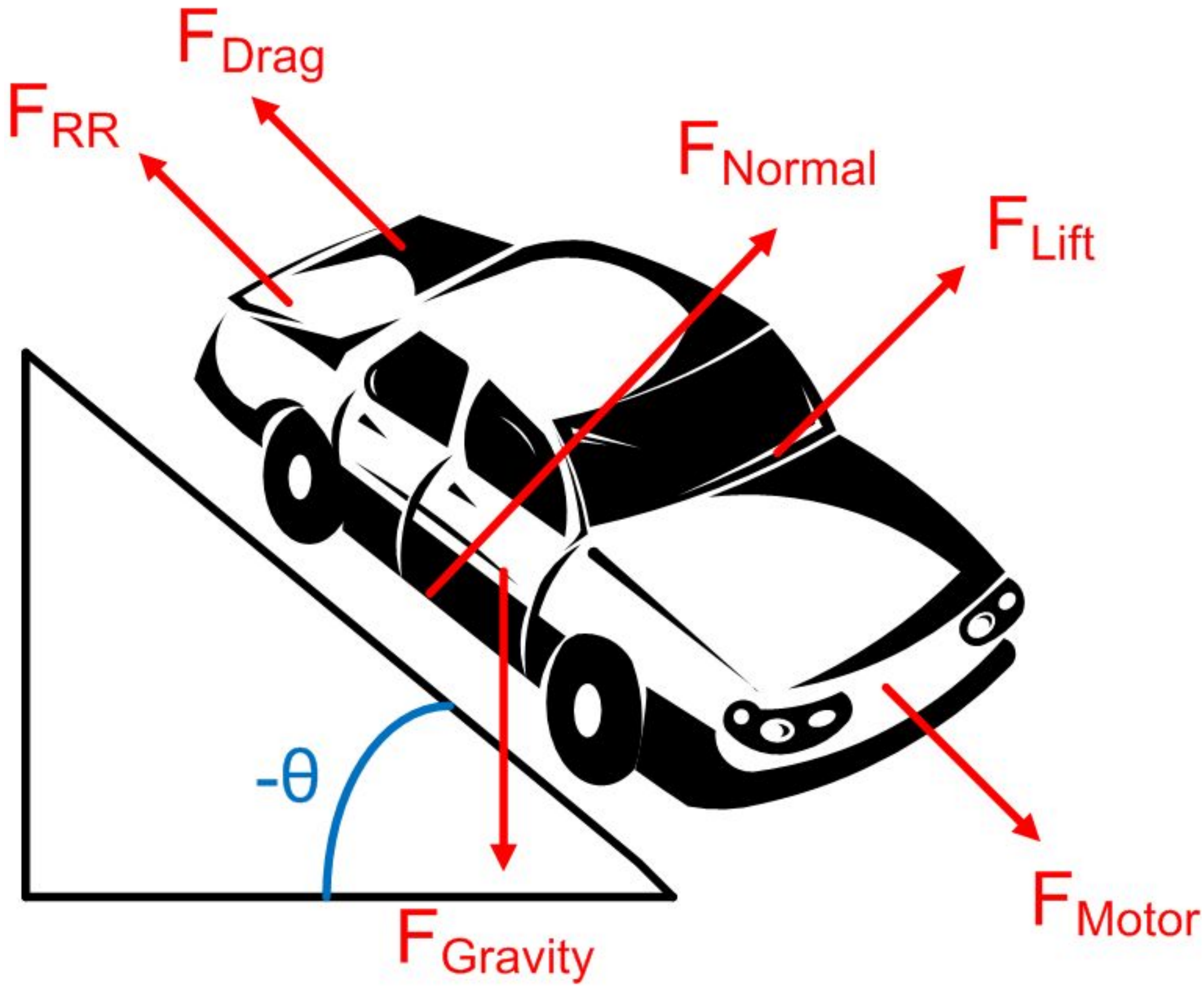
High Way Driving Cycle



Urban Driving Cycle



Forces To be Overcome by an Automobile



Resistance Forces on A Vehicle

- The major components of the resisting forces to motion are comprised of :
- Acceleration forces (F_{accel} = ma & $I\alpha$ forces)
- Aerodynamic loads (F_{aero})
- Gradeability requirements (F_{grade})
- Chassis losses ($F_{roll\ resist}$).

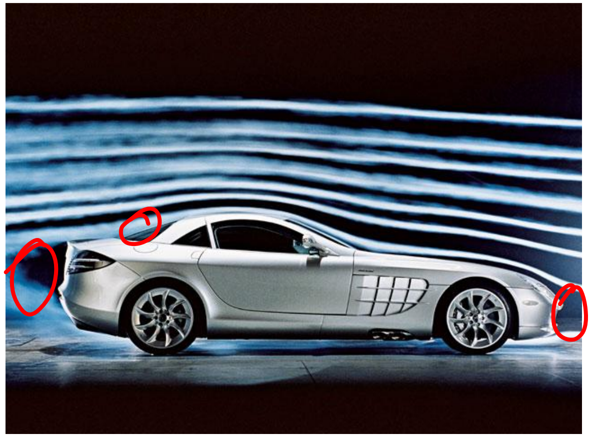
$$F = \underbrace{F_{aero} + F_{rr} + F_g}_{\text{present always.}} + \underline{ma}$$

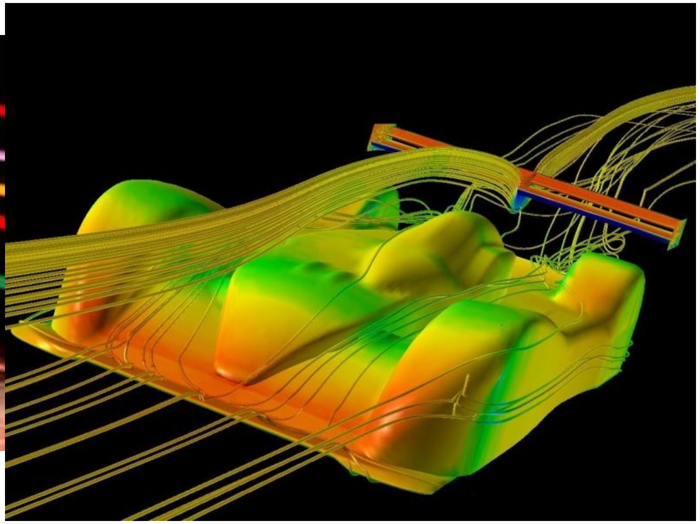
only during acceleration

Aerodynamic Force : Flow Past A Bluff Body

Composed of:

1. Turbulent air flow around vehicle body (85%)
2. Friction of air over vehicle body (12%)
3. Vehicle component resistance, from radiators and air vents (3%)



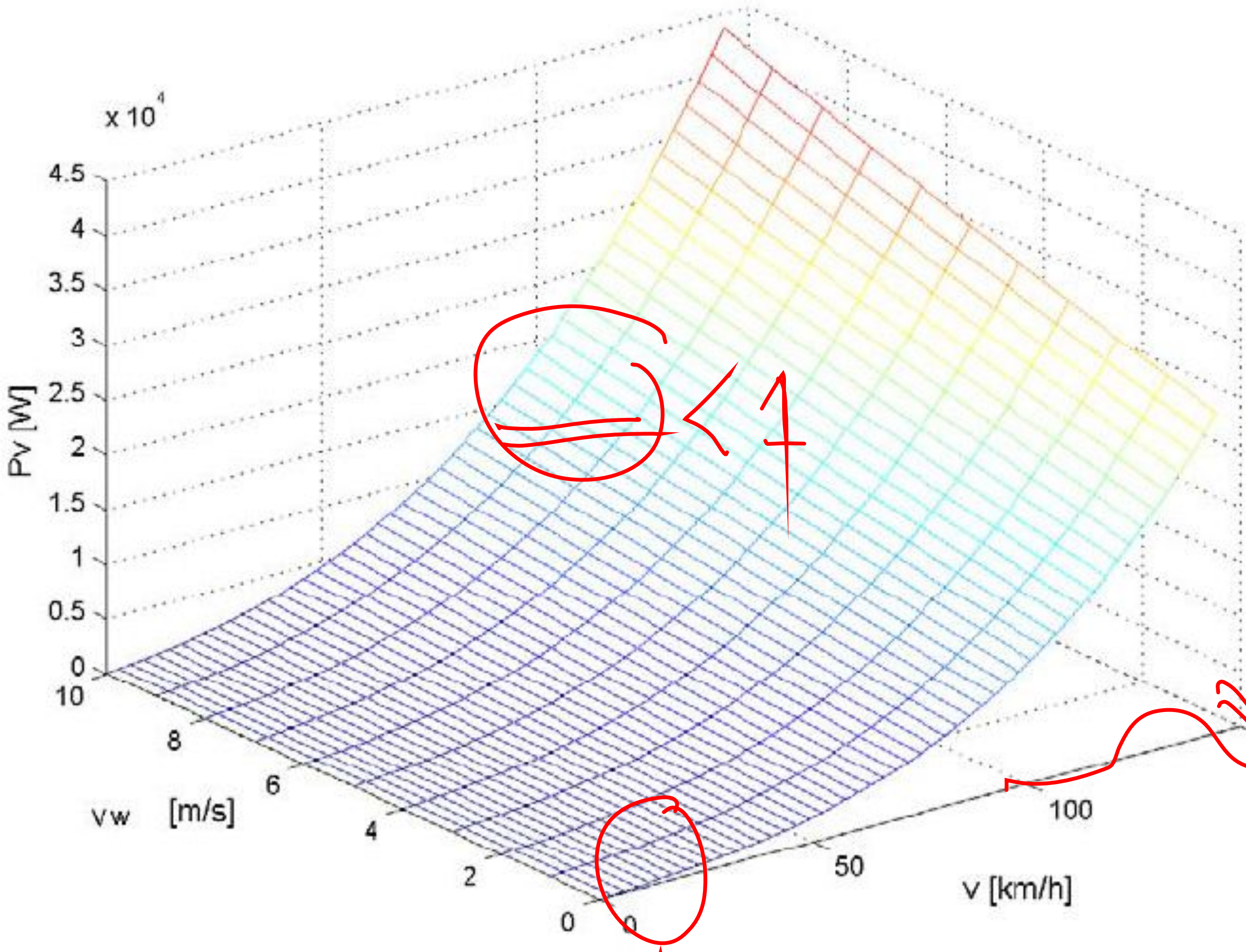


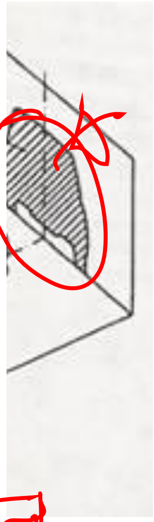
Aerodynamic Resistance on Vehicle

Dynami

Drag For

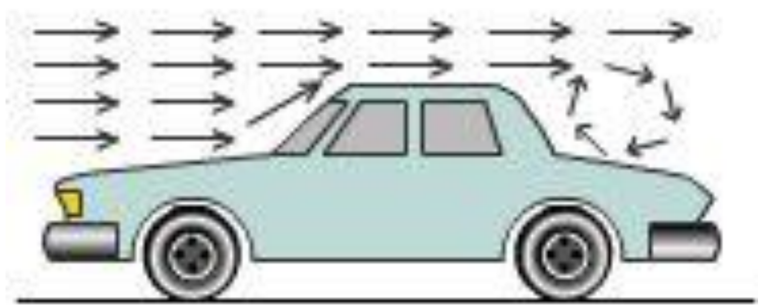
F_d





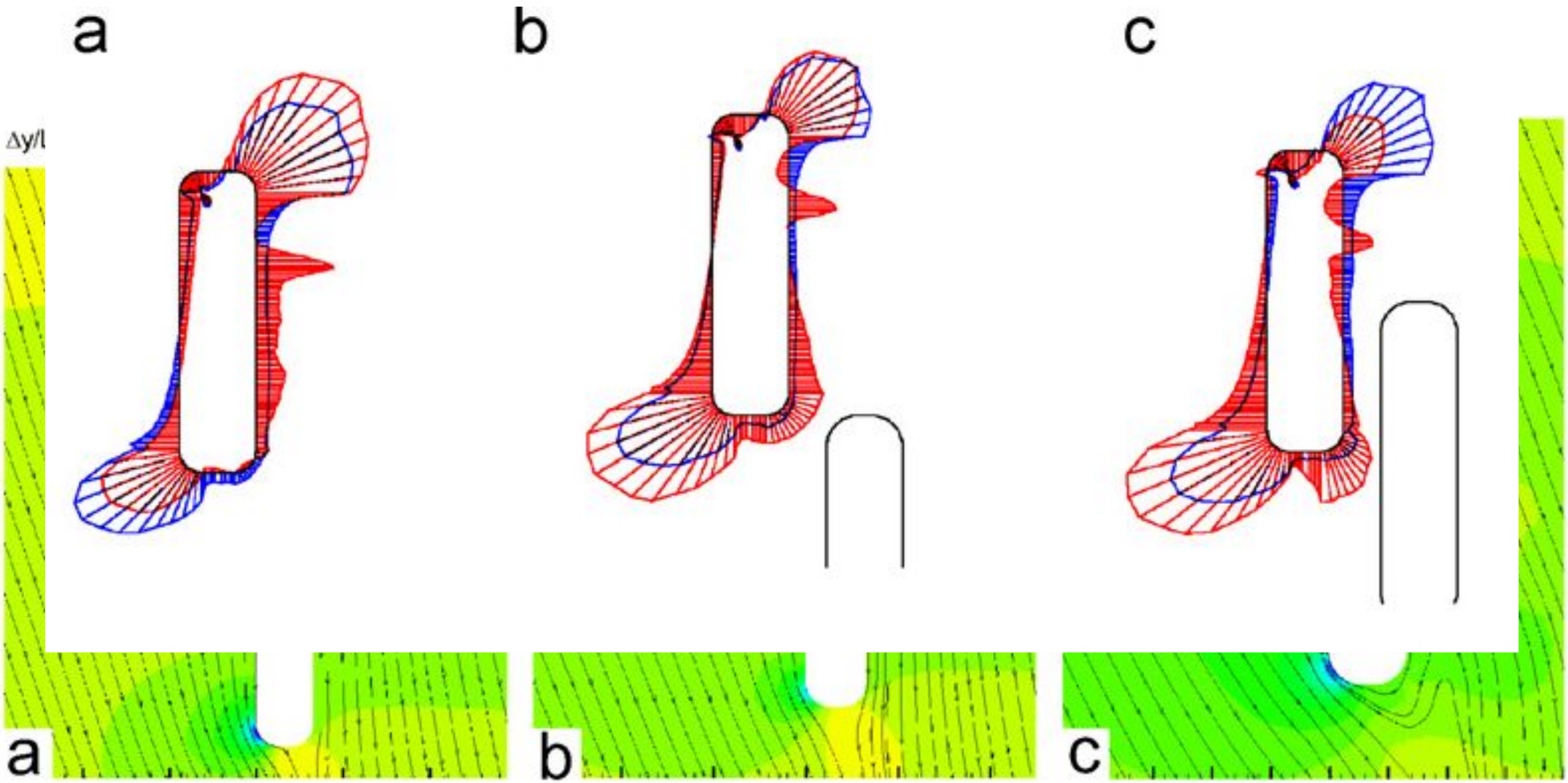
Aero Power $P = F_{d,design} V$

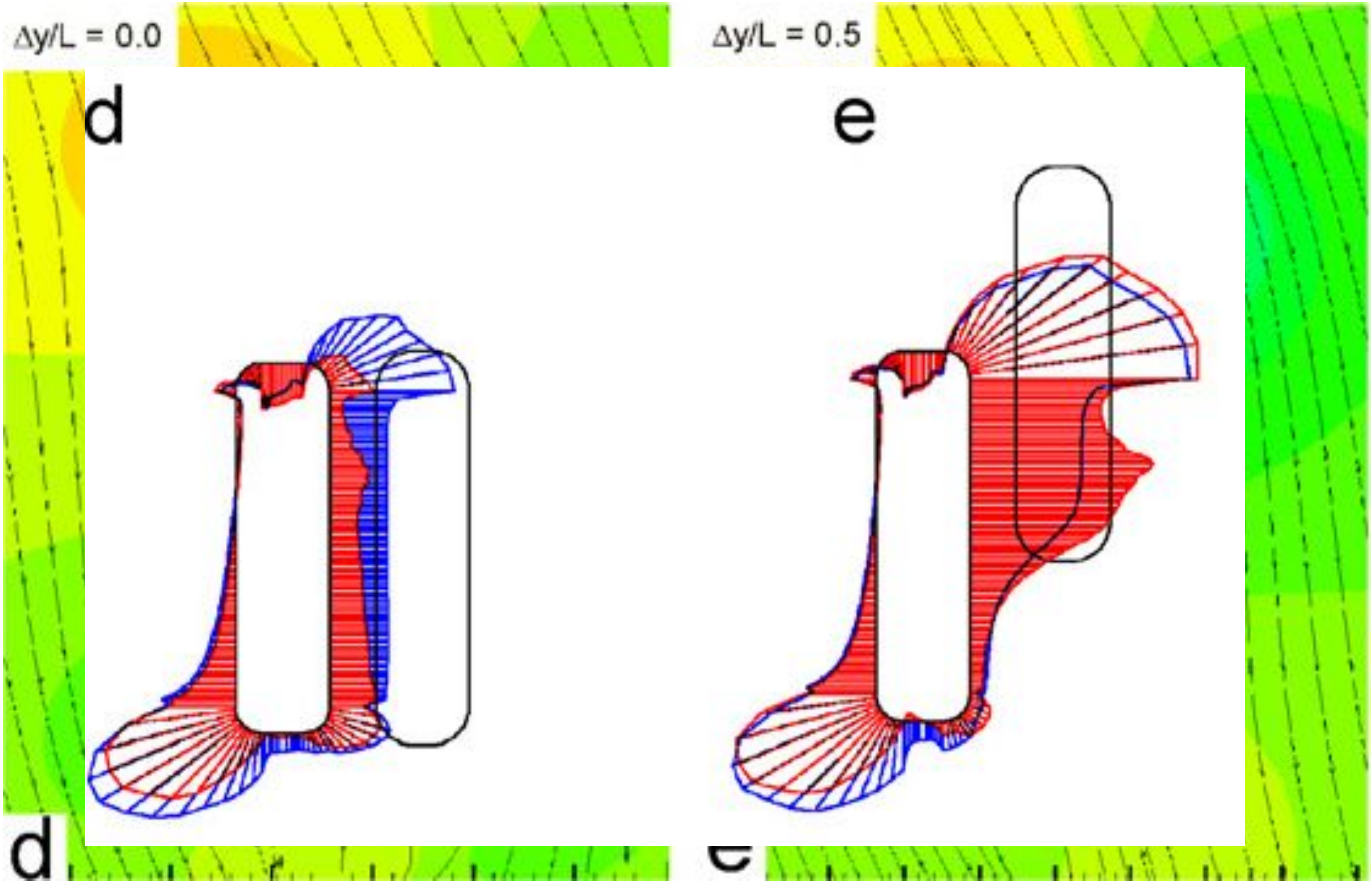
C_d = coefficient of drag ρ = air density ≈ 1.2 kg/m^3
A = projected frontal area (m^2)
f(Re) = Reynolds number
v = vehicle velocity (m/sec)
V_0 = head wind velocity

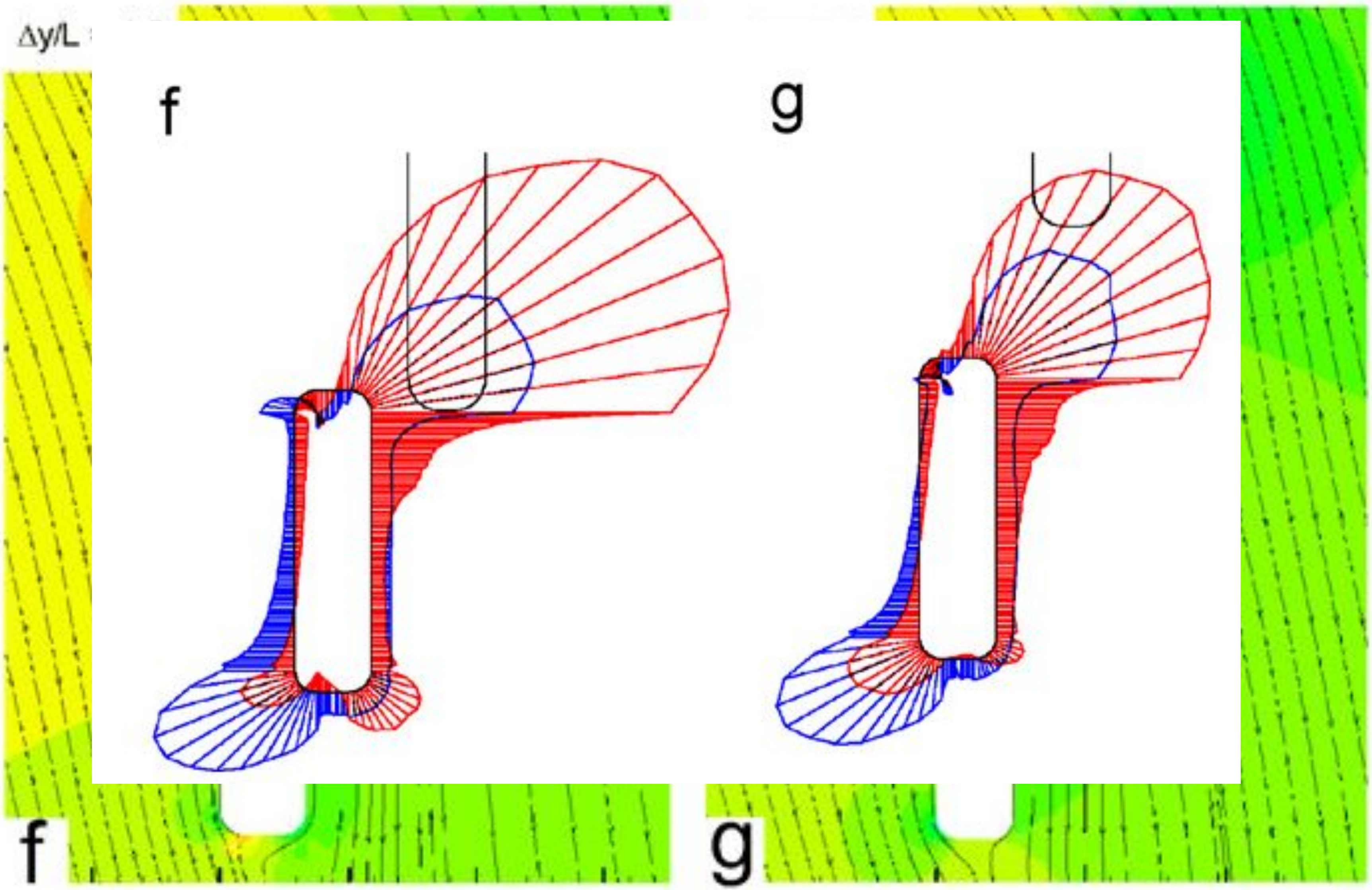


$$P_{aero} = \frac{1}{2}(1.2)\, C_d\, A\, V(V + V_0)^2$$

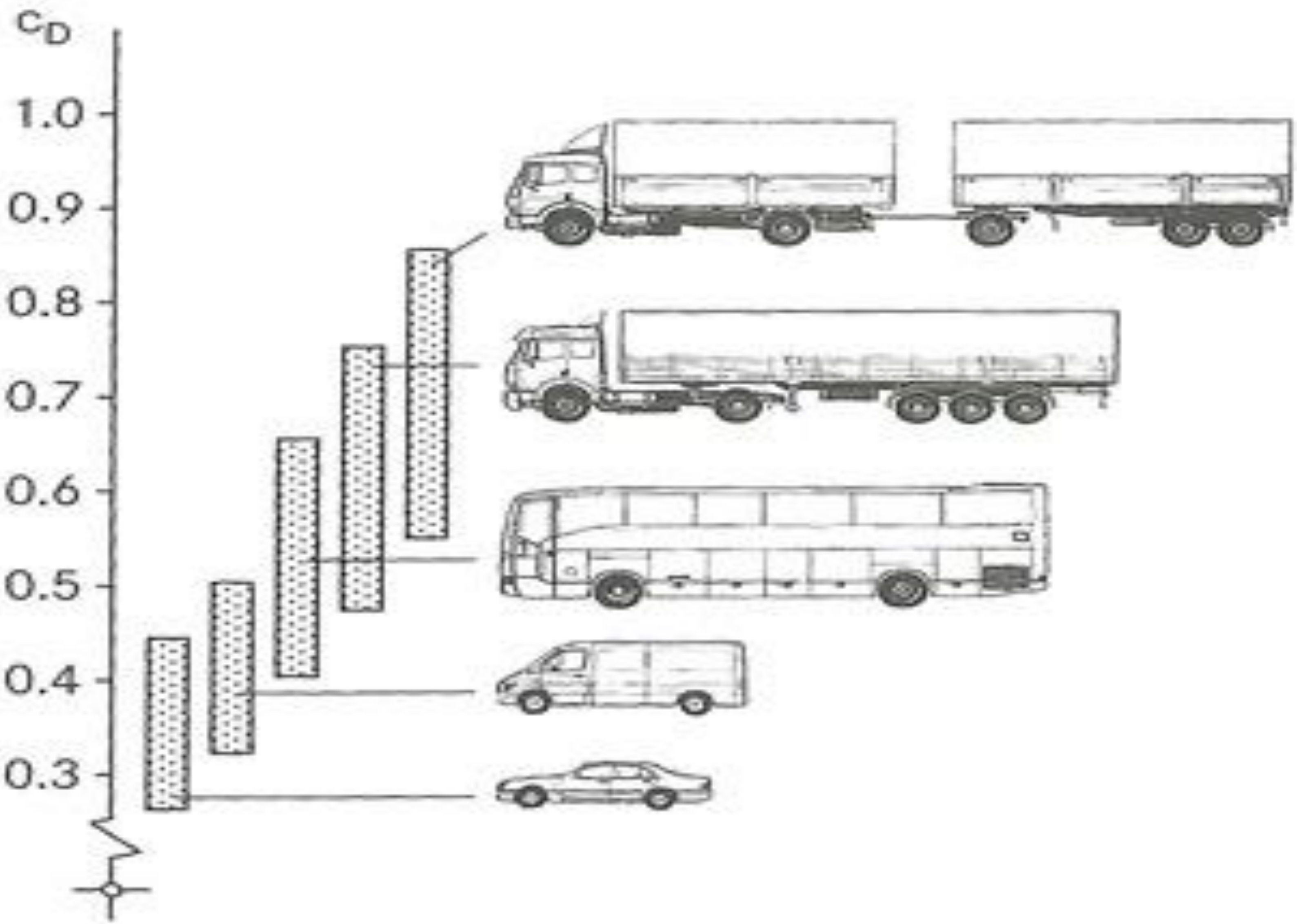
Aerodynamic Drag on An Accelerating Vehicles



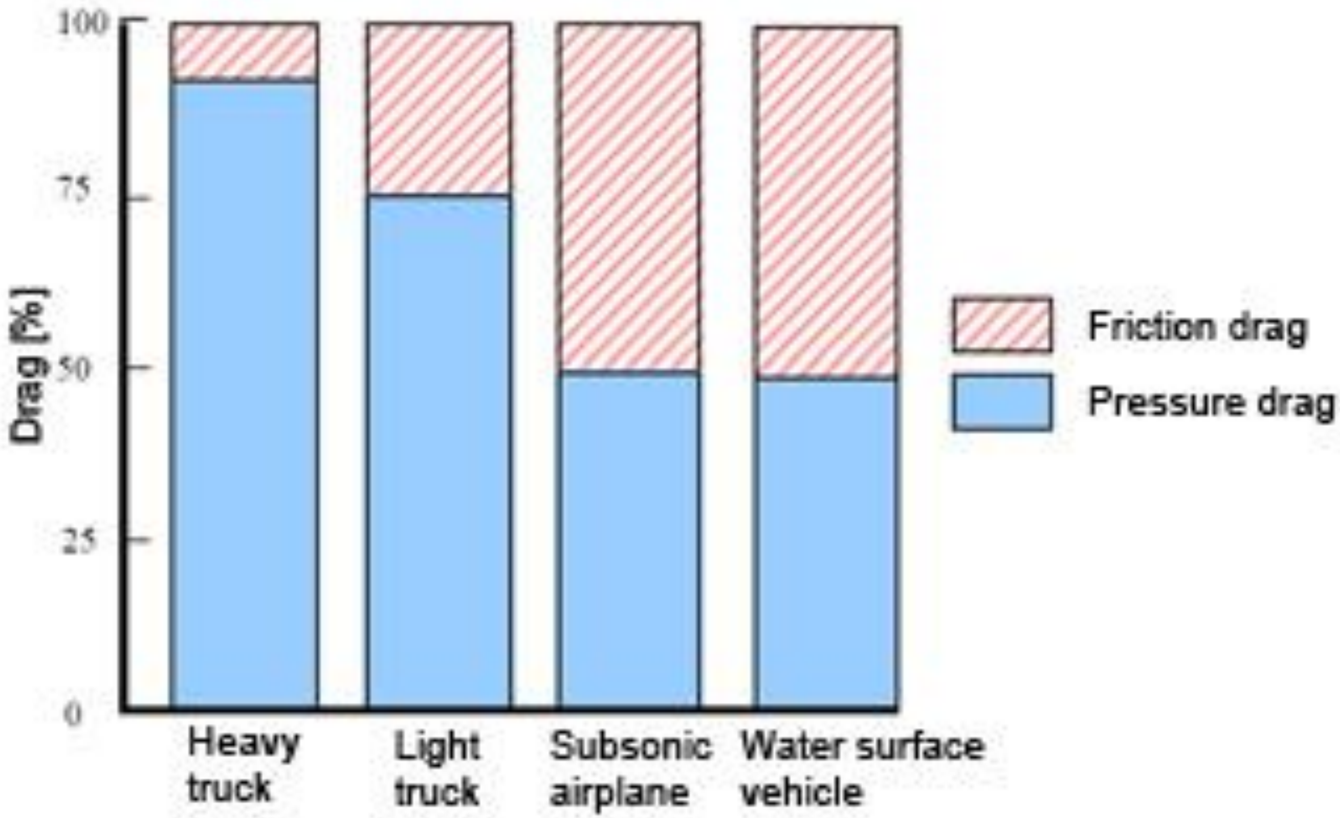

Δy/L = 0.0
Δy/L = 0.5
d
e
d
e


Δy/L
f
g
f
g

Purpose, Shape & Drag



Shape & Components of Drag



Some examples of $\mathbf{C_d}$:

- The typical modern automobile achieves a drag coefficient of between 0.30 and 0.35.
- SUVs, with their flatter shapes, typically achieve a C_d of 0.35–0.45.
- Notably, certain cars can achieve figures of 0.25-0.30, although sometimes designers deliberately increase drag in order to reduce lift.
- 0.7 to 1.1 - typical values for a Formula 1 car (downforce settings change for each circuit)
- 0.7 - Caterham Seven
- at least 0.6 - a typical truck
- 0.57 - Hummer H2, 2003
- 0.51 - Citroën 2CV
- over 0.5 - Dodge Viper
- 0.44 - Toyota Truck, 1990-1995

- 0.42 - Lamborghini Countach, 1974
- 0.42 - Triumph Spitfire Mk IV, 1971-1980
- 0.42 - Plymouth Duster, 1994
- 0.39 - Dodge Durango, 2004
- 0.39 - Triumph Spitfire, 1964-1970
- 0.38 - Volkswagen Beetle
- 0.38 - Mazda Miata, 1989
- 0.374 - Ford Capri Mk III, 1978-1986
- 0.372 - Ferrari F50, 1996
- 0.36 - Eagle Talon, mid-1990s
- 0.36 - Citroën DS, 1955
- 0.36 - Ferrari Testarossa, 1986
- 0.36 - Opel GT, 1969
- 0.36 - Honda Civic, 2001
- 0.36 - Citroën CX, 1974 (the car was named after the term for drag coefficient)
- 0.355 - NSU Ro 80, 1967

- 0.34 - Ford Sierra, 1982
- 0.34 - Ferrari F40, 1987
- 0.34 - Chevrolet Caprice, 1994-1996
- 0.34 - Chevrolet Corvette Z06, 2006
- 0.338 - Chevrolet Camaro, 1995
- 0.33 - Dodge Charger, 2006
- 0.33 - Audi A3, 2006
- 0.33 - Subaru Impreza WRX STi, 2004
- 0.33 - Mazda RX-7 FC3C, 1987-91
- 0.33 - Citroen SM, 1970
- 0.32064 - Volkswagen GTI Mk V, 2006 (0.3216 with ground effects)
- 0.32 - Toyota Celica,1995-2005
- 0.31 - Citroën AX, 1986
- 0.31 - Citroën GS, 1970
- 0.31 - Eagle Vision
- 0.31 - Ford Falcon, 1995-1998
- 0.31 - Mazda RX-7 FC3S, 1986-91
- 0.31 - Renault 25, 1984
- 0.31 - Saab Sonett III, 1970
- 0.30 - Audi 100, 1983
- 0.30 - BMW E90, 2006
- 0.30 - Porsche 996, 1997
- 0.30 - Saab 92, 1947

- 0.195 - General Motors EV1, 1996
- 0.19 - Alfa Romeo BAT Concept, 1953
- 0.19 - Dodge Intrepid ESX Concept , 1995
- 0.19 - Mercedes-Benz "Bionic Car" Concept, 2005 ([2] mercedes_bionic.htm) (based on the boxfish)
- 0.16 - Daihatsu UFEIII Concept, 2005
- 0.16 - General Motors Precept Concept, 2000
- 0.14 - Fiat Turbina Concept, 1954
- 0.137 - Ford Probe V prototype, 1985