## Ex. 1 Power system of a vehicle

The total power, *P*, needed from a vehicle's power system must be sufficient to compensate for *aerodynamic drag*, *rolling resistance*, *changes in elevation*, and to provide for *vehicle acceleration* and *auxiliary power* for vehicle accessories.

The power system may consist of a fuel cell plus peak power storage device(s). Criteria established by the Partnership for a New Generation of Vehicles (PNGV) specify that:

a) The fuel cell system (without peak power device) must provide enough power to sustain a speed $v = 55$ mph on a road inclined with 6.5 percent grade.

b) The output of the fuel cell system plus peak power device must allow acceleration for high speed passing of $a = 3$ mph/s on a level road from $v = 65$ mph.

1. Schematize the external forces acting on the vehicle.
2. Write a general expression for the total power necessary to drive the vehicle.
3. Estimate the minimum power needed to satisfy each of the two criteria established by the PNGV for a conventional mid-size passenger vehicle.

*Thinking further:*

- How to estimate the range of the vehicle, resp. dimension the energy storage?
- The solution to this problem can also be applied to ex. 1 of series 4.

*Useful information:*

1 mph = 1.609 km/h = 0.447 m/s
Assume typical temperature and pressure for driving conditions.
The road's angle of inclination, $\alpha$, can be computed from the percent grade of its slope.

Solve the problem with the following hints, which can be assumed for the mid-size passenger vehicle:
Mass: $m = 1350\ \mathrm{kg}$ (vehicle mass) $+ 250\ \mathrm{kg}$ (mass of passengers plus cargo) $= 1600\ \mathrm{kg}$
Coefficient of aerodynamic drag: $C_\mathrm{d} = 0.3$
Area of the vehicle normal to flow direction: $A_\perp = 2\ \mathrm{m}^2$
Coefficient of rolling resistance: $C_\mathrm{r} = 0.01$
Efficiency of motor, controller, and gearing: $\varepsilon = 0.77$
Auxiliary power (lights, radio, wipers, air conditioner, cigarette lighter, etc.): $P_\mathrm{aux} = 400\ \mathrm{W}$