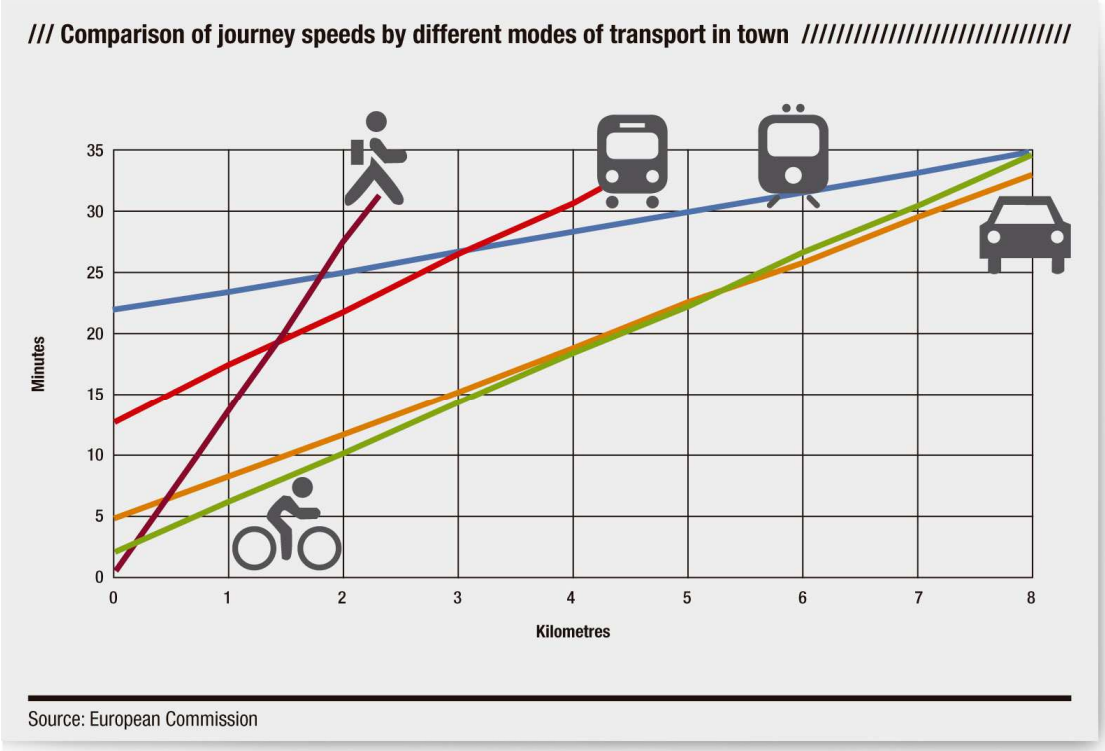
Part II (10 points)

Problem 1 (5 point)



a) Your destination is 2 km ahead. Calculate the average speed (km/h) per each of the five modes of transportation according to the figure data, and what would be more adequate in terms of time spent and fewer emissions. (1 point)
b) Estimate the final energy per pkm for each motorized mode. (1 point)
c) Estimate the well-to-whells (WtW) emissions of the train in g/km, knowing that it consumes (final energy) 12 kWh/km and is fed by average European electricity mix. (1 point)
d) Estimate the GHG emissions for bus and car, assuming fuel C_7H_{14}, LHV 40 MJ/kg, density 0.8 kg/L, 50 L/100km and 7 L/100km (1 point)
e) Decide which motorized road transport mode is faster and, simultaneously, emits low levels of GHG emissions (two objectives to minimize) to move 2 km in commuting trips. (1 point)

Problem 2 (5 point)

Ozone (O_3) formed during the day has as precursors NO and HC emissions. Estimate for a fleet of 100 Euro 4 gasoline cars, according to Tier 3 methodology, hot emissions, average speed 30 km/h and 15 000 km/year:

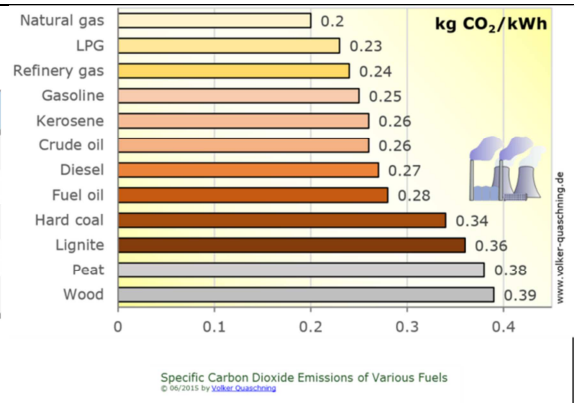
a) Yearly HC emisisons; (1.5 point)
b) Yearly NO emisisons; (1.5 point)
c) Yearly O_3 emissions. (2 point)

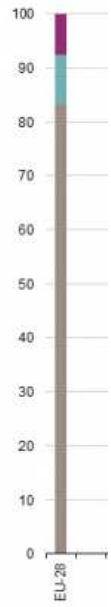
Assume that O_3 formation could be represented by,

$$C_8H_{17} + NO + 2O + 2O_2 \Rightarrow C_8H_{15}O + H_2O + O_3 + NO_2$$

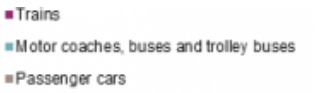
Information: Table 1. European average electricity mix, typical g/kWh factors. Transmission losses (9% of the output). Pkm in % by mode and final energy by mode.

EU-27 Energy Mix (2011)	
Oil	35%
Gas	24%
Coal and other solid fuels	17%
Nuclear	14%
Renewables	10%

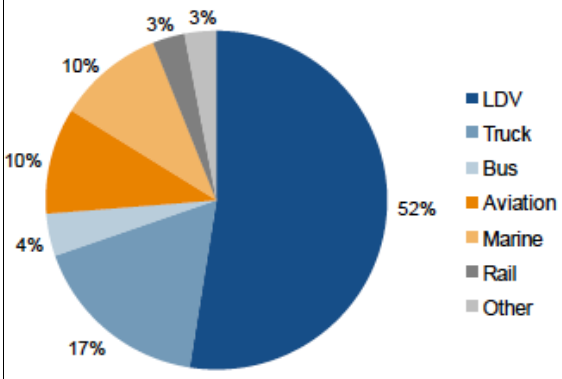




Overall 5.19 *10^6 million passenger-kilometers



Overall 2200 Mtoe (1 toe= 41.9 GJ)



EF (g/km)= (a + c × V + e × V²)/(1 + b × V + d × V²)

Pollutant	Emission Standard	Engine capacity	Speed Range (km/h)	R^2	a	b	c	d	e
CO	Euro 1	All capacities	10-130	0.87	1.12E+01	1.29E-01	-1.02E-01	-9.47E-04	6.77E-04
	Euro 2	All capacities	10-130	0.97	6.05E+01	3.50E+00	1.52E-01	-2.52E-02	-1.68E-04
	Euro 3	All capacities	10-130	0.97	7.17E+01	3.54E+01	1.14E+01	-2.48E-01	
	Euro 4	All capacities	10-130	0.93	1.36E-01	-1.41E-02	-8.91E-04	4.99E-05	
HC	Euro 1	All capacities	10-130	0.82	1.35E+00	1.78E-01	-6.77E-03	-1.27E-03	
	Euro 2	All capacities	10-130	0.95	4.11E+06	1.66E+06	-1.45E+04	-1.03E+04	
	Euro 3	All capacities	10-130	0.88	5.57E-02	3.65E-02	-1.10E-03	-1.88E-04	1.25E-05
	Euro 4	All capacities	10-130	0.10	1.18E-02		-3.47E-05		8.84E-07
NO_x	Euro 1	All capacities	10-130	0.86	5.25E-01		-1.00E-02		9.36E-05
	Euro 2	All capacities	10-130	0.52	2.84E-01	-2.34E-02	-8.69E-03	4.43E-04	1.14E-04
	Euro 3	All capacities	10-130	0.80	9.29E-02	-1.22E-02	-1.49E-03	3.97E-05	6.53E-06
	Euro 4	All capacities	10-130	0.71	1.06E-01		-1.58E-03		7.10E-06