SAMPLE ASSIGNMENT

Here are examples of swimming speeds and size for a variety of organisms, from bacteria to whales[1]. What is the relation between speed and size? What are the physical constraints that result in such an apparent strong correlation between speed *versus* size?

Swimming speed and length in animals.

Species	Length	Swimming Speed (cm/sec)	Reference
1. *Bacillus subtilus*	2.5 μm	1.5×10^{-3}	*Tabulae Biologicae*
2. *Spirillum volutans*	13.0 μm	1.1×10^{-2}	idem
3. *Euglena* sp.	38.0 μm	2.3×10^{-2}	idem
4. *Paramecium* sp.	220.0 μm	1.0×10^{-1}	idem
5. *Unionicola ypsilophorus* (water mite)	1.3 mm	4.0×10^{-1}	Welsh (1932, *J. Gen. Physiol.* 16:349)
6. *Pleuronectes platessa* (plaice, larval)	7.6 mm	6.4	Boyar (1961, *Trans. Amer. Fish. Soc.* 90:21)
7. *P. platessa*	9.5 mm	11.5	idem
8. *Carassius auratus* (goldfish)	7.0 mm	75	Bainbridge (1961, *Symp. Zool. Soc. London* 5:13)
9. *Leuciscus leuciscus* (European dace)	10.0 cm	130	idem
10. *L. leuciscus*	15.0 cm	175	idem
11. *L. leuciscus*	20.0 cm	220	idem
12. *Pomolobus pseudo harengus (river herring)*	30.0 cm	440	Dow (1962, *J. Conseil Internat. Explor. Mer* 27:77)
13. *Pygoscelis adeliae* (Adélie penguin)	75.0 cm	380	Meinertzhagen (1955, *Ibis* 97:81)
14. *Thunnus albacares* (yellowfin tuna)	98.0 cm	2,080	Walters and Firestone (1964, *Nature* 202:208)
15. *Acanthocybium solanderi* (wahoo)	1.1 m	2,150	idem
16. *Delphinus delphis* (common dolphin)	2.2 m	1,030	Hill (1950, *Sci. Prog.* 38:209)
17. *Sibbaldus musculus* (blue whale)	26.0 m	1,030	idem

Hints:

The drag coefficient (C_d) and its relation to the Reynolds number (Re) may give some insight into the effect of size on speed. At what size does turbulent flow dominate (Re > 1)?

The viscosity (η) of water is $1.787 \bullet 10^{-3}$ poise at 0ºC, $1.002 \bullet 10^{-3}$ poise at 20ºC, $0.653 \bullet 10^{-3}$ poise at 40ºC. A poise has units of Pa sec; Pascal (Pa) has units of N m^{-2}; Newton (N) has units of kg m sec^{-1}. The kinematic viscosity (υ) of water is $1.787 \bullet 10^{-6}$ m^2 sec^{-1} at 0ºC, $1.004 \bullet 10^{-6}$ m^2 sec^{-1} at 20ºC, $0.658 \bullet 10^{-6}$ m^2 sec^{-1} at 40ºC. The kinematic viscosity is the viscosity divided by the density ($\upsilon = \eta/\rho$) (m^2 sec^{-1} = N m^{-2} / kg m^{-3}).

[1] McMahon TA and JT Bonner (1983) On Size and Life. Scientific American. pp. 152