

Suggestion for a Non-Quiz Assessment Tool

Students are encouraged to investigate further in each activity.

- Activity 1 – the rate of emptying of different fluids such as honey or water.
- Activity 2 – the rate of emptying as a function of tilt angle, or the limiting case while the pipe is very short.
- *Activity 3, 4 – the relationship between body mass and time to urinate

* We will find that urination time is not actually constant, but varies very slowly with body mass. So that over the range of animals in nature, it just appears constant.

We write the length, diameter of the urethra and volume as a function of body mass. This permits us to compare

$$L = aM^{0.3}$$

$$D = bM^{0.3}$$

$$V = cM$$

Using these variables, we can now estimate the time to urinate in terms of body mass.

$$\text{cross-section of urethra} \quad A = \frac{1}{4} \pi D^2 \sim M^{2/3}$$

$$\text{velocity of urine} \quad u = \sqrt{2gL} \sim M^{1/6}$$

$$\text{flowrate} \quad Q = uA \sim M^{5/6}$$

$$\text{bladder volume} \quad V \sim M$$

Conclusion:

$$\text{Time for urinating} \quad T = V/Q \sim M^{1/6}$$