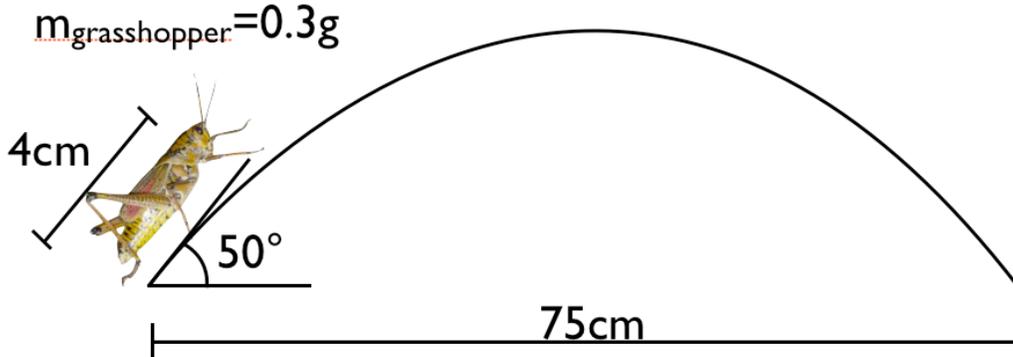


2013 OAPT Conference: Biophysics in the Classroom

Grasshoppers:

Question: A grasshopper of mass 0.3g has hind legs that extend 4cm during takeoff at an angle of $\theta=50^\circ$ to the horizontal. The total distance of the jump is 75cm. What power does the grasshopper exert during the jump?



Solution (answer: $P=0.78\text{W}$):

Comparing grasshoppers to humans: How much power does Mike, the 100kg human, exert while competing in the long jump competition? Mike's legs extend 0.5m during the jump at an angle of 35° and he is able to jump a horizontal distance of 4m. (answer: $P=1.3 \times 10^4\text{W}$)

Geckos:

Questions:

- 1) How much force/ mm^2 does it take for a 55g gecko to hang upside down if each foot is 115mm^2 ? (answer: $1.2 \times 10^{-3}\text{N}/\text{mm}^2$)
 - 2) Each gecko foot contains setae ($14\,400$ setae/ mm^2). Each setae can withstand up to $200\mu\text{N}$. What is the minimum surface contact that a gecko must have to hang upside-down? (answer: 0.19mm^2)
 - 3) If all four feet are in full contact how much mass could a gecko theoretically hold? (answer: 130kg)
- Source: W. R. Hansen and K. Autumn. Evidence for self-cleaning in gecko setae. *PNAS*, 102 (2005).

Diffusion qualitative experiment:

Observe the difference in how food colouring diffuses in cold vs. hot water.

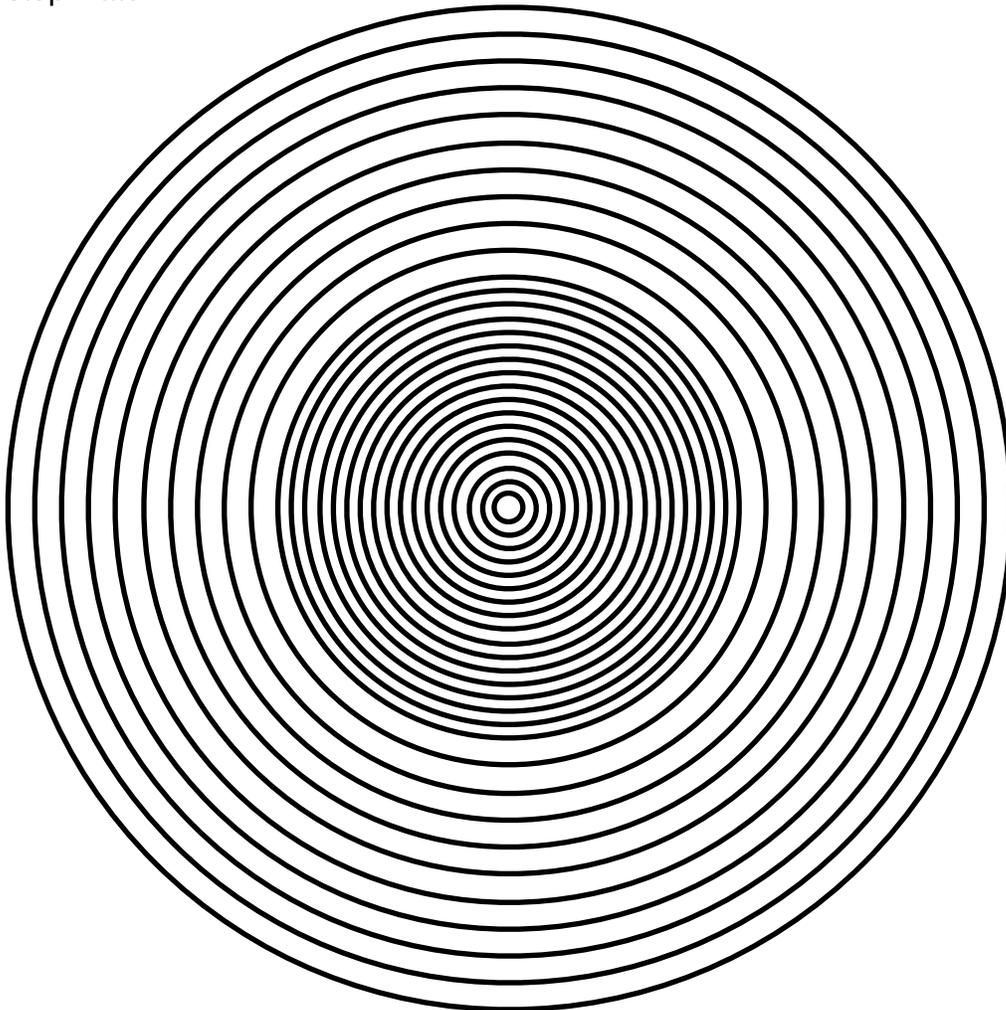
Equating the kinetic energy (equipartition) we see that velocity of the particles scales with the temperature:

$$Ek = \frac{1}{2}mv^2 \propto kT \rightarrow \langle v^2 \rangle \propto kT/m$$

Diffusion quantitative experiment:

Measure the radius as a function of time (2D). Dye molecules perform random walk, $r \propto \sqrt{t}$. Students can test the random walk scaling using a coin on a 1D axis - one step right for heads and one step left for tails. After x flips the square root of the average squared distance from the origin (root mean squared) will be \sqrt{x} . Each step is equivalent to one time step.

Equipment: clear petrie dish or pyrex container, food colouring, paper to measure radius (see below), stop watch.



small rings: 1.8 mm apart
large rings: 3.6 mm apart