PHYS 1901 Physics Advanced
Tutorial 3: Mechanics

A. Qualitative Questions:

1. You throw a ball vertically into the air and catch it when it returns. Answer parts **a** and **b** first ignoring air resistance, and then taking it into account.

a. What happens to the ball's kinetic energy during the flight?

b. What happens to the total energy?

c. What happens to the energy of the ball as you catch it and it comes to rest?

d. Why is it easier, and less painful, to catch a ball while moving your hands backwards?

2. Rebecca and Brent are on safari, and have taken a boat out on a lake to do some fishing. They're well prepared, with plenty of fishing gear, lunch, raincoats and warm jumpers. They throw in a line and see a host of little fish descend upon the bait and guzzle it and the line. Brent pokes the paddle at them to see what they do, and they eat that too. At this point Rebecca recognises the fish as piranhas, and also the problem that they are now in the middle of the lake, with no paddle, and surrounded by piranhas. She suggests that Brent walk on the boat away from the shore, and because of conservation of momentum this will make the boat go towards the shore.

a. Will this get them to shore?

b. What should they do to get back to shore?

B. Demonstration Questions:

1. *Bouncing balls*

Hold the little ball atop the big ball and drop them together. Explain what you observe.

Does the same thing happen if you drop them with the big ball atop the little one?

2. *Newton's cradle*

Explain the difference between the two types (one with steel balls and one with lead balls) of apparatus on display.

Can you explain the behaviour of the balls with only energy conservation or do you need conservation of momentum as well?

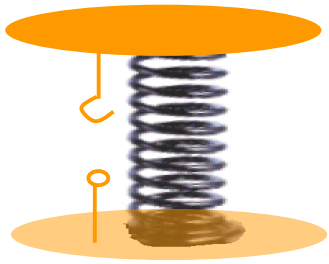
C. Quantitative Questions:

1. *Jumping jack*

A jumping jack, a non-battery operated child's toy, consists of two equal masses, m, joined by a spring with spring constant k and relaxed length l. When the toy is laid horizontally the spring is compressed to a length l-d, and a latch holds the two masses close together. The toy is then rotated to sit vertically on a table and the catch is released.

a. What is the minimum value of d which will result in the upper mass to rise when the catch is released?

b. What is the minimum value of d for the lower mass to lift off the table when the catch is released?



2. *Voyager 2*

Voyager 2 was one of a pair of spacecraft launched to explore the planets of the outer solar system and the interplanetary environment. Voyager 2 lifted off in August 1977, and flew by Jupiter (closest approach July 1979), Saturn (August 1981), Uranus (January 1986), and Neptune (August 1989). Voyager is still speeding away from the Sun and sending back data, taking measurements of the interplanetary magnetic field, plasma, and charged particle environments.

Voyager 2 utilized a slingshot manoeuver as it approached Jupiter to then move off in the opposite direction on its way to Saturn. A sling shot manoeuver can be modelled as an elastic collision. Voyager 2 approached Jupiter with a velocity of 12 km.s^{-1} (relative to the Sun). The orbital speed of Jupiter around the Sun is 13 km.s^{-1}.

a. What was Voyager 2's speed after the slingshot encounter, relative to both Jupiter and the Sun?

b. What assumptions did you need to make to calculate this speed?