Physics 100 HW 4 (Due 1/7/07) Name S. Olsen

1. Suppose you jump vertically upward with an initial upward speed of 3 m/s. (You will reach a maximum height of about 0.5 m in 0.3 s.)

   a) What is your initial momentum? (i.e., your momentum just as you leave the ground.) momentum $= mV = 90\,kg \cdot 3\,m/s$

   $= 270\ kg\,\frac{m}{s}$

   b) This momentum is balanced by the earth, which recoils in the opposite direction. Just when you leave the ground, how fast does the earth move? ($M_{earth} = 6 \times 10^{24}$ kg.) $M_e V_e = -270\ kg\ m/s \Rightarrow V_e = \frac{-270\ kg\ m/s}{6 \times 10^{24}\ kg}$

   $V_e = 4.5 \times 10^{-23}\ m/s$

   c) After 0.3 s, the gravitational force that you exert on the earth will stop its motion, and it will fall back to you. How far has the earth moved during the 0.3 s it moves away from you? (Remember that the average speed of the earth during the time it moves away from you is *half* of its initial speed.)

   $dist = v_{avg}\,t = \frac{V_E}{2} \times 0.3\,s = \frac{4.5 \times 10^{-23}}{2}\,m/s \times 0.3\,s$

   $= 6.8 \times 10^{-24}\ m$

2. Suppose that everyone of the 1.2 billion people in China gathered in one spot and jumped up, all at exactly the same time, and all with an initial upward speed of 3 m/s. (Assume everyone's mass is the same as yours.)

   a) How fast would the earth recoil? 1.2 billion times faster

   $V_E = 1.2 \times 10^{9} \cdot 4.5 \times 10^{-23}\ m/s = 5.4 \times 10^{-14}\ m/s$

   b) How far would it move? 1.2 billion times further

   $dist = 1.2 \times 10^{9} \times 6.8 \times 10^{-24}\ m = 8.5 \times 10^{-15}\ m$

3. When Newton wrote down his three law's of motion, he implicitly assumed that they were equally valid at all times in the past and all times in the future.

   What symmetry does this correspond to?

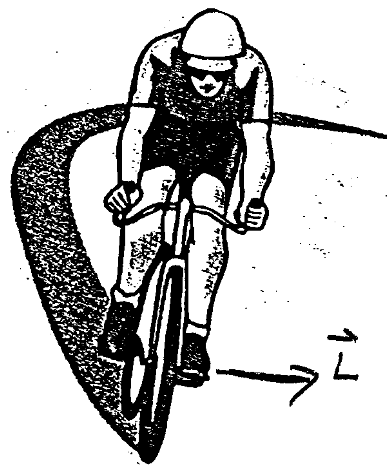
   Time translation symmetry

   What conservation law does this imply?

   Conservation of Energy

4. What is the direction of the angular momentum vector of the wheels of a bicycle when it is rolling forward?

Horizontally towards the left

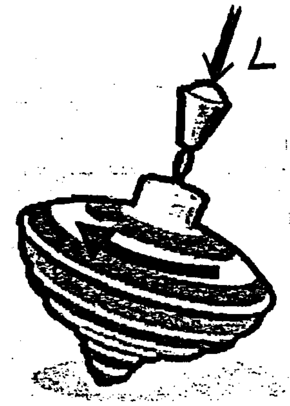


5. Why is it easier to balance on a bicycle when it is moving than when it is stopped?

Conservation of angular momentum keeps the axles of the bicycle wheels horizontal

6. Indicate the direction of the angular momentum vector on the top shown in the figure on the right. Which way will it precess? ...out of the page? ... into the page?...

Torque is into the page
⇒ top will precess out of the page

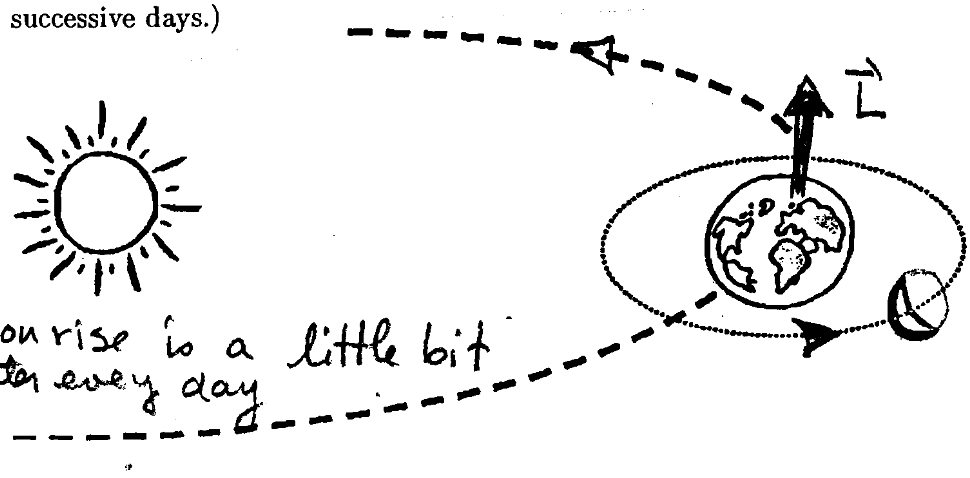


7. In reference to the figure at the bottom of the page:

a) Indicate on the figure the direction that the Earth is spinning and indicate the direction of its angular momentum vector. (Here you'll need to remember that sunrise is in the east.)

b) The angular momentum associated with the earth's (daily) rotation, its (yearly) orbit around the sun, and the moon's (28 day) orbit around the earth are all in (very nearly) the same direction. Indicate with arrows the direction of the earth's and moon's orbital motion on the figure below.

c) From this, figure out how the time of moonrise (or moonset) changes on successive days (i.e. is it earlier or later)? (Check your result by observing the sky on successive days.)



Moonrise is a little bit later every day