Physics of Sports

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Assignment 2

Assigned date: January 22nd, 2018. Due date: January 29th, 2018

Your name: _____

(All problems taken from Lisa, Michael. *The Physics of Sports*. McGraw-Hill Higher Education, 2015)

1. According to Wikipedia, the mass of Mark Cavendish plus his bike is 79 kg. For moderate lengths of time, he can do useful work on a bike at 250 W. Ignoring air drag and rolling friction, how long will it take him to ride 2 mi (3218 m) up the hill shown in the figure? Assume he rides at a fixed speed.

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2. When a bat hits a ball, it can do work on the ball. Consider these three cases: (1) A 100 ft/s pitch is batted back at 100 ft/s. (2) An 80 ft/s pitch is batted back at 100 ft/s. (3) A ball is batted off the tee (that is, the ball is initially stationary) at 100 ft/s.

   (a) In which case did the bat do the most work?

   (b) In which case did the bat do the least work?

   (c) Do your answers make sense? Why or why not?

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3. Before the rise of cable television, ABC's Wide World of Sports was the place to watch sports. The show opened with the now familiar catchphrase "the thrill of victory and the agony of defeat," while film clips appeared on the screen. The clips used for the thrill of victory varied over time, but for decades, "the agony of defeat" line was spoken over a famous clip of a spectacular wipeout of Yugoslavian ski jumper Vinko Bogataj. During terrible weather at a ski-flying world championship in Oberstdorf, West Germany, Bogataj tried to adjust for bad conditions midway down the ramp but completely lost control and tumbled wildly off the side at its bottom into a scattering crowd. A video search for "agony of defeat" on the Internet will instantly bring up the clip.

(a) The 82-kg Bogataj left the ramp about 45 m lower than his starting position. (That is, the difference in elevation was 45 m.) If you ignore the slowing forces of kinetic friction and wind drag, what was his kinetic energy at that point?

(b) What was his speed at that point?

(c) If Bogataj has simply fallen straight down 45 m rather than skiing down a ramp, what would be his kinetic energy?

(d) After hitting the ground, Bogataj crashed wildly and descended down the hill another 20 vertical meters before coming to rest. Here friction cannot be ignored! How much total work was done on Bogataj to bring him to rest?

(e) In part (a) you were told to ignore friction and air, but based on your knowl- edge of friction (from chapter 3) and drag (chapter 5), which one would be more important to account for?

4. In this problem, we assume that diving boards obey Hooke's law, which is only approximately true.

In diving from a springboard, timing and the direction of the force from the board are crucial. Too much board deflection, and the diver is thrown too much forward. Too fast or slow of a board oscillation, and the diver's timing is thrown off and he wastes energy. Using a roller to set the fulcrum of the board, divers can adjust the board's springiness and deflection. Moving the fulcrum toward the diving end produces a stiffer board. The optimal board setting depends on the diver's weight and technique.

According to The Guardian newspaper, the average mass of a diver at the 2012 Olympics in London was 59.8 kg. The lightest in the Games was China's 16-year-old Yadan Hu, weighing in at a mere 36 kg (79 lb). While her main event is the 10-m platform dive, she also competes in the 3-m springboard.

When she jumps 0.9 m in the air and lands on the end of the springboard, it deflects downward about 0.7 m and returns to horizontal in 300 ms. These are typical values for a well-tuned board.

(a) What is Hooke's constant of the board?

(b) Divers sometimes just stand on the end of the board before a competition, to get a feeling for Hooke's constant. If she simply stood on the end of the board (without having jumped), how far would it deflect?

If she had jumped higher (say, 1.2 m) before landing on the board, would it have taken more, less, or the same amount of time to return to horizontal?

(d) Is she at equilibrium when the board is maximally deflected after she lands on it?

(e) The heaviest diver at that Olympics wasGermany's Stephan Feck,at 79kg. If he also landed on the same board after an initial approach jump 0.9 m high, would the board's force point more forward or less forward than it did with Hu? (There is no need for numbers here.)

(f) How long will it take for the board to return to horizontal?

(g) To properly tune the board's timing for his body mass, should he increase or decrease Hooke's constant?

(h) Does properly tuning Hooke's constant affect the resulting direction of the force of the board on Feck? How?

(i) Besides the mass and approach-jump height, what other factors affect the down- ward deflection and timing of the board?