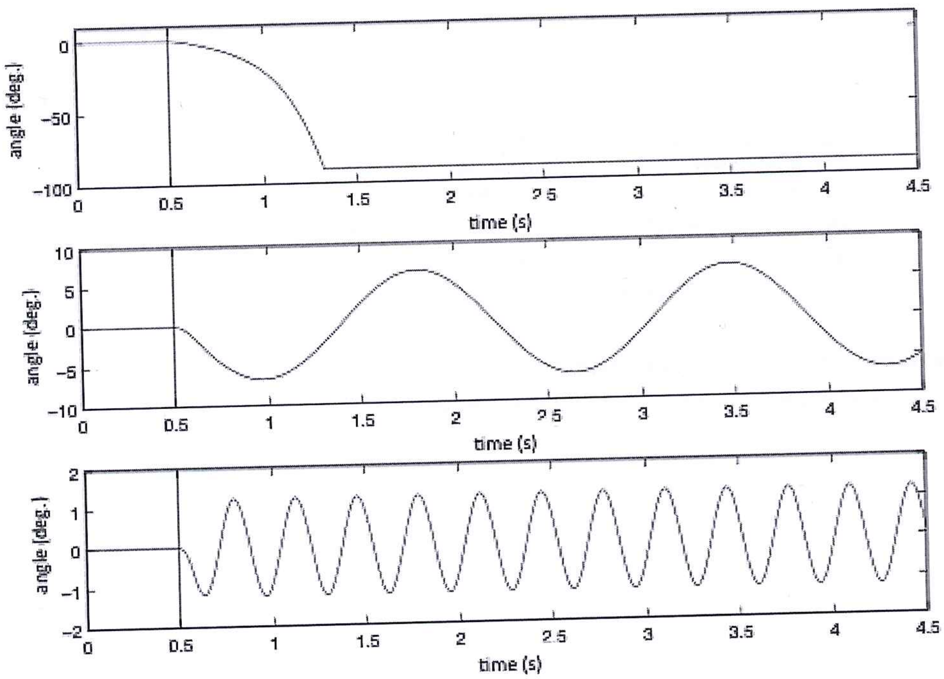
Biophysical Concepts in HMS
Wednesday 10/12/2012, 8.45-11.45
4 questions; all question are equally weighted; for weighting of sub-questions, see indications between brackets
Please, answer questions 3 and 4 on a separate sheet. Don't forget to write your name and student number on both sheets.

1) Three systems, each consisting of an inverted pendulum supported by a spring, are exposed to a short-lasting external perturbation (a very brief negative moment with a peak of -0.1 Nm applied at t=0.5s). The three pendulums have the same mass and length.
   a) Explain the response in the top two panels in terms of the stability of these systems. (3 points)
   b) What is the difference between the two systems, represented in the lower two panels? (1 points)
   c) Which features of the responses did you use to answer question b? (2 points)

The inverted pendulum supported by a spring can be used as a model for a segment and some of the structures that stabilize the segment's orientation in the human musculoskeletal system.
   d) Describe how "biological springs" can change the response of a segment to a perturbation from a response as illustrated in the middle panel to a response as illustrated in the lower panel. (3 points)
   e) What happens to the response in the middle panel when the mass of the pendulum is increased; does it tend towards the response in the top or bottom panel? Motivate your answer. (3 points)

The resistance that a spring offers is a function of its length and hence of the orientation of the pendulum.
   f) What type of element must be added to the systems in the lower two panels, to make sure that the oscillations disappear? What is the resistance that this element produces a function of? (2 points)



2) Patients with knee osteoarthritis often have problems with controlling knee joint movement, which results in buckling, i.e. sudden yielding of the knee during weight acceptance on the affected leg, during gait.
   a) Explain, based on the theory on control of joint movement, why a reduced knee joint stiffness, or in other words high knee joint laxity, and muscle strength have an interaction effect on gait performance in knee osteoarthritis patients (6 points)
   b) Explain, based on the theory on control of joint movement, why poor knee proprioception and muscle strength have an interaction effect on gait performance in knee osteoarthritis patients (6 points)

Postural sway, expressed as the standard deviation of the center of pressure in the antero-posterior direction, is tested in a group of knee osteoarthritis patients. When patients are standing on their affected leg, their sway is significantly larger than when they are standing on their non-affected leg. Vibration on the knee extensor muscles during this test increases sway when standing on the unaffected leg but has no significant effect when standing on the affected leg.

   c) Explain this finding (6 points).

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3) Heart rate recordings are often used to estimate exercise intensity. Although the current heart rate monitors are reliable, there are also some problems using this method.
   a) Describe 3 commonly encountered problems with this method and explain how these problems make estimation of exercise intensity difficult or even invalid. (3 points)
   b) Discuss whether heart rate recordings can be used (and if so, how) to estimate exercise intensity in cardiac patients who use beta-blockers and in patients who had a cardiac transplantation. (4 points)
   c) A specific point of exercise intensity is the ventilatory threshold. Describe the 2 most common ways to determine this threshold and explain why the use of this ventilatory threshold as an indication of exercise intensity is questionable. (3 points)

4) According to Jones et al. (2010), the Critical Power (CP) concept constitutes a practical framework in which to explore mechanisms of fatigue and help resolve crucial questions regarding the plasticity of exercise performance and muscular systems physiology.
   a) Below is a schematic illustration of the power–time (P–t) relationship for high-intensity exercise illustrating the location of the Lactate Threshold relative to the CP for healthy, physically active young men. Describe how this relationship can be determined, what W' stands for, and explain why the LT is lower than the CP (4 points).

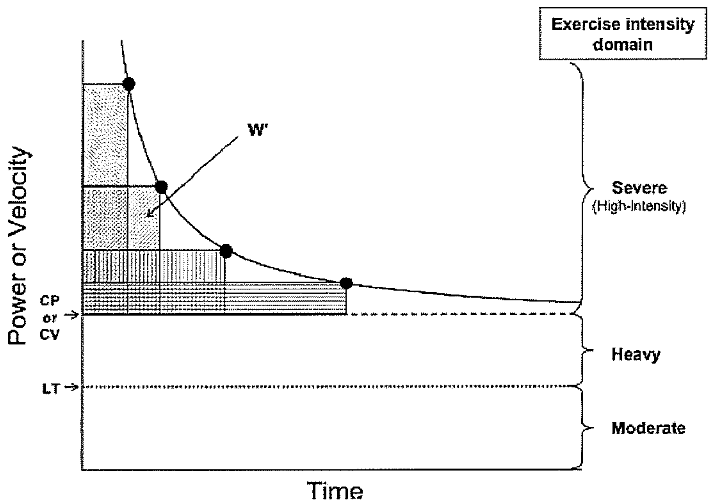

FIGURE 2—Schematic of the power–time (*P–t*) relationship for high-intensity exercise illustrating the location of the LT (synonymous with the GET) relative to CP for healthy, physically active young men.

   b) The CP model as described in Morton (2006) is based on several assumptions. One of the assumptions is "Exhaustion, and by implication termination of exercise, occurs when all of AWC (Anaerobic Work Capacity) have been utilised.". Discuss why this assumption is not fully correct (2 points)
   c) Walsh (2000) discussed the two primary mechanisms by which a muscle can increase its absolute CP. Describe these two physiological mechanisms. (4 points)