Running the first iteration of “Physics of the human body”

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Physics of the human body

(Phys 0410/0411) Honors 1-credit supplements to the first half of algebra-based introductory Physics sequence (Phys 0110/0111) that apply physics concepts to the human body and its interactions with the physical environment.

Students are expected to be equipped with basic algebra and geometry, and will learn other mathematical tools as needed. Phys 0110/Phys 0111 is a co-requisite. (Phys 0410 is not a prerequisite to Phys 0411)
Supplements topics

[PHYS0410]
The topics explored in this course include: human proportions, human motion, strength and balance, blood circulation, body temperature regulation.

[PHYS0411]
The topics explored in this course include: lungs and breathing, nervous and other electric stimuli, electrophysiology, human vision.
Course goals

“At the end of this course the successful student will be able to:”

• **Apply physics principles to the human body**
• Develop moderate competence in modeling
• Develop *(further)* problem solving skills
• Connect Physics with other *(life science)* domains
• Develop confidence to tackle *(human body)* problems
Course content (PHYS 0410)

Introduction; physical observables
Human dimensions; scaling
Human motion: range, analysis
Human motion: running, sprinting
Human motion: jumping
Friction in the human body, joints
Momentum: falling, punching
Torque: strength and balance
Oscillations: Walking
Elastic properties of the body
Blood circulation (basics)
Body temperature regulation
(Final Presentations)
Workflow (first run)

Pre-class primers ("food for thought")

In-class discussions, problems, examples

Suggested follow-ups (optional)
In-class activities

- Student answers to “Food for thought”
- Conceptual discussions
- Examples with interactive prompts
- (Worked) modeling activities
- Group problems *(with feedback)*
Food for thought

Newton's third law is summarized as: "For every action, there is an equal and opposite reaction." Most frequently, we apply this to contact forces between the parts of some mechanical system. You can apply this law virtually everywhere. *Come up with two examples of a physiological application of Newton's third law*, and we will discuss them in class.
Newton’s third law for humans

*List instances in which Newton’s third law applies to any part of the human body.*

Students answers (in random order):
- Jumping (legs pushing on ground)
- Running (legs pushing on ground)
- Walking (legs pushing on ground)
- Holding a weight in one’s hand
- Swimming (legs push against water)
- Breathing (diaphragm?)
Application: vertical jump

To jump vertically up from rest, a human begins in a crouching position (center of mass is lower than what it is in the standing position). Then, legs push the ground with a force that has to greater than the weight of the body.
Problem with scaffold

**Height of vertical jump**

Predict how high will be your jump if you have crouched for a distance $c$ (measured from standing position).

(a) What is the **acceleration** produced by the net force?
(b) How quickly do feet lose contact with the ground?
(c) What is your maximum height in the air?

Broccio - Physics of Human Body
Range of long jump

To jump forward *while running*, a human does a similar thing as what we saw for vertical jump, plus runs horizontally. What is a plausible range for a human long jump?
Keeping your balance in spite of a shove

Alan who weighs 690 N is standing with his feet close together. A lame prankster is about to push him at shoulder level (~1.5 m above ground). How large a push would be able to tip Alan away from his standing position?
Rigid bar model

Standing tiptoe on one foot

A dancer is standing tiptoe on one foot, which is a strenuous position. The Achilles tendon pulls on her heel. Let us model the foot as a rigid bar and also neglect the foot’s own weight among the forces acting on the foot.

(a) How large is Achilles tendon force $\vec{T}$ on the foot?
(b) How large is shin bone force $\vec{R}$ on the foot?
How tall can a human get?

Robert Wadlow 2.72 m tall

Giraffa camelopardalis 5.88 m tall
Second-last week, in-class survey

• *Compilation* of questions (?) taken from:
  • e-CLASS (*confidence* to solve problems related to human body using physics)
  • AAPS (attitudes and *approaches* to problem solving)
  • EBAPS (Epistemological *Beliefs* Assessment for Physical Science)