

# Locomotion

16-311: Introduction to Robotics

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## Learning Objectives

1. Reiterate the tradeoffs between various locomotion strategies.
2. Explore the inverted pendulum models for walking.

# 1 Wheels

1. Name two benefits of wheels as they pertain to robotics.
2. Name one drawback of wheels as they pertain to robotics.
3. You are building a robot to perform dance routines to entertain hospital patients. What method would you use to steer your vehicle and why? Skid steer? Ackerman? Synchrodrive? Articulated axles? Omni wheels? Mecanum wheels?
4. You are developing a vehicle for space. It has to be as light weight as possible and travel across sand-like terrain. Explain how many wheels and actuators you would use and in what configuration you would place them in? Explain your answer.

## 2 Legged locomotion

1. What are two advantages of legs for robots?
2. What is one disadvantage of legs for robots?
3. What is the main difference between walking and running?
4. Analyze the graph below. If the horse will automatically change to a different gait based on which is metabolically lower, at which about speed will the horse change from walk to trot and at which speed will the horse likely change from trot to gallop? Explain why you picked these speeds.

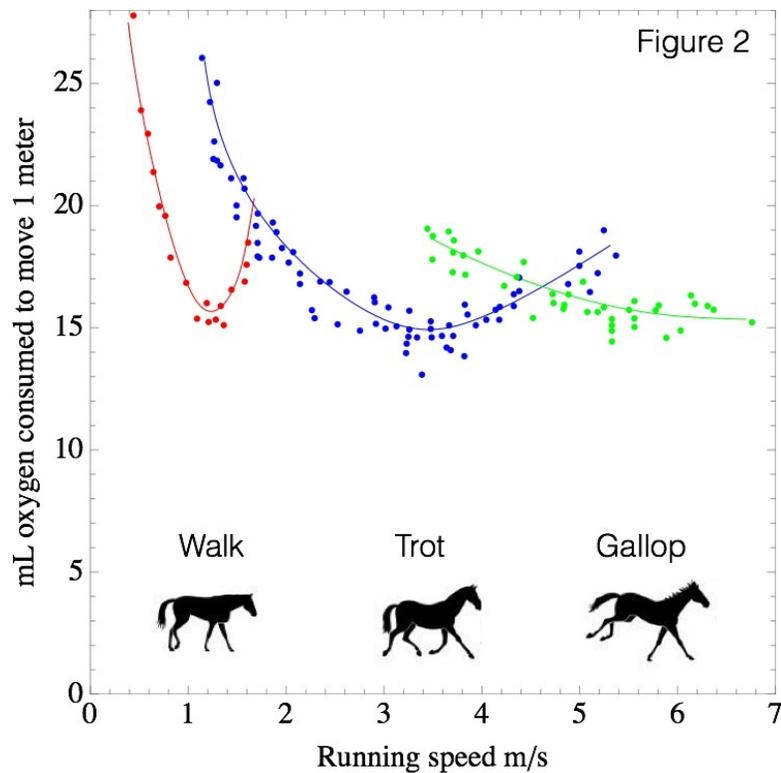


Figure 1: Data are from Hoyt, D.F. and C.R. Taylor. 1981. Gait and the energetics of locomotion in horses. *Nature* 292:239-240. Obtained from [https://stewartcalculus.com/data/BIOCALCULUS/BB/BB\\_Chapter3/E3.2.7/Example3.2.7/index.html](https://stewartcalculus.com/data/BIOCALCULUS/BB/BB_Chapter3/E3.2.7/Example3.2.7/index.html)

### 3 Inverted Pendulum Models

1. We can use a force balance in the y direction to estimate the maximum velocity we can travel with the inverted pendulum model (IPM). We know that we cannot move faster than what would cause us to become airborne at the peak of stance. Balance the downward force of gravity with the apparent centrifugal force at this point ( $\frac{mv^2}{r}$  where r is the radius that we are rotating about) to determine the maximum speed that can be achieved in the inverted pendulum model in terms of  $g$  and  $l$ .
2. Is this estimated maximum speed reasonable? What would be the approximate maximum speed of a human using this calculation? What is it actually?
3. Is the linear inverted pendulum model (LIPM) realistic? Explain in two to three sentences.

### What To Submit

Submissions are due on Gradescope by the date specified in the Syllabus.

1. Create a .pdf file with the written answers ALL THE SECTIONS.
2. Make sure you have answers and explanations for each subquestion.