Solution Problem 7

7a) A shot putter’s release height (where the shot leaves the hand) is $h_0 = 1.91$ m. He can propel the shot to a total velocity of $v_0 = 10.5$ m/s. What is the optimal release angle ($\alpha$) to achieve a maximum distance?
How to solve

There might be several ways of approaching this problem. I chose to find a system of equations to be able to calculate the variable of interest:

The shot will simply follow the rules of projectile motion. The coordinate system’s origin is at the bar on the ground (close to the foot):
Flight distance: \( L = vx \times tf \); \( tf = \text{flight time} \)

\[ vx = v_0 \times \cos \alpha \]

Flight height (general, as a function of time (t)):

\[ h = h_0 + vy \times t - 0.5 \times g \times t^2 \]; \( g = 9.81 \text{ m/s}^2 \)

When the shot hits the ground \( h \) will be 0

So:

\[ 0 = h_0 + vy \times tf - 0.5 \times g \times tf^2 \]; \( vy = v_0 \times \sin \alpha \)
How to solve - 2

Now we have a system of 2 equations and two unknowns L and tf. The second one is a quadratic equation which gives two solutions (only the larger one applies). Setting that one into the first gives L.

There is a webpage with the final result:
http://people.brunel.ac.uk/~spstnpl/BiomechanicsAthletics/ShotPut.htm

This webpage also gives some discussion about question 7 b) (the main point, starting from our energy approach, is that lifting the shot to a higher release height will require to transfer more potential energy to it. Given that our musculoskeletal system has a limit this may not be beneficial, i.e., at the cost of reducing kinetic energy. At the same velocity and angle any shot weight will result in the same flight distance. But with reference to the above pretty much everything will change so likely the flight distance will be longer with a lighter shot.)
Problem 7 - II

7b) The previous question was largely idealized. Consider: The athlete is unlikely to change the angle without changing body position. How would this change?

As soon as he changes the angle the velocity of the shot will be affected; which factors will play into this (anatomical, physics (energetics), ...)? How would a smaller shot affect the putting distance?

(In 7a (simple) and more importantly in 7b)