

# Basics of Physics with Biophysics

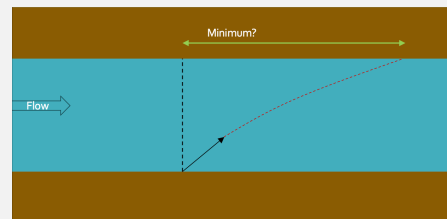
1. semester 2024/25

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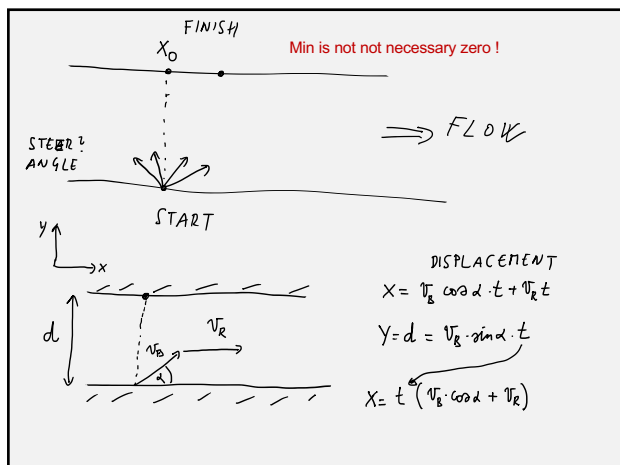
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## Exercise

We want to cross the river, and our boat is going twice as slow as the river's current. In which direction (angle!) do we have to steer the boat so that the distance to the starting point is the shortest?



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$$x = d \frac{\cos \alpha}{\sin \alpha} + \eta \frac{d}{\sin \alpha} \quad \text{where } \eta = \frac{v_R}{v_B}; \text{ we can set } d=1$$

$X(\alpha)$  find min.

$$X'(\alpha) = 0$$

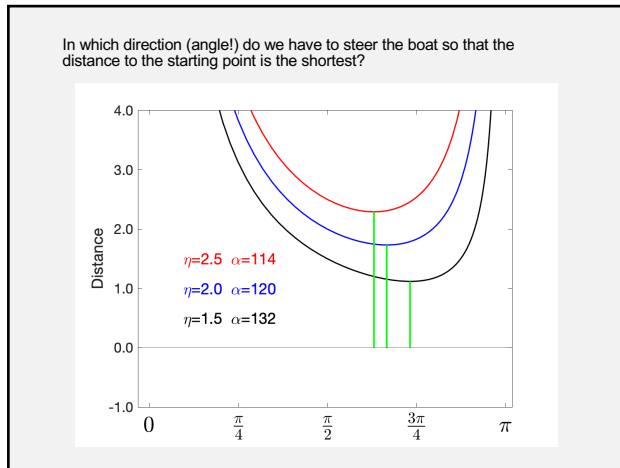
$$X'(\alpha) = d \left( -\frac{\sin \alpha}{\sin^2 \alpha} + \frac{(-1) \cos \alpha}{\sin^2 \alpha} + \eta \frac{(-1) \cos \alpha}{\sin^2 \alpha} \right) =$$

$$= d \left( -1 - \frac{\cos^2 \alpha}{\sin^2 \alpha} - \eta \frac{\cos \alpha}{\sin^2 \alpha} \right)$$

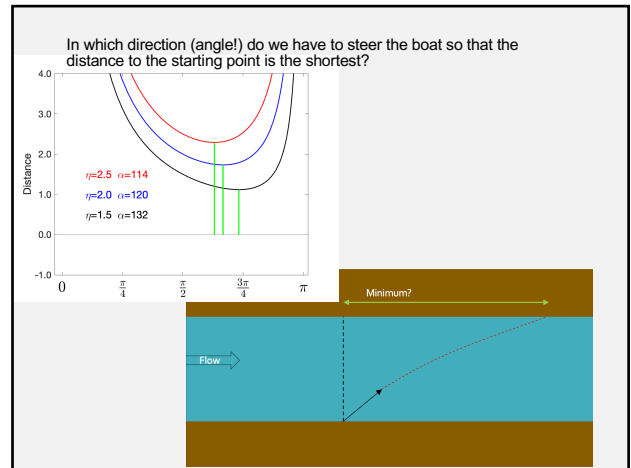
$$\underbrace{-1 - \frac{\cos^2 \alpha}{\sin^2 \alpha}}_{=0} - \eta \frac{\cos \alpha}{\sin^2 \alpha} = 1$$

$\sin^2 \alpha + \cos^2 \alpha = 1$

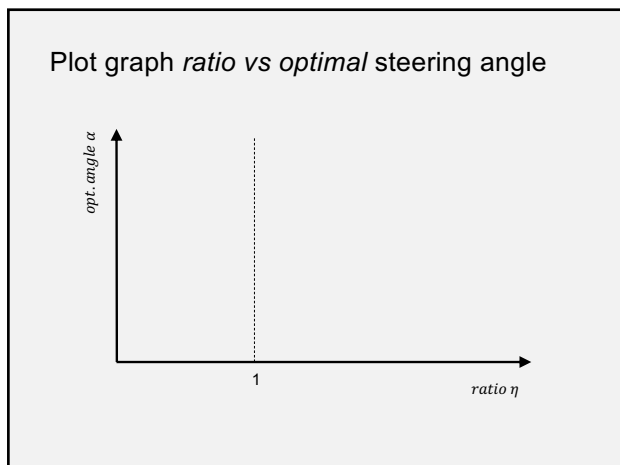
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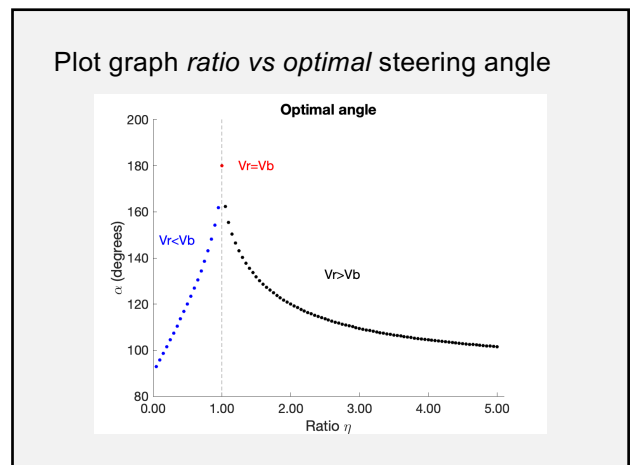
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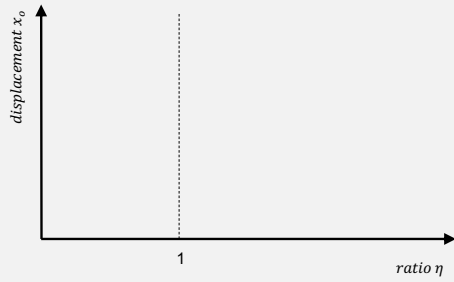


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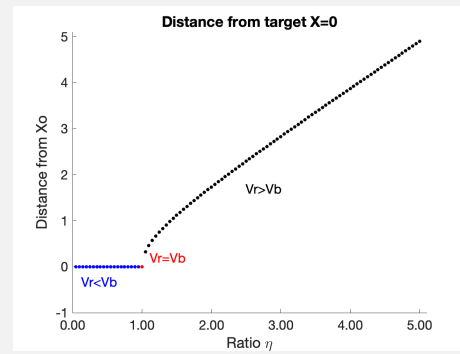


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Plot graph ratio vs "min" displacement

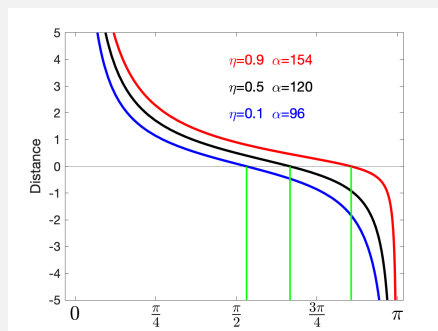


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Plot graph ratio vs displacement from  $x_0$ 

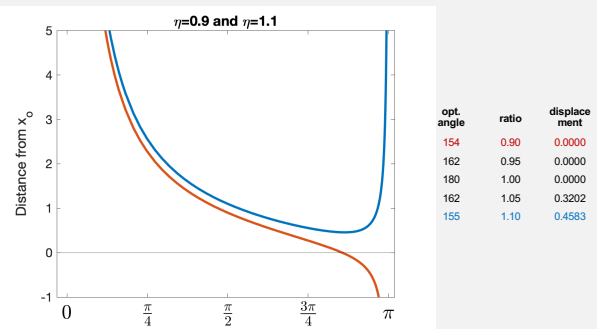
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Fast boat, ratio is less than 1?



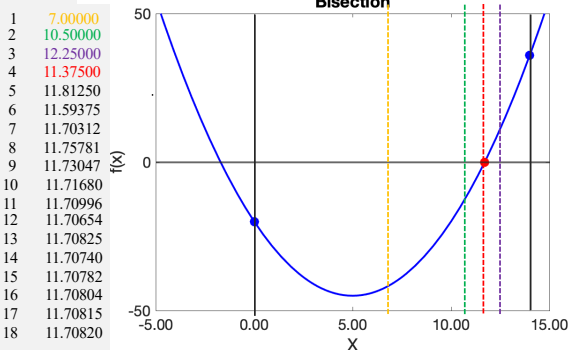
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$$\text{ratio } \eta = \frac{v_r}{v_b}; \quad \eta < 1 \text{ and } \eta > 1$$



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## Bisection



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Preliminaries:  
find derivative of  $f(x)$   
derivative is "df(x)"  
linear function is  $y=kx+n$

choose initial  $x_0$

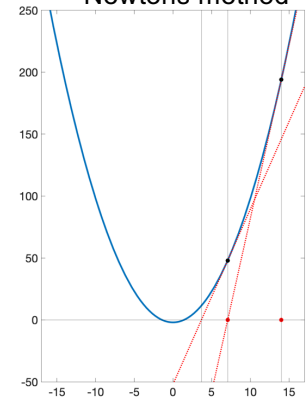
slope  $k_0$  is  $df(x_0)$   
 $y_0$  value is  $f(x_0)$ , (if not df!)  
find intercept  $n_0 = y_0 - k_0 x_0$   
Thus, tangent which goes through  $(x_0, y_0)$  is  $y = k_0 x + n_0$

The next step is to find the point that is closer to the zero point, or is this the point where lin.fun. intersects the x-axis?

Set  $y=0$ , or  $0 = k_0 x + n_0$  and find new "x", which is now  $x_1$ , this is step  $i+1$

repeat until convergence

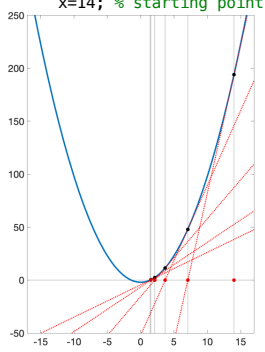
## Newtons method



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```
% function
f=@(x) x.^2 -2;
```

```
x=14; % starting point
```

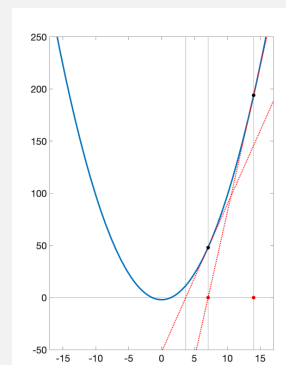


```
Start
slope= 28.00 intercept= -198.00
x= 14.0000
y=194.0000
```

```
Iteration i= 1
slope= 14.14 intercept= -52.01
x= 7.0714
y= 48.0051
Iteration i= 2
slope= 7.35 intercept= -15.52
x= 3.6771
y= 11.5213
Iteration i= 3
slope= 4.22 intercept= -6.45
x= 2.1105
y= 2.4543
Iteration i= 4
slope= 3.06 intercept= -4.34
x= 1.5291
y= 0.3381
Iteration i= 5
slope= 2.84 intercept= -4.01
x= 1.4185
y= 0.0122
```

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## Newtons method



$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

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