Supplemental Problem

S1[1]. (20 pts.) While on a visit to Minnesota ("Land of 10,000 Lakes") you sign up to take an excursion around one of the larger lakes. When you go to the dock where the 1500-kg boat is tied, you find that the boat is bobbing up and down in the waves, executing simple harmonic motion with amplitude of 20 cm. The boat takes 3.5 s to make one complete up-and-down cycle. When the boat is at its highest point, its deck is at the same height as the staionary dock. As you watch the boat bob up and down, you (mass 60 kg) begin to feel a bit woozy, due in part to the previous night's dinner of lutefisk. As a result, you refuse to board the boat unless the level of the boat's deck is within 10 cm of the dock level. How much time do you have to board the boat comfortbly during each cycle of up-and-down motion?

[1]This problem is from Young and Freedman's *University Physics*

Supplemental Problem (S1) Solution

In[1]:=
```
A = 20 (* Amplitude *);
T = 3.5;
```

In[3]:=
```
ω = 2 π / T
```

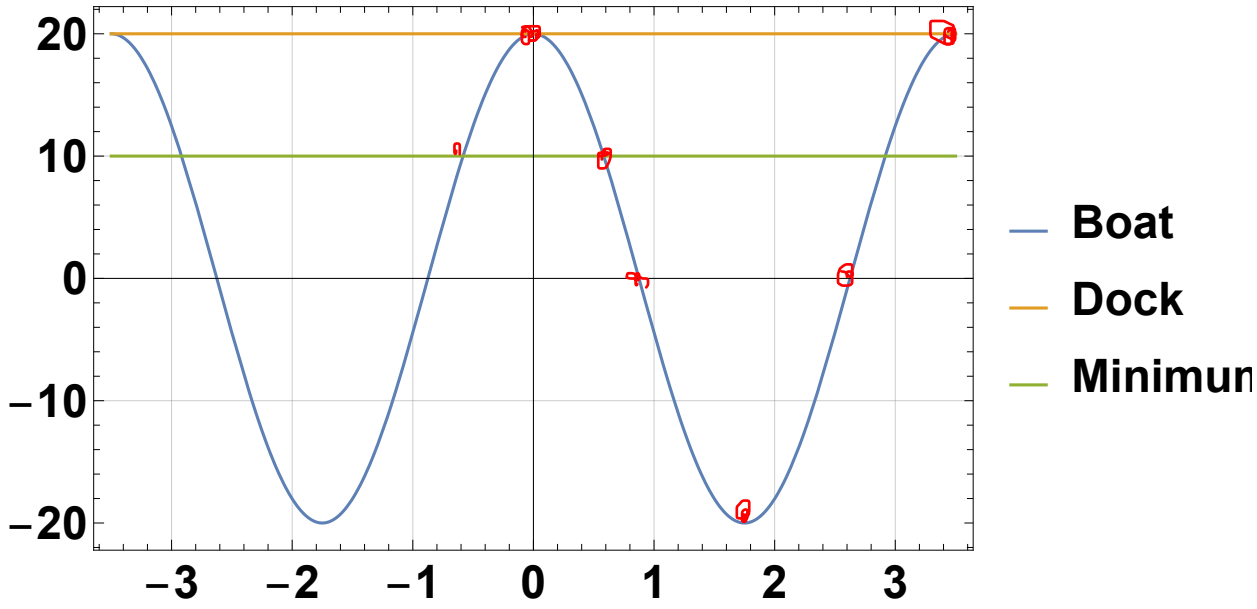
Out[3]=
```
1.7952
```

In[4]:=
```
y[t_] := A Cos[ω t]
```

Consider a plot showing the positions of the boat and dock, and the position of the minimum height at which you will get on the boat.

In[8]:=
```
graph = Plot[{y[t], 20, 10}, {t, -T, T},
  PlotLegends → {"Boat", "Dock", "Minimum Height"}, GridLines → Automatic,
  Frame → True, ImageSize → Scaled[0.8], LabelStyle → "Large"]
```

Out[8]=



Between roughly about -0.5 and +0.5 seconds, the boat is high enough to board.

In[9]:=
```
times = Solve[y[t] == 10, t]
```

Solve: Inverse functions are being used by Solve, so some solutions may not be found; use Reduce for complete solution information.

Out[9]=
```
{{t → -0.583333}, {t → 0.583333}}
```

In[10]:=
```
tmin = t /. times[[1]]
```

Out[10]=
```
-0.583333
```

In[11]:=
```
tmax = t /. times[[2]]
```

Out[11]=
```
0.583333
```

In[12]:=
```
Δt = tmax - tmin
```

Out[12]=
```
1.16667
```

You have approximately 1.17 seconds.