



## Algebra Problem: Analysing Subsea Cable Tension for Ocean Conservation

### Authors

Araceli Queiruga Dios, Universidad de Salamanca (Spain).

Ion Mierlus Mazilus, Universitatea Tehnica de Constructii Bucuresti (Romania).

### Type of activity

The problem presents an application of algebra and geometry to solve a problem using quadratic equations, system of linear equations, and Pythagorean Theorem.

### Target educational level

It can be addressed to last courses of High School students and to any university student from STEM degrees.

### Initial information

Sustainable Development Goal 14 focuses on conserving and sustainably using the oceans, seas, and marine resources. In mechanical engineering, **ensuring the integrity of subsea infrastructure is crucial to prevent pollution (e.g., from broken cables or damaged sensors) and protect marine ecosystems.**

Consider a scenario where engineers are designing a system to deploy and monitor underwater sensors for studying ocean currents and marine life. These sensors are attached to a long cable that needs to be anchored to the seabed while maintaining specific tension limits to prevent breakage and avoid disturbing the marine environment.

### Source

Problem adapted from AI tool (Gemini).

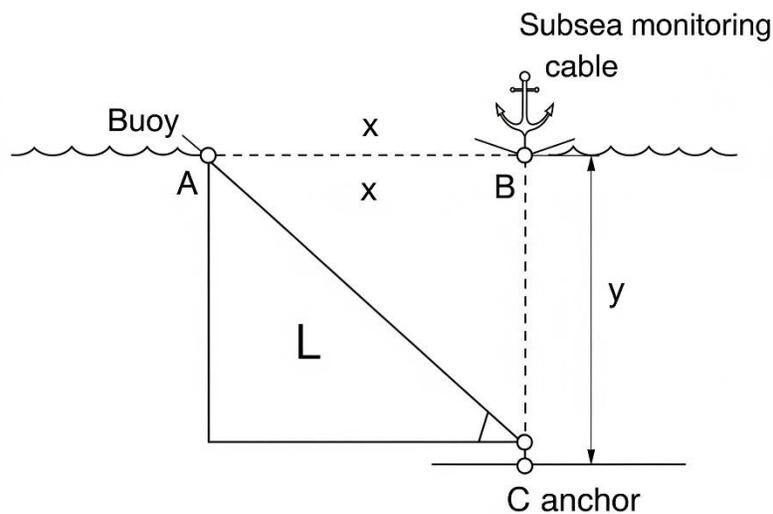


### Problem statement

An engineering team is designing the deployment of a subsea monitoring cable. The cable needs to support several sensors at different depths. For simplified analysis, consider the cable is taut and forms a straight line from a surface buoy to an anchor point on the seabed.

The cable's total length is  $L$  meters. The horizontal distance from the buoy (point  $A$  on the surface) to a point directly above the anchor (point  $B$  on the surface) is  $x$  meters. The depth of the anchor point (from point  $B$  to the anchor at point  $C$ ) is  $y$  meters. The design specifications require that the depth ( $y$ ) must be 3 times the horizontal distance ( $x$ ). Additionally, the total cable length ( $L$ ) must be 20 meters greater than the horizontal distance ( $x$ ).

Determine the required horizontal distance ( $x$ ), the anchor depth ( $y$ ), and the total cable length ( $L$ ).



### Solution:

1. Pythagorean Theorem: The cable forms the hypotenuse of a right-angled triangle, with  $x$  and  $y$  as the other two sides.

$$x^2 + y^2 = L^2$$



2. The depth must be 3 times the horizontal distance, i.e.,  $y = 3x$
3. The total cable length must be 20 meters greater than the horizontal distance,  $L = x + 20$ .
4. The system of equations can be solved using any method. With Wolfram Mathematica, the values can be calculated by using:

```
Solve[x2+y2==L2&&y==3x&&L==x+20,{x,y,L}]/N
```

5. Where the solution is:

```
{{x → -4.80506, y → -14.4152, L → 15.1949},  
{x → 9.24951, y → 27.7485, L → 29.2495}}
```

6. Thus, the required dimensions for the subsea cable deployment are (distance cannot be negative):
  - Horizontal distance ( $x$ ): Approximately 9.25 meters.
  - Anchor depth ( $y$ ): Approximately 27.75 meters.
  - Total cable length ( $L$ ): Approximately 29.25 meters.