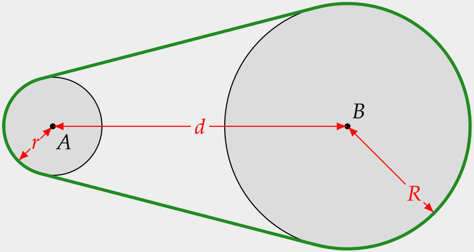
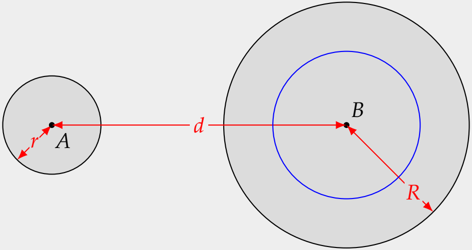
Miscellaneous Nerdery

Updated on: September 9, 2025



Two pulleys, centred at A and B, have radii r and R. The distance from A to B is d.

Determine the length of the belt required to go round both pulleys.



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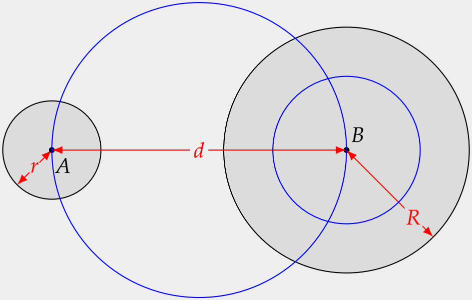
Geometry :: Belt-Length



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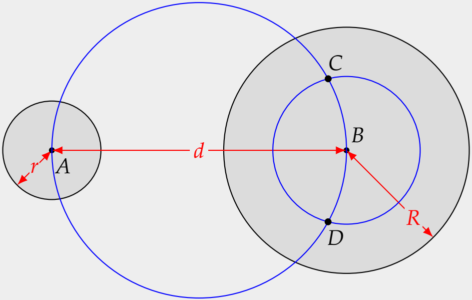
2. Construct a circle with diameter AB.



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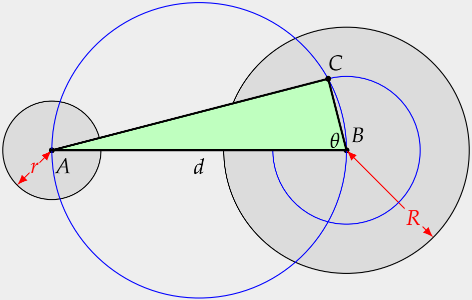
3. These two circles intersect at C and D. Due to the horizontal axis of symmetry through A and B, we only need perform calculations on one half of the system.



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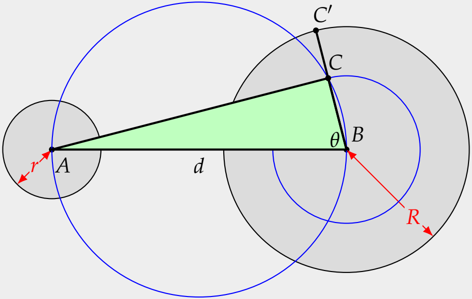
4. Consider $\triangle ABC$: $\angle ACB = 90^\circ$ since it is an angle inscribed in a semicircle. Then:

$$AC = \sqrt{d^2 - (R-r)^2}$$

$$\theta = \sin^{-1}\left(\frac{\sqrt{d^2-(R-r)^2}}{d}\right)$$



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5. Extend line BC to C' on the circumference of pulley B. CC' has length r.

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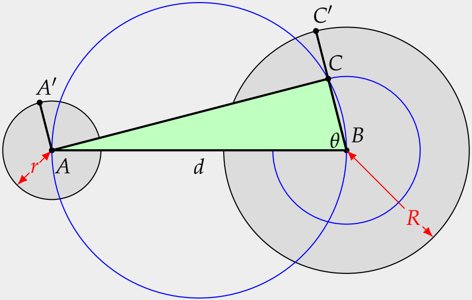

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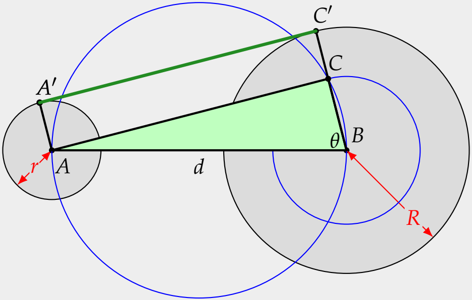
6. Draw AA', of length r and parallel to CC', as shown.



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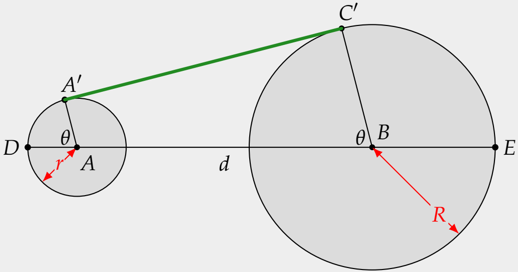
7. Draw $A'C'$: $A'C'CA$ is a rectangle so

$$A'C' = AC = \sqrt{d^2 - (R-r)^2}$$



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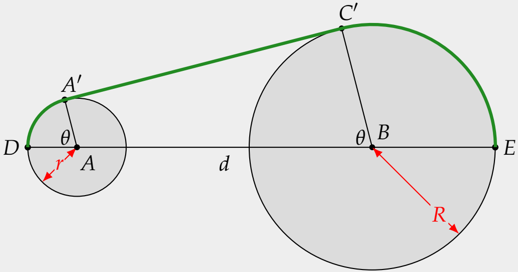

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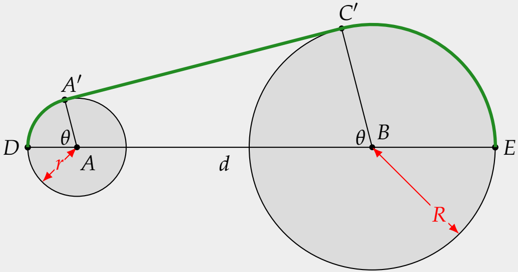
9. The angles (θ and $\pi - \theta$) that these arcs subtend at the pulley centres, with the radius of each pulley, are used to determine the arc-lengths (θ in radians):

$$DA' = r\theta \text{ and } C'D = R(\pi - \theta)$$



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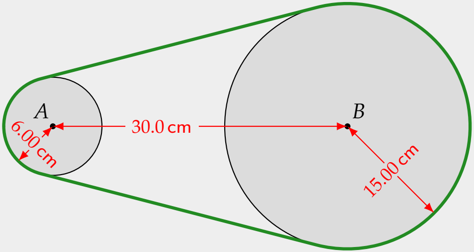
10. Belt-length:

$$= 2\left(DA' + A'C' + C'E\right)$$

$$= 2\left(r\theta + \sqrt{d^2 - (R-r)^2} + R(\pi - \theta)\right)$$

where

$$\theta = \sin^{-1}\left(\frac{\sqrt{d^2 - (R-r)^2}}{d}\right)$$



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Example:

$$\theta = \sin^{-1}\left(\frac{\sqrt{d^2 - (R-r)^2}}{d}\right) = \sin^{-1}\left(\frac{\sqrt{6.00^2 - 1.50^2}}{6.00}\right) = 1.3181 \text{ (radians)}$$

$$\text{B-L} = 2\left(6.00 \times 1.3181 + \sqrt{6.00^2 - 1.50^2} + 15.00 \times (\pi - 1.3181)\right) = 82.141$$

The belt length is 82.1 cm.