Heave Ho

When a large ship docks, a mooring line upwards of 10cm in diameter must be passed to the dock. Since this would be impossibly heavy to throw, a 'heaving line' is thrown first – a ball (or, traditionally, a monkey's fist knot) provides a weight for the end, and once caught can be used to haul across the mooring line.

A deck-hand is practising heaving lines on the beach. Due to the weight on the end and the light material the line is made from, it can be modelled as a particle moving under projectile motion. On a horizontal surface, the deck-hand can cast the line a distance of 20 metres. Assuming he throws at 45°, calculate the speed at which he releases the line.

The sailor now needs to throw the heaving line from the deck of his ship, 10 metres above the height of the dock. Calculate how close the ship needs to be for him to make the shot, assuming he throws with the same speed, at the same angle.

A heaving line gun can fire a line with three times the velocity of the deck-hand.
How far away could the ship be from the dock, and still manage to reach it using the gun?

Heave Ho Solutions

When a large ship docks, a mooring line upwards of 10cm in diameter must be passed to the dock. Since this would be impossibly heavy to throw, a 'heaving line' is thrown first – a ball (or, traditionally, a monkey's fist knot) provides a weight for the end, and once caught can be used to haul across the mooring line.

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$$Horizontal\ motion: \quad v = \frac{s}{t} \quad \Longrightarrow \quad v\cos 45 = \frac{20}{t} \quad \Longrightarrow \quad t = \frac{20}{v\cos 45}$$

$$Vertical\ motion: \quad s = 0 \quad u = v\sin 45 \quad v = - \quad a = -9.8 \quad t = \frac{20}{v\cos 45}$$

$$s = ut + \frac{1}{2}at^2 \quad \Longrightarrow \quad 0 = \frac{20v\sin 45}{v\cos 45} - 4.9\left(\frac{20}{v\cos 45}\right)^2 = 20 - \frac{3920}{v^2}$$

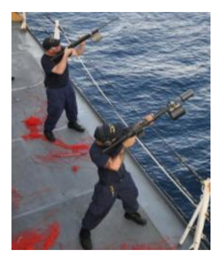
$$\Longrightarrow \quad v^2 = \frac{3920}{20} = 196 \quad \Longrightarrow \quad \boldsymbol{v = 14ms^{-1}}$$

The sailor now needs to throw the heaving line from the deck of his ship, 10 metres above the height of the dock. Calculate how close the ship needs to be for him to make the shot, assuming he throws with the same speed, at the same angle.

$$Vertical\ motion: \quad s = -10 \quad u = 14\sin 45 \quad v = - \quad a = -9.8 \quad t = ?$$

$$s = ut + \frac{1}{2}at^2 \quad \Longrightarrow \quad -10 = 14t\sin 45 - 4.9t^2 \quad \Longrightarrow \quad t = 2.76s \quad or \quad t = -0.74s$$

$$Horizontal\ motion: \quad v = \frac{s}{t} \quad \Longrightarrow \quad 14\cos 45 = \frac{x}{2.76} \quad \Longrightarrow \quad \boldsymbol{x = 27.3m\ to\ 3\ s.f.}$$



A heaving line gun can fire a line with three times the velocity of the deck-hand.

How far away could the ship be from the dock, and still manage to reach it using the gun?

$$Vertical\ motion: \quad s = -10 \quad u = 42\sin 45 \quad v = - \quad a = -9.8 \quad t = ?$$

$$s = ut + \frac{1}{2}at^2 \quad \Longrightarrow \quad -10 = 42t\sin 45 - 4.9t^2 \quad \Longrightarrow \quad t = -0.32s \quad or \quad t = 6.38s$$

$$Horizontal\ motion: \quad v = \frac{s}{t} \quad \Longrightarrow \quad 42\cos 45 = \frac{x}{6.38} \quad \Longrightarrow \quad \boldsymbol{x = 189m\ to\ 3\ s.f.}$$