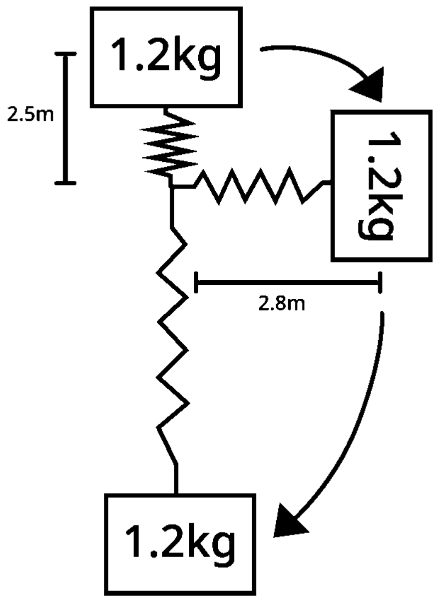
1. A dude is spinning their 1.2kg mass attached to a spring in a vertical oval at 33 rpm. At the top of the spin the mass is spinning at a radius 2.5m, then at 90° the mass is spinning at a radius of 2.8m. What will the radius be at the bottom of the spin?




**<u>NOT TO SCALE</u>**

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# Solution!

**Givens**

$m = 1.2kg$

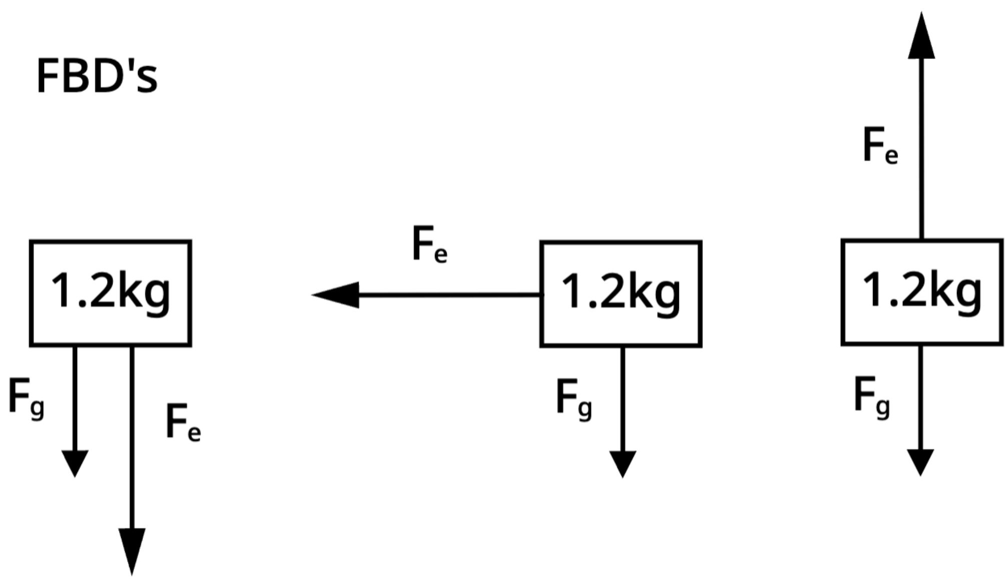
$f = 33rpm\ (0.55hz)$

$r_1 = 2.5m$

$r_2 = 2.8m$

$r_3 = ?$

**FBD's**




| | | |
|---|---|---|
| $e_1,\ \theta_1 = 0°$ | $e_2,\ \theta_2 = 90°$ | $e_3,\ \theta_3 = 180°$ |
| $F_c = F_{e_1} + F_g$ | $F_c = F_{e_2}$ | $F_c = F_{e_3} - F_g$ |
| $ma_c = F_{e_1} + mg$ | $ma_c = F_{e_2}$ | $ma_c = F_{e_3} - mg$ |
| $m(4\pi^2 rf^2) - mg = F_{e_1}$ | $m(4\pi^2 rf^2) = F_{e_2}$ | $m(4\pi^2 rf^2) + mg = F_{e_3}$ |
| $m(4\pi^2 r_1 f^2 - g) = F_{e_1}$ | $m(4\pi^2 r_2 f^2) = F_{e_2}$ | $m(4\pi^2 r_3 f^2 + g) = F_{e_3}$ |

$$1.2kg(4\pi^2(2.5m)(0.55hz)^2 - 9.8N/kg) = F_{e_1}$$

$$F_{e_1} = 24.067\text{N}$$

$$1.2kg(4\pi^2(2.8m)(0.55hz)^2) = F_{e_2}$$

$$F_{e_2} = 40.126\text{N}$$

Solving for the elastic forces at $\theta = 0°$, $\theta = 90°$

$$F_e = kx$$
$$F_{e_1} - F_{e_2} = k\Delta x$$
$$24.067N - 40.126N = k(2.5m - 2.8m)$$
$$k = 53.530N/m$$

Calculating the spring constant by taking the difference in elastic forces from 0°and 90° and dividing it by the difference in displacement.

$$F_{e_2} = kx_2$$
$$40.126N = (53.530N/m)x_2$$
$$x_2 = 0.750m$$
$$r_2 - x_2 = x_0$$
$$2.8m - 0.750m = x_0$$
$$x_0 = 2.05m$$

Calculating the length of the spring when it is not compressed or stretched which will be referred to as $x_0$

$$m(4\pi^2 r_3 f^2 + g) = F_{e_3}$$
$$m(4\pi^2 r_3 f^2 + g) = kx_3$$
$$1.2kg(4\pi^2 r_3 0.55hz^2) + 1.2kg(9.8N/kg) = (53.530N/m)(r_3 - x_0)$$
$$1.2kg(4\pi^2 r_3 0.55hz^2) + 1.2kg(9.8N/kg) = (53.530N/m)(r_3 - 2.05m)$$
$$r_3 = 3.09945m$$

Finding the radius at 180° by substituting x with the radius minus the unstretched spring length

∴ Therefore the radius of the spin will be 3.1m at the bottom of the spin.

**Assumptions**

1. There is no air resistance
2. The dude is on the surface of earth
3. The spring loses no energy to the environment when it is deformed
4. The dude is spinning the weight without moving his hand (the axis of rotation never moves)