Key

WIZARD DUEL

1. Saruman manages to get Gandalf's body whirling around in a circle during this classic duel. The radius of the circle in which Gandalf is moving is 20.0m, and he was moved completely around the room in 1.50s. (Gandalf has a mass of ~200. kg)
   a. What was the **speed** of Gandalf?
   b. What was the centripetal acceleration?
   c. What was the Centripetal force needed?

2. Saruman practiced this trick on his *Palantír.* This is a 6.00 kg crystal, which the wizard spun in a circle of circumference 10.0 m at a speed of 10.0 m/s.
   a. How much time did it take for the object to go around once?
   b. What was the centripetal acceleration?
   c. What was the centripetal force?

Answers:
1) **a.** 83.8 m/s **b.** 351 m/s^2 **c.** 70200 N
2) **a.** 1.00 s **b.** 62.8 m/s^2 **c.** 377 N

$v = ?$

1) $r = 20.0m$ $T = 1.50s$ $m = 200.kg$ $\Sigma F = \frac{mv^2}{r}$

a) $v = \frac{2\pi r}{T} = \boxed{83.8 m/s}$ $v = \frac{2\pi(20.0m)}{1.50s}$ b) $\vec{a} = \frac{v^2}{r} = \boxed{351 m/s^2}$ c) $\boxed{7.02 \times 10^4 N}$

2) $2\pi r = 10.0m$ $v = 10.0 m/s$ $m = 6.00kg$

a) $v = \frac{2\pi r}{T}$ $T = \frac{2\pi r}{v} = \boxed{1.00s}$ b) $\vec{a} = \frac{v^2}{r}$ $\frac{(10.0 m/s)^2}{10.0m/2\pi} = \boxed{62.8 m/s^2}$

c) $F = \frac{mv^2}{r} = \boxed{377N}$

Key

$R_E = 6.37\times10^6\,m$

6. The International Space Station (ISS) orbits at an average altitude of 340 kilometers.

↓ meters

$0.34\times10^6\,m$

a) Calculate the force holding the ISS in orbit.
b) How fast is the ISS moving?
c) What is the acceleration of the ISS?
d) How long does it take the ISS to orbit the Earth?

$$F_g = \frac{Gm_1m_2}{r^2}$$

mass of ISS = 417,289 Kg

total r = R_E + altitude

$6.37\times10^6\,m + 0.34\times10^6\,m = 6.71\times10^6\,m$

a) $$F_g = \frac{GM_E M_{ISS}}{(6.71\times10^6\,m)^2} = \boxed{3.69\times10^6\,N}$$

b) $$\Sigma F_{in} = \frac{mv^2}{r}$$

$$F_g = \frac{m_{(ISS)}v^2}{r} = \frac{GM_E M_{ISS}}{r^2} \qquad V = \sqrt{\frac{GM_E}{(6.71\times10^6\,m)}} = \boxed{7.7\times10^3\,\frac{m}{s}}$$

c) $$\Sigma F_{in} = \frac{mv^2}{r} \qquad a_c = \frac{V^2}{r} = \boxed{8.8\,\frac{m}{s^2}}$$

d) $$v = \frac{2\pi r}{T} \qquad T = \frac{2\pi r}{V}$$

$$\frac{2\pi(6.71\times10^6\,m)}{(7.7\times10^3\,\frac{m}{s})} = \boxed{5.5\times10^3\,s}$$