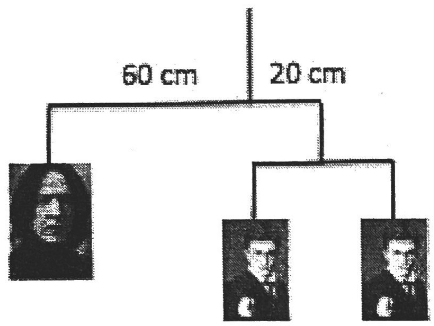
Circular Motion, Torque and Gravitation Review Sheet

Go back to the Circular Motion Essential Questions, the Circular Motion Problem Set, the Torque handout, and the gravitation handouts. **This review sheet will be taken as a grade.**

Torque ($F_1r_2 = F_2r_2$)

1. A Harry Potter fan makes the mobile below using photographs. If Snape's photograph has a mass of 5.0 g, find the mass of a Harry Potter photograph. (The two Harry Potter photographs are identical in mass.)



$5.0\,g \times 60\,cm = m(20\,cm)$

$m = 150\,g$

each is 75 g

Circular Motion

	Friction	Gravitation	Tension (when the rope is sagging)
FBD	F_n, F_s, $F_g = mg$	F_g	T_y, T_x, F_g
Net force equation	$F_s = mv^2/r$	$F_g = \frac{mv^2}{r}$	$T_x = mv^2/r$
Substitute for centripetal force	$\mu_s(mg) = mv^2/r$	$\frac{Gm_1m_2}{r^2} = \frac{m_1v^2}{r}$	
Solve for v	$v = \sqrt{\mu_s g r}$	$v = \sqrt{\frac{Gm_2}{r}}$	$v = \sqrt{\frac{T_x r}{m}}$
Solve for ... $\mu_s = \frac{mv^2}{r \cdot F_n}$	$\mu_s = \frac{v^2}{rg}$	$m_2 = \frac{v^2 r}{G}$	$T = \frac{T_x}{\cos\theta}$ or $T = \sqrt{T_x^2 + T_y^2}$

2. A student is spinning a film ... d of T = 0.41 s and a radius from the axis of rotation of ... he angle that the string sags below the horizontal.

$T_x = \frac{mv^2}{r}$

$= \frac{(.03\,kg)(8.6\,m/s)^2}{.45\,m}$

$= 4.9\,N$

$v = \frac{2\pi r}{T} = 8.4\,m/s$

$T_y = mg$ $\quad T_y = .3\,N$

$\tan\theta = \frac{T_y}{T_x}$

$\theta = 5.4°$

$T = 4.9\,N \quad \theta = 3.5°$

3. Find the coefficient of static friction if the maximum speed you can drive around a traffic circle (r = 42 m) on wet road is 8.3 m/s. The mass of the car is 1000 kg.

$\mu_s mg = \frac{mv^2}{r}$

$\mu_s = \frac{v^2}{rg} = .16$ or $\mu_s = \frac{mv^2}{r \cdot F_n}$

4. A moon orbits a planet with v = 5.57×10^3 m/s at an orbital radius of 1.39×10^8 m. Draw an FBD, write the net force equation, solve for m_2, and identify the planet. (Saturn: m = 5.69×10^{26} kg, Uranus: 8.76×10^{25} kg, Neptune: 1.03×10^{26} kg).

$m_2 = \frac{v^2 r}{G} =$ ~~3.3 x 10~~ 6.5×10^{25} kg closest to Uranus.

5. Find the value of the gravitational field that the moon in the previous question experiences at that orbital radius.

$g = \frac{Gm}{r^2} = .224$ m/s²

6. Find the value of the gravitational field the moon experiences in the following scenarios. Come up with 3 possibilities for 12 g.

m	r	g	Value for g (m/s^2)
m	r	g	1.96 m/s^2
4m	1/3 r	~~4~~ g 36g	70.56 ~~87~~ m/s²
80 m	2 r	$\frac{80}{4} = 20$g	39.2 m/s²
12	1	12 g	23.52 m/s²
3	$\frac{1}{2}$	12 g	↓
1	$\frac{1}{\sqrt{12}}$	12 g	

7. The super-massive black hole in the center of the Milky Way Galaxy has a mass equal to 4.5 million solar masses (m = 9.0×10^{36} kg). Find the tangential speed of the Earth around the black hole. The Earth is 27,000 light-years away from the black hole. 1 light year = 9.46×10^{15} m.

$v = \sqrt{\frac{Gm}{r}} = \sqrt{\frac{(6.67 \times 10^{-11} N m^2/kg^2)(9 \times 10^{36} kg)}{2.55 \times 10^{20} m}} = 1534$ m/s

1500 m/s

8. Using the same information as #8, find the orbital radius around the black hole at which the escape velocity would be the speed of light, 3×10^8 m/s. This distance is called the event horizon of the black hole because within that distance nothing can be known since light cannot escape.

6.5×10^9 m

$v = \sqrt{\frac{Gm_2}{r}}$

$v^2 = \frac{Gm_2}{r}$

$r = \frac{Gm_2}{v_{esc}^2} =$ ~~1.3 x 10^{10}~~ m