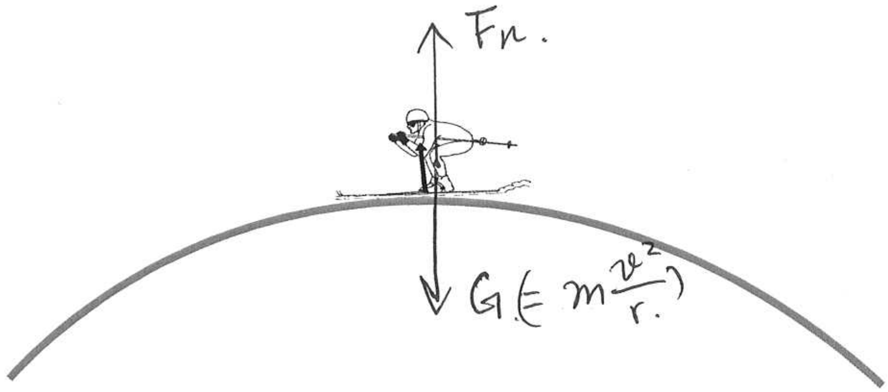
Physics Circular Motion , Gravitation and SHM test. **Name:**

1. A **50kg** skier is riding over a hill as shown below. The hill has a **radius of 20m**



(a) Sketch the force(s) acting on the skier assuming she stays in contact with the ground (2)

It is possible that the skier could be travelling with a speed at the top of the hill such that they briefly leave the surface.

(b) What is the acceleration of the skier at the instant they leave the surface? (1)

~~$a = \frac{v^2}{r} = $~~ 9.81.

(c) Show that the speed at which the speed must be travelling in order to **briefly** leave the surface is 14 ms^{-1}. (2)

$\frac{v^2}{r} = 9.81$ $v = \sqrt{9.81 \times 20} = \underline{14}$ ✓

Assume now the skier were to reach the top of the hill with half the speed determined in question (c) (3)

(d) What **normal force** does the skier experience while travelling with a speed of half of the value required to leave the surface? (2)

$\frac{1}{4}\frac{v^2}{r}$ $\frac{3}{4} \times 500 = \underline{375\ N}$ (125)

$v = \frac{2\pi}{T} r$ $T = 3 hrs.$ $r = 8 \times 10^6 m.$

2. A spacecraft is in orbit about an unknown planet. Its orbital period is 3 hours and its orbital radius is 8000 km.

(a) What is the acceleration of the spacecraft? (2)

$$F = ma = m\frac{v^2}{r} = m\frac{4\pi^2}{T^2} r.$$

$$a = \frac{4\pi^2}{(3\times60\times60)^2} 8\times10^6 = 2.7 \approx 3 \text{ m/s.}$$

(b) What is the mass of the planet? (2)

$$\cancel{\frac{GmM}{r^2} = m}$$

$$\frac{GmM}{r^2} = ma$$

$$6.67\times10^{-11} M = (8\times10^6)^2 \times 3.$$

$$M = 3\times10^{24} \text{ kg}$$

(c)Why does the astronaut inside the spacecraft accelerate at the same rate as the spacecraft? (2)

$$\cancel{F = ma} \quad ma = mG\frac{mM}{r^2}$$

$$a = G\frac{M}{r^2},$$ which is ~~a~~ constant.

(c) The spacecraft fires its rockets so as to briefly speed up . What happens to its orbital path? (2)

~~$\frac{r^3}{T^2}$ is constant~~

~~As $v\uparrow$,~~

$$m\frac{v^2}{r} = G\frac{Mm}{r^2}$$

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

$v\uparrow$, $r\downarrow$, smaller path.

(d) A new orbital radius is established that is twice as far away from the planet. How does the Universal Law of Gravity account for the acceleration in this orbit? (2)

$$a = \frac{v^2}{r} = \frac{\frac{1}{2}v_0^2}{2r_0} = \frac{1}{4}a.$$