Read 6.1-6.3

TA's

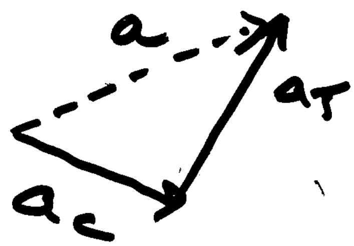
Discussion sections
make all the same average

Office hours on monday very
empty. Great time to stop by
and discuss issues

missing book from Physics
Action Center

H.W #5 Due Today
H.W #6 available

a_T Tangential acceleration



Total acceleration

$$\vec{a} = \vec{a}_c + \vec{a}_T$$

magnitude of a

$$a^2 = a_c^2 + a_T^2$$

$$|a| = \sqrt{a_c^2 + a_T^2}$$

ex) while driving your car you accelerate from 0 to 22 m/s along a road that follows a circular path of radius 87 m that turns 90°

a) what is the tangential acceleration?

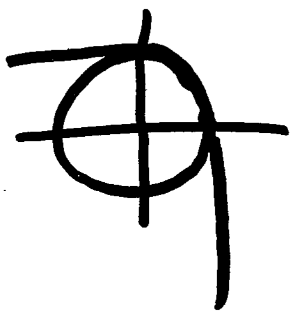
b) what is the centripetal acceleration (when v = 15 m/s)

want a_T

$V_0 = 0$ m/s

$V_f = 22$ m/s

$$V_f^2 = V_0^2 + 2a_T \Delta x$$



$$\Delta x = \frac{2\pi r}{4} = 137\,m$$

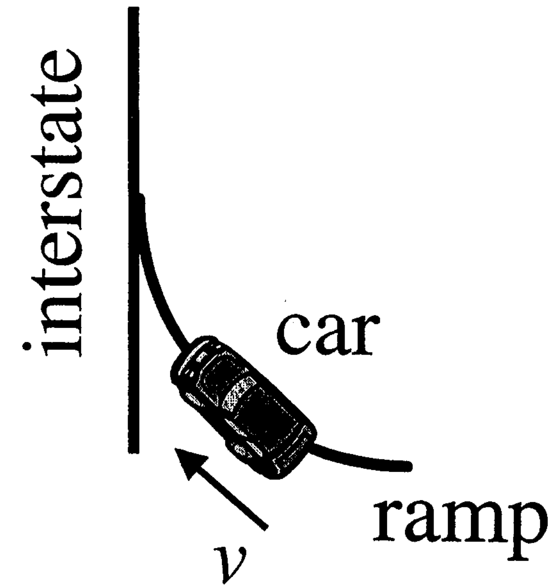
$$(22\,m/s)^2 = 0^2 + 2a_T(137\,m)$$

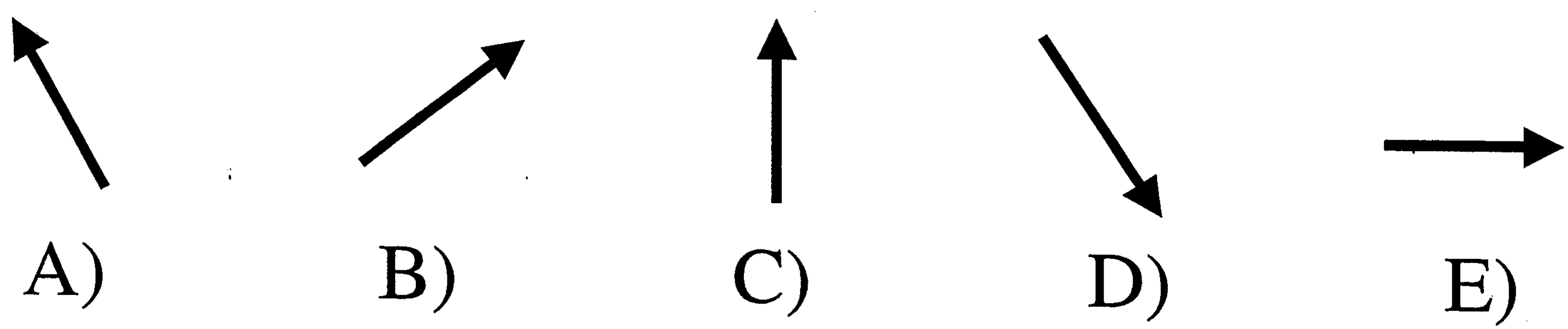
$$a_T = \underline{1.7\,m/s^2}$$

b) $$a_c = \frac{v^2}{r} = \frac{(15\,m/s)^2}{87\,m} = \boxed{2.58\,m/s^2}$$

Interactive Question

A car is speeding up as it enters the interstate on a circular entrance ramp as shown in the figure at right. What is the direction of the acceleration of the car when it is at the point indicated?





Interactive Question

If an object's speed is increasing, it is possible to have:

A) Constant tangential acceleration

B) Constant centripetal acceleration

C) Neither constant tangential or centripetal acceleration

D) Both constant tangential and centripetal acceleration

Newton's Law of universal gravitation

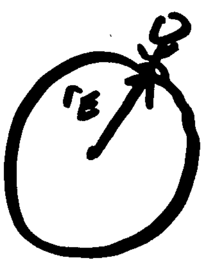
$$\boxed{F = \frac{G m_1 m_2}{r^2}}$$

G = constant

$= 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$

on surface of earth

m_p = mass of person



$$F = \frac{G m_E m_p}{(r_E)^2}$$

constant

g

$m_E = 5.98 \times 10^{24}\ kg$

$r_E = 6.38 \times 10^{6}\ m$

$F = \text{constant} \cdot m$

$= g m$

Circular orbits

what is speed of a satellite in orbit around earth at a distance of 12,200 km above surface?

$G = 6.67 \times 10^{-11}\ N\text{-}m^2/kg^2$

$r_e = 6.38 \times 10^{6}\ m$

$m_e = 5.97 \times 10^{24}\ kg$

$$F = \frac{G m_e \cancel{m_s}}{r^2} = \frac{\cancel{m_s} v^2}{r}$$

$$V = \sqrt{\frac{G m_E}{r}}$$

$$V = \sqrt{\frac{6.67 \times 10^{-11}\ N\text{-}m^2/kg^2 \cdot 5.97 \times 10^{24}\ kg}{6.38 \times 10^{6}\ m + 1.22 \times 10^{7}\ m}}$$

$$\boxed{4630\ m/s}$$

KEPLERS 3 LAWS

1) Planets move in elliptical orbits with sun at one focal point

2) A line drawn from the sun to any planet sweeps out equal areas in equal time intervals

3) Square of orbital period of any planet is proportional to the cube of the average distance from the planet to the sun

$T^2 = \text{constant } r^3$

$T_1^2 = \text{const } r_1^3$

$T_2^2 = \text{const } r_2^3$

$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$$

3) is easy to show

Although planets move in elliptical orbits, they are almost circular

m_p : planet mass

$$F = \frac{G m_p m_{sun}}{r^2} = \frac{m_p V^2}{r}$$

$$V = \sqrt{\frac{G m_{sun}}{r}}$$

$$V = \frac{2\pi r}{T} = \sqrt{\frac{G m_{sun}}{r}}$$

square both sides

$$\frac{4\pi^2 r^2}{T^2} = \frac{G m_{sun}}{r}$$

$$T^2 = r^3 \left(\frac{4\pi^2}{G m_{sun}} \right)$$

$$\underline{T^2 = \text{const } r^3}$$

Let's see if this works

$T^2 = \text{const } r^3$

$\text{const} = T^2/r^3$

mercury: $T = 88$ Days

$r = 58 \times 10^6$ km

$\text{const} = \frac{(88)^2}{(58)^3} = \underline{.04}$

venus: $T = 226$ days

$r = 108 \times 10^6$ km

$\text{const} = \frac{(226)^2}{(108)^3} = \underline{.04}$

earth $T = 365$ days

$r = 150 \times 10^6$ km

$\text{const} = \frac{(365)^2}{(150)^3} = \underline{.04}$

ex) Jupiter is 5.2 times as far from the sun as earth. What is the length of Jupiter's year?

$$T_E^2 = \text{const}\, r_e^3$$
$$T_J^2 = \text{const}\, r_J^2$$

$$\frac{T_E^2}{T_J^2} = \frac{r_e^3}{r_J^3}$$

$$\frac{(1\ \text{year})^2}{T_J^2} = \frac{r_e^3}{(5.2 r_e)^3}$$

$$T_J^2 = (5.2)^3 \cdot (1\text{year})^2$$

$$\Rightarrow \underline{T_J = 12\ \text{years}}$$

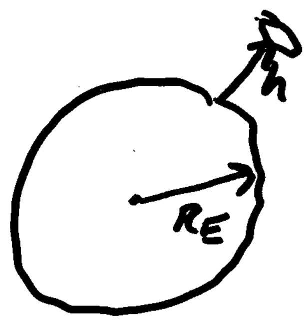
Artificial Gravity

what is the value of "g" for a person in space station?

weightless → $g = 0$?

$$F = \frac{G m_E m_p}{r^2} = \text{weight}$$

$$\frac{W_{orbit}}{W_{earth}} = \frac{\dfrac{G m_E m_p}{(R_E + h)^2}}{\dfrac{G m_E m_p}{(R_E)^2}}$$



$h \approx 600\,km$

$R_E \approx 6400\,km$

$$\frac{W_{orbit}}{W_{earth}} = \frac{(R_E)^2}{(R_E + h)^2} = \frac{(6400\,km)^2}{(7000\,km)^2} = .84$$

"g" ≠ 0!

astronaut has

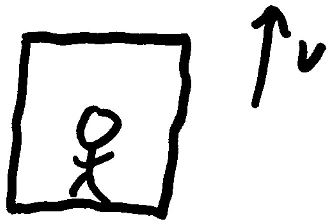
$\underline{\underline{.84\,g}}$

so why is astronaut "weightless"

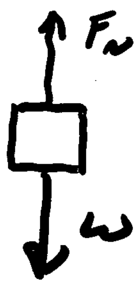
apparant weight

elevator moving at const Velocity

person on scale



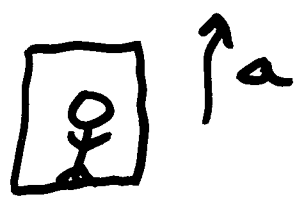
F.B.D Person



$F_N - w = 0$

$F_N = w$ Reading on scale $= F_N$ $=$ weight

Now have elevator accelerating upward

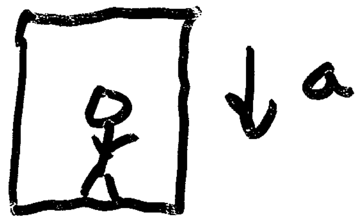


$F_N - w = ma$

$F_N = w + ma = mg + ma = m(g+a)$

scale reading $m(g+a)$ <u>larger</u>

accelerating downward



$F_N - w = -ma$

$F_N = -ma + w = -ma + mg = m(g-a)$

scale reading $m(g-a)$ <u>smaller</u>

so if accelerating downward at "g" (cable snaps)

scale reading $m(g-g) = 0$

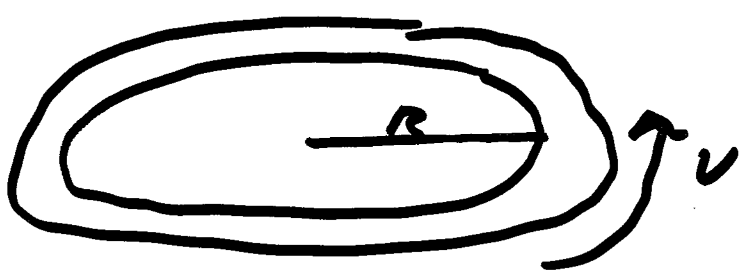
<u>weightless</u>

we see that acceleration acts similar to gravity → weight

so if in deep space very far from earth $g \simeq 0$

Can make artificial gravity using acceleration

Easiest is to use centripetal acceleration



$$a_c = \frac{v^2}{R}$$

For earth gravity

$$\frac{v^2}{R} = 9.8\,m/s^2$$