Read 6.1-6.3

Finish chapter 5 today

Exam Next Monday (March 11)
7:30 A.M chp 4-5 only

H.W Due today

Next H.W available
(chp 5+6)

SO FAR we have only looked at uniform circular motion.

motion in a circle with constant speed.

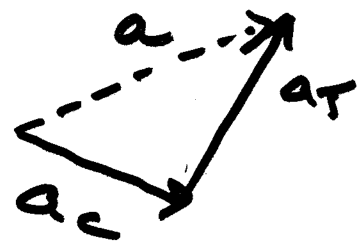
NOW look at NON-uniform circular motion

motion in a circle with varying speed

FOR example

car accelerating by pushing on gas pedal while going around a corner

a_T Tangential acceleration



Total acceleration

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

magnitude of a

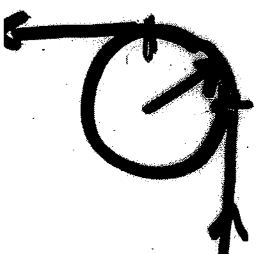
$$a^2 = a_c^2 + a_T^2$$

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

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? (magnitude)

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



$v_0 = 0\ m/s \quad v_f = 22\ m/s \quad a_T = ? \quad \Delta x = \frac{2\pi r}{4}$

$v_f^2 = v_0^2 + 2a_T(\Delta x)$

$\frac{2 \cdot \pi \cdot 87\ m}{4} = 137\ m$

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

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

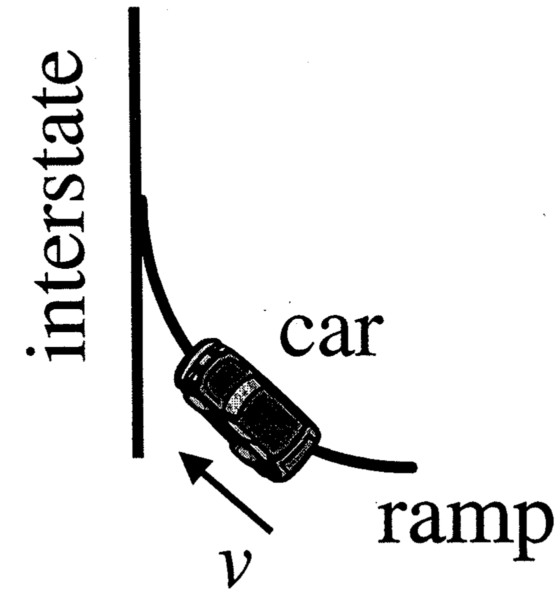
b) $a_c = \frac{(15\ m/s)^2}{87\ m} = \boxed{2.58\ m/s^2}$ $\qquad a_c = \frac{v^2}{r}$

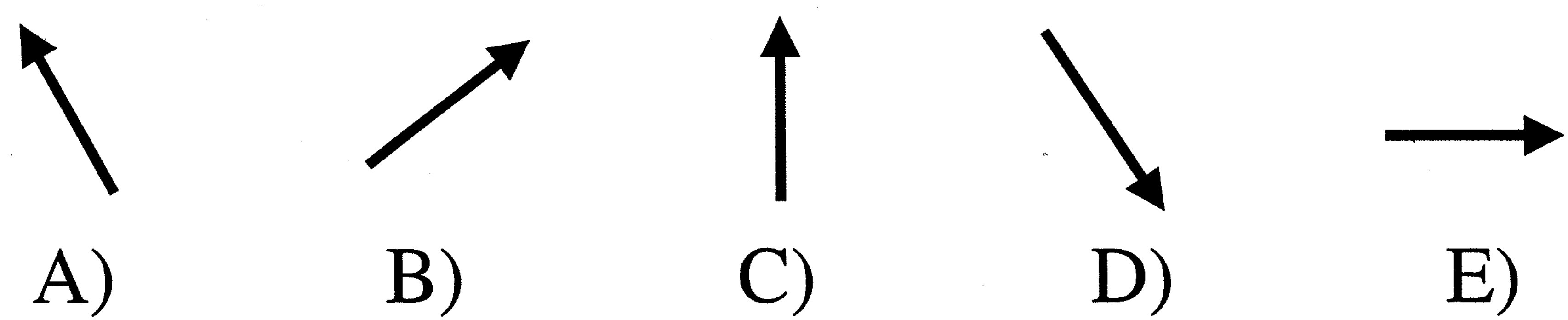
what is acceleration?

$a = \sqrt{(1.7)^2 + (2.58)^2} = \boxed{3.09\ m/s^2}$

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

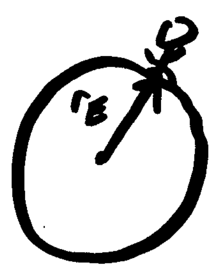
$$F = \frac{G m_1 m_2}{r^2}$$

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

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

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

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

$= gm$

Circular orbits

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

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

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

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

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

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

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

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

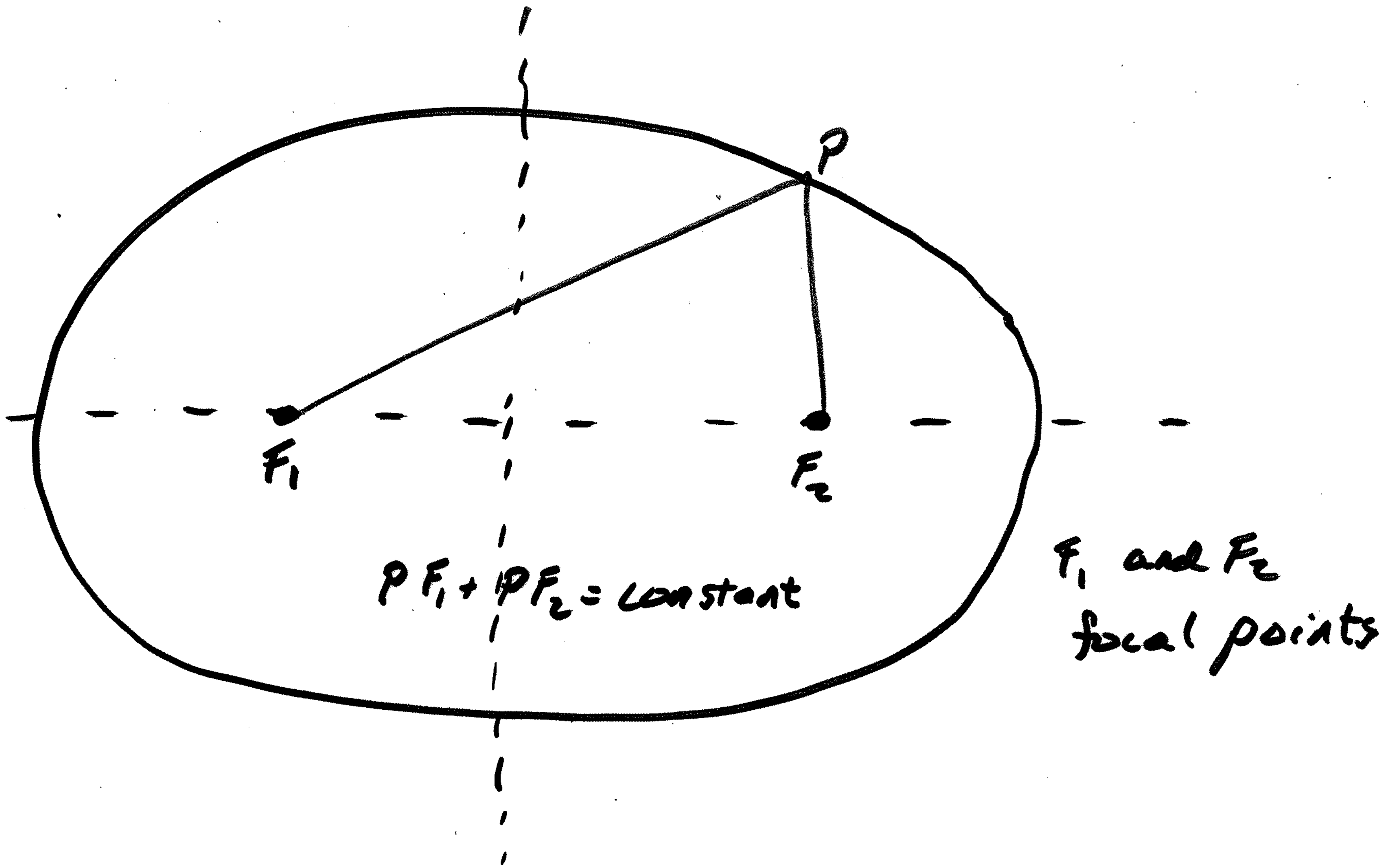
3) Square of orbital period of any planet is proportional to the cube of the average distance from the planet to the sun

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

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

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

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


P
F1
F2
PF1 + PF2 = constant
F1 and F2
focal points

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

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