MOTION IN A CIRCLE   Ch.3

الحركة الدورانية

* $\theta = \frac{S}{r}$

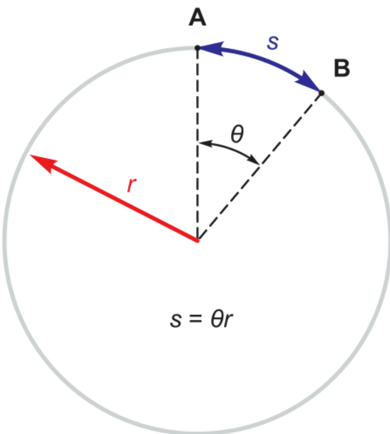
$\theta = 2\pi \leftarrow S = 2\pi r$ لما تكون

*لازم تكون θ بال rad بس

$x \rightarrow \theta$

$v \rightarrow \omega$

$a \rightarrow a_c$



* $\omega = \frac{v}{r}$ / $\omega = \frac{\Delta\theta}{\Delta t}$

(+) عكس عقارب

(−) مع عقارب

* $f = \frac{\text{عدد الدورات}}{t} \rightarrow \omega = 2\pi f$

*عند الدورة الكاملة

التردد ← Hz أو s^{-1}

$\pi = 3.14$

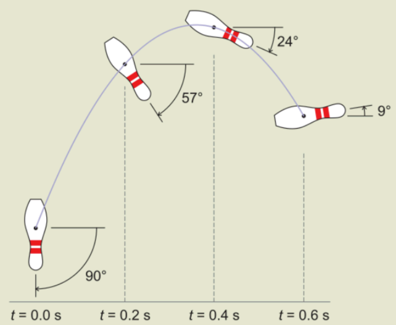
*عشان نحول من درجة ← راديان: $\frac{\theta^\circ}{360^\circ} * 2\pi$

Example 3.1 ***Angular displacement and angular velocity***

Problem:
A juggler throws a bowling pin as shown in Figure 3.2.

(a) What is the angular velocity of the pin?

(b) What will the angular displacement of the pin be at a time of 0.9 s?



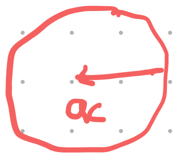
$\Delta\theta = \omega t$

① $\omega = \frac{\Delta\theta}{\Delta t} \rightarrow \frac{-33^\circ}{0.2} * \frac{2\pi}{360} = -2.87 \frac{rad}{s}$ مع عقارب الساعة

② $\theta_f - \theta_i = \omega t + \frac{1}{2}\alpha t^2$ مش عارف ليش اعتبر $0 = \alpha$

$= \frac{90}{360} * 2\pi + -2.87 * 0.9$

$1.57 - 2.58 = -1.013 rad$ مع عقارب الساعة



* $V = \frac{2\pi}{T}$ where $T \to$ (دورة)

السرعة الخطية تتغير باستمرار
في الحركة الدورانية لأنه
الجسم يغير من اتجاهه دائماً
وبالتالي يوجد دائماً سرعة
وتسارع خطي

Key concept:
If an object is travelling in a circle at constant speed, its instantaneous acceleration is always pointed exactly toward the centre of the circle.

centripetal acceleration. التسارع يكون نحو المحور

* $a_c = \frac{v^2}{r}$ تسارع مركزي

* $F_c = m a_c \to \frac{m v^2}{r}$

$\alpha = \frac{a}{r}$ تسارع دائري
تسارع يكون حول محور الدوران

القوة إلي بتحرك لما تكون
سيارة بتدور ← الاحتكاك
قمر والأرض ← جذب عام
والحبل ← قوة شد

Example 3.2 ***Angular velocity and centripetal force***

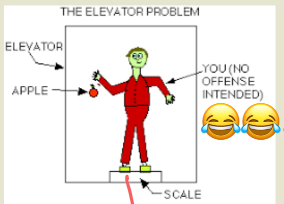
Problem: A 45 kg child is riding the rollercoaster at an amusement park. A portion of the track is made up of two semicircular sections as shown in Figure 3.4, one with a radius of 10 m and the other with a radius of 16 m. The rollercoaster travels along this section of track at a *constant speed* of 7 m s^{-1}.

(a) In what direction is the child accelerating at point A?

(b) In what direction is the child accelerating at point B?

(c) If the child was on bathroom scales, what would they read (in kg) at point A?

(d) If the child was on bathroom scales, what would they read (in kg) at point B?



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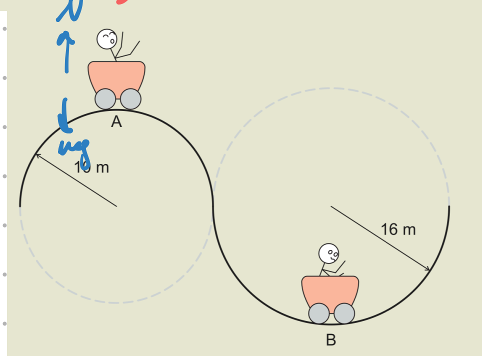
هاد هو



a) قصة سرعة مركزية ← دايماً نحو المركز

b) = = = =

c) بده نحسب N

$\Sigma F = N - mg$

$\frac{m v^2}{r} = N - mg \to N = 230\ N$

$m = 23\ Kg$

3.1 (a) Convert the following values from radians to degrees: (i) $\frac{\pi}{6}$ (ii) $\frac{\pi}{4}$ (iii) $\frac{\pi}{2}$ (iv) 0.1 (v) $\frac{3\pi}{4}$

(b) Convert the following values from degrees to radians: (i) 1° (ii) 45° (iii) 60° (iv) 180° (v) 360° Answer: (a) (i) 30° (ii) 45° (iii) 90° (iv) 5.7° (v) 135°

(b) (i) $\frac{\pi}{180}$ or 0.018 radians (ii) $\frac{\pi}{4}$ or 0.79 radians (iii) $\frac{\pi}{3}$ or 1.05 radians (iv) π or 3.14 radians (v) 2π or 6.28 radians.

a) rad → deg ⇒ $\frac{\quad}{2\pi} * 360°$

i) $\frac{\pi}{6} * \frac{360}{2\pi} = 30°$

ii) $\frac{\pi}{4} * \frac{360}{2\pi} = 45°$

iii) $\frac{\pi}{2} * \frac{360}{2\pi} = 90°$

iv) $0.1 * \frac{360}{2\pi} = 5.73°$

v) $\frac{3\pi}{4} * \frac{360}{2\pi} = 135°$

b) deg → rad

i) $1° * \frac{2\pi}{360} = 0.017$ rad

ii) $45° * \frac{2\pi}{360} = 0.785$ rad

iii) $60° * \frac{2\pi}{360} = 1.046$ rad

iv) $180 * \frac{2\pi}{360} = 3.14$ rad

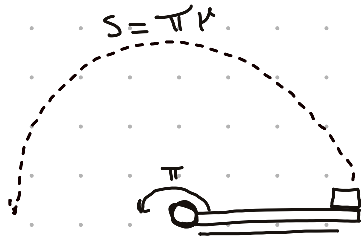
v) $360 * \frac{2\pi}{360} = 2.09$ rad

3.2 In a particular rear-end car collision the driver's head rotates 45° backward before being stopped by the headrest. What is the average angular velocity of the driver's head if the duration of the collision was 0.1 s? Answer: $\omega_{av} = 7.9$ radians s^{-1}

$\theta = 45^\circ \rightarrow \frac{45}{360} * 2\pi = 0.785$ rad

$\omega = \frac{\Delta\theta}{\Delta t} \rightarrow \frac{0.785}{0.1} = 7.85$ rad/s

3.3 When an athlete throws a javelin her forearm snaps through an angle of approximately π radians in 0.20 s. The athlete's hand moves with approximately constant speed, the length of her forearm is 45 cm, and the combined mass of her forearm and javelin is 2.0 kg. Assuming that the system is well approximated by a mass of 2.0 kg located 45 cm from the pivot, what force do the ligaments holding the forearm to the elbow need to exert? Answer: $F = 220$ N



$\theta = 3.14$ rad $\Delta t = 0.2$ s $r = 45$ cm $= 0.45$ m

$m = 2$ kg

لازم عند نهاية
pivot ما بناخذ θ
بناخذ S

$F_c = m a_c \rightarrow F = \frac{m v^2}{r} = 2 * \frac{\left(\frac{3.14 * 0.45}{0.2}\right)^2}{0.45} = 220$ N

3.4 (a) A 3800 kg car travels round an unbanked corner (i.e. a horizontal road) at the recommended speed of 65 km h^{-1}. The radius of curvature is 80 m. What is the force that the road exerts on the car to keep it in motion around the corner?

(b) What force would the road need to exert if the car was travelling at 100 km h^{-1}? Answer: (a) $F = 16 \times 10^3$ N (b) $F = 37 \times 10^3$ N

A) $m = 3800$ kg $v = 65$ km/h $r = 80$ m

$F = \frac{m v^2}{r} \rightarrow \frac{3800 * \left(\frac{65 * 1000}{3600}\right)^2}{80} = 15.4 * 10^3$ N

b) $F = \frac{m v^2}{r} \rightarrow \frac{3800 * \left(\frac{100 * 1000}{3600}\right)^2}{80} = 36.65 \times 10^3$ N

3.5) A car is traveling around a circular race track at 180 km h-1. If a single lap of the track is 2.4 km long, what is the angular velocity of the car (in rad s-1)? Answer: 0.13 rad s-1

3.6 If the car in problem 3.5 weighs 2500 kg, what is the centripetal force acting on the car as it travels around the track? Answer: 16 *10^3 N

Single lap → طول المسار

3.5) $V = 180$ km\h $r = \frac{2.4}{2\pi}$ km $2\pi r$ = المحيط

$$\omega = \frac{V}{r} \rightarrow \frac{\frac{180 \times 1000}{3600}}{\frac{2.4 \times 1000}{2\pi}} = 0.13 \text{ rad/s}$$

3.6) $$F = m\frac{V^2}{r} \rightarrow \frac{2500 * \left(\frac{180 * 1000}{3600}\right)^2}{\frac{2.4 \times 1000}{2\pi}} = 16 \times 10^3 N$$

3.7 An adventurous ant finds herself at the end of a fan blade when it is switched on. It is a high speed fan with blades measuring 0.20 m long. If she has a mass of 0.20 g and can hold on to the fan blade with a maximum force of 0.0124 N. What is the maximum number of *revolutions per minute* the fan can run at before she will be flung off? Answer: 154 rpm

$r = 0.2$ m $m = 0.2 \times 10^{-3}$ $F = 0.0124$

$\frac{rev}{min}$ $$F = \frac{m(\omega r)^2}{r}$$

$$0.0124 = 0.2 \times 10^{-3} (\omega)^2 \, 0.2$$

$$\omega = 17.60 \text{ rad/s}$$

$$\frac{17.60}{2\pi} * 60 = 168.1 \text{ rpm}$$

3.8 An 8.0 m radius merry-go-round completes one revolution every 7.0 s.

(a) What is the angular velocity of the merry-go-round?

(b) With what speed are children moving when they ride on the merry-go-round?

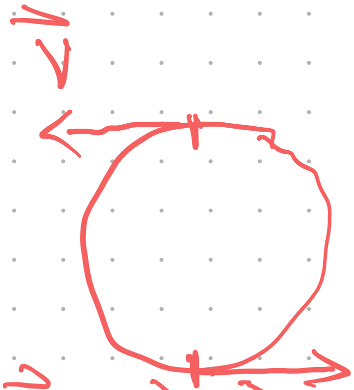
(c) What is the centripetal *acceleration* these children feel when riding on the merry-go-round?

(d) What is the average acceleration of each child over the course of half a revolution of the merry-go-round?

(e) What is the average acceleration of each child over the course of a full revolution turn of the merry-go-round?

Answer: (a) $0.90\ \mathrm{rad\,s^{-1}}$ (b) $7.2\ \mathrm{m\,s^{-1}}$ (c) $6.5\ \mathrm{m\,s^{-2}}$ (d) $4.1\ \mathrm{m\,s^{-2}}$ (e) $0\ \mathrm{m\,s^{-2}}$

$V = \frac{2\pi 8}{7}$



$\vec{a} = \frac{\vec{V} - -\vec{V}}{\frac{T}{2}}$

a) $r = 8$ m, $t = 7$ s, $\omega = \frac{v}{r}$

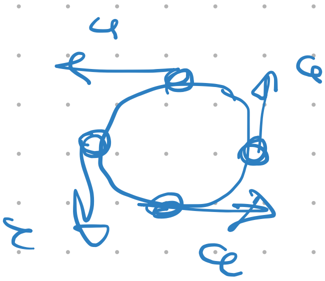
$S = 2\pi r \rightarrow \omega = \frac{\frac{2\pi r}{t}}{r} \rightarrow \frac{2\pi}{7} = 0.89$ rad/s

b) $v = \omega r \rightarrow 0.89 * 8 = 7.17$ m/s

c) $a_c = \frac{v^2}{r}$ $\frac{(7.17)^2}{8} = 6.42$ m/s²

d) ?

e) = 0



مع حمزة بالمحاضرة