**Assignment 3 Due 1/31**

**(Circular Kinematics)**

**Problem 1.** (a) What is the centripetal acceleration of an Earthling around the equator? Note that the circumerance of the Earth is about 24000 miles.

First let’s convert the circumference to meters: C = 24000∙1600 = 2.8×107m. And the radius corresponding to this is R = C/2π = 6.2×106m. Also, our speed would be: vs = Δs/Δt = C/24hours = 2.8×107m/(24∙3600)s = 440m/s. So,

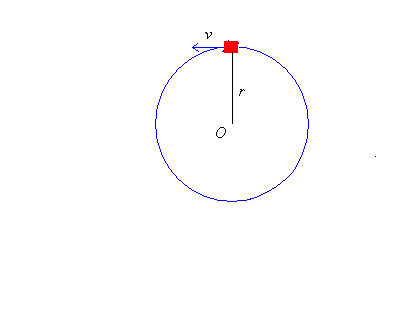


(b) What is the centripetal acceleration of the Earth around the Sun? The distance between Earth and Sun is about 1.5×1011m.

In this case, our speed around the Sun is vs = C/365days = 2πR/365days = 2π(1.5×1022m)/[365∙24∙3600] = 30000m/s. Therefore,



**Problem 2.** Consider a fighter pilot undergoing flight simulation training. Suppose she starts from rest at the top of the circle (R = 5m) with a tangential acceleration of 2m/s2.



(a) when will she have traveled a quarter circle?

The arc length formula is s = s0 + v0st + (1/2)ast2. Taking the initial arc length to be (π/2)R, the final arc length will be πR. And so we’ll have:



(b) what will be her tangential speed?

It’s given by,



(c) what will be the magnitude and direction of her acceleration?

The acceleration would be:



**Problem 3**. Two runners, Martha and George are racing around a circular track, whose radius is 60m. Suppose Martha runs counterclockwise, starting from rest with an acceleration of 0.2m/s2, and George runs clockwise at a constant speed of 6m/s.

(a) write an expression for Martha’s arc velocity vs, and arc position s, as a function of time.

For Martha,



(b) write an expression for George’s arc velocity vs, and arc position s, as a function of time.

For George,



(c) When will they meet the first time? At what angle (express as a positive angle)?

They meet the first time when …



The angle at which they meet is given by θ = s/R. Let’s use Martha’s position formula (though we could use George’s)….



(d) When will they meet the second time? At what angle (express as a positive angle)?

They meet the second time when,

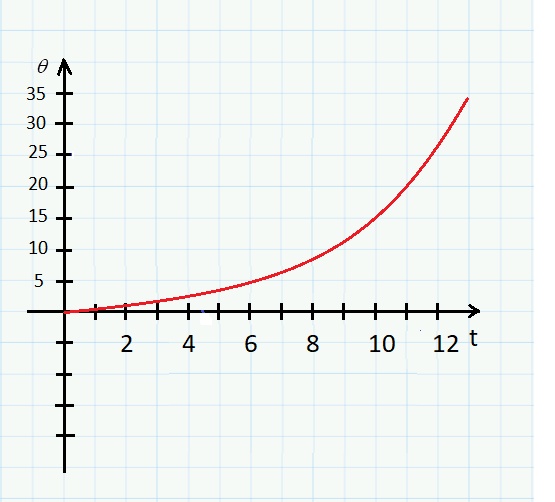


This time, let’s use Martha’s position formula



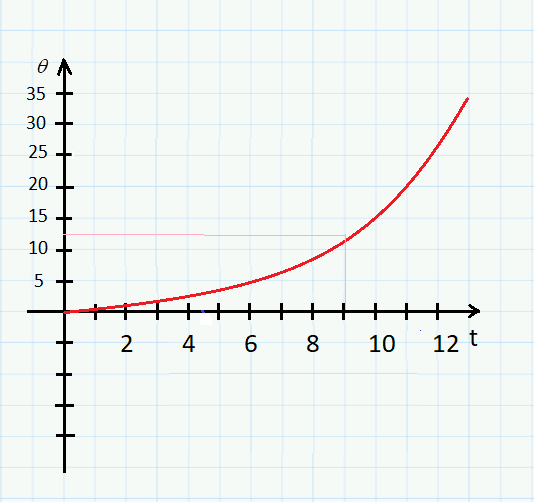
**(Angular Kinematics)**

**Problem 4.** You’re a rather slow figure skater learning to spin. The angle you’ve rotated through as a function of time is plotted below (θ is measured in radians):



(a) Approximately when has he spun through 2 revolution?

This will be when θ = 4π = 12.6rad. And this appears to be about t = 9s.



(b) What is his average angular velocity between 0 and 10s?

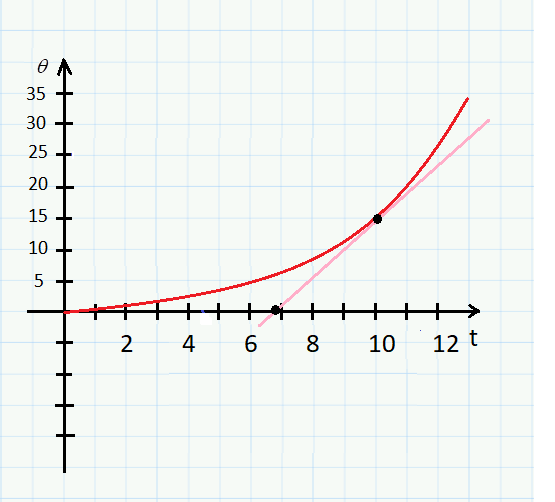
Average angular velocity is:



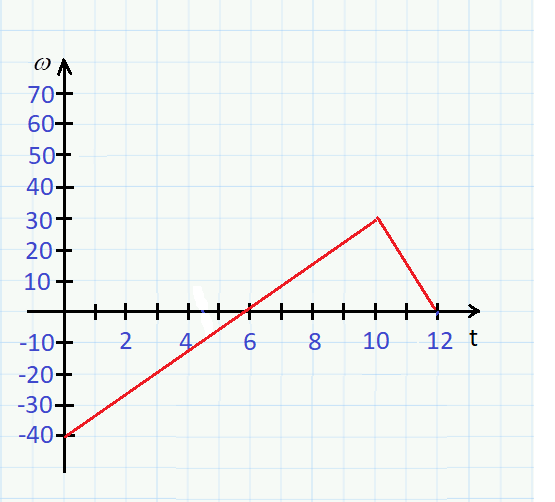
(c) Estimate his angular velocity at t = 10s.

This would be about (using the two points on the line):





**Problem 5.** A yo-yo’s angular velocity (in rad/s) is shown below.



(a) When is it speeding up? Slowing down?

It’s speeding up between (6s, 10s), and it’s slowing down between (0s,6s) and (10s,12s)

(b) What is its average angular acceleration between t = 3s and 12s?

Average angular acceleration is:



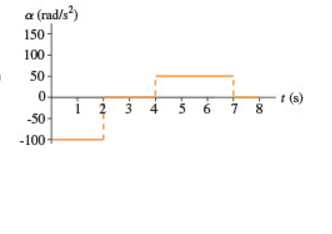
(c) What is its maximum instantaneous angular acceleration?

This would be the maximum (magnitude of) slope, which is the slope of the curve between 10s and 12s.

So,



**Problem 6.** A blender’s angular acceleration is given by the following graph. Assuming it starts from rest…



(a) when is the blender speeding up? and when is it slowing down?

It’s speeding up (clockwise) between the (0,2) time interval, it’s rotating at constant speed between (2,4), and it’s slowing down between (4,7).

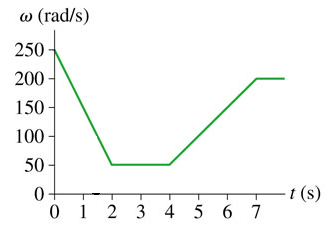
(b) what maximum angular speed does the blender attain during the 8s time interval? Which direction is it turning in?

It’s max angular speed would be at t = 2s. And this speed would be:



The negative sign is indicative of clockwise motion.

**Question 7**. The angular velocity of a flywheel is illustrated below. When did the wheel complete 60 revolutions?



The wheel will complete 60 revolutions when θ = 60(2π) rad = 120π rad = 377rad. This will happen at some time t, illustrated above. According to formula θ = θ0 + ∫ωdt = 0 + ∫ωdt, we need the area under the graph from 0 to t to equal 377rad. The area up to t = 2s is θ = (2s)∙(250rad/s + 50rad/s)/2 = 300rad. So it won’t have happened by then. The area up to t = 4s is θ = 300rad + (2s)(50rad/s) = 400rad. So now we’ve gone too far. We need the area after t = 2s to be 77 rad, and this will happen when Δt∙(50rad/s) = 77 → Δt = 77/50 = 1.54s. So t = 2s + 1.54s = 3.54s.

**Problem 8.** When you turn on your fan, it goes from an angular speed of 0 rev/s, to an angular speed of 5 rev/s in a time span of 4s.

(a) What is the angular acceleration of the fan in rad/s2?

Well,

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(b) What was the fan’s angular velocity at t = 3s in rad/s? (in rpm)?

And,

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and this corresponds to:



(c) What is the angular displacement of the fan in these first 3s in rad? (in rev)?

So,

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Which corresponds to:

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(d) The fan blade has a length of 45cm; what distance has the tip of the fan blade rotated through by 3s?

The distance is given by the arc length s = rθ. So,

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(e) How fast is the tip of the blade moving after 3s?

To get the speed of the blade we will use the formula v = rω. So:

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(f) What is the magnitude of the total acceleration of the tip at that time? (in g’s)?

This is a = √(as2 + ac2), where as = rα, and ac = rω2. So,



which would be:

