HOMEWORK SET 1: CONSTANT ACCELERATION IN ONE DIMENSION
Due: Wednesday, September 4, 2024

Kinematics:

$$x = x_0 + v_0 t + \tfrac{1}{2} a_0 t^2, \quad v = v_0 + at,$$
$$v^2 = v_0^2 + 2a(x - x_0), \quad x = \tfrac{1}{2}(v + v_0)t$$

1) A load of bricks is being lifted by a crane at a steady velocity of 5 m/s when one brick falls off 6 m above the ground.

a) What is the greatest height the brick reaches above the ground?
(Use a *single* calculation to do this, not two! Carefully think of which equation to use! Which variable do you know something about at the maximum height and which variable do you not care about?)

b) How long does it take to reach the ground?

c) What is its speed just before it hits the ground?

Answers: a) y_{max} = 7.28 m, b) t_{air} = 1.73 sec, c) v_{hit} = 11.9 m/s downward

2) At t = 0, a stone is dropped from a cliff above a lake; 1.6 s later another stone is thrown downward from the same point with an initial speed of 32 m/s. Both stones hit the water at the same instant. Find the height of the cliff. (Which variable is the same for both stones?) Answer: y_{cliff} = 27.5 m

3) A passenger is running at her maximum velocity of 8 m/s to catch a train. When she is a distance d from the nearest entry to the train, the train starts from rest with a constant acceleration a = 1.0 m/s^2 away from her.

a) If d = 30 m and the passenger keeps running, will she be able to jump onto the train?
(Assume she is not Sha'Carri Richardson … ***she*** probably doesn't have to run for trains! Which variable has to be the same for the passenger and train for the passenger to jump on of x, v, a, and t?)

b) The critical separation distance is that at which the passenger can just catch the train. Determine its value. (Determine d_c analytically … you end up with a quadratic expression for t giving two roots … under what circumstance does the quadratic have a single root?). What is the speed of the train when the passenger catches it? What is the train's average speed for the time interval from t = 0 until she catches it?

c) With Mathematica, Python (or other plotting program such as Desmos), sketch the position function x(t) for the train, choosing x = 0 at t = 0. On the same graph sketch x(t) for the passenger for various initial separation distances d, including d = 30m and the critical separation distance d_c such that she just catches the train.

Answers: a) t_{catch} = 6 s or 10 s (explain each), b) d_{crit} = 32 m, $v_{T,catch}$ = 8 m/s, $\langle v_T \rangle$ = 4 m/s

4) During a panic stop, a car decelerates at 7 m/s^2.

a) What is the angular acceleration of its 0.280 m radius tires? Answer: α = -25 rad/sec^2

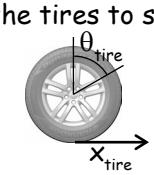
b) For ω_0 = 95 rad/s, how many revolutions does it take the tires to stop? Answer: θ = 28.7 rev

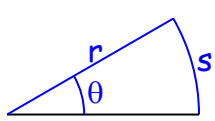
c) How long does it take? Answer: t = 3.80 s

d) How far does the car travel in this time? Answer: x = 50.6 m

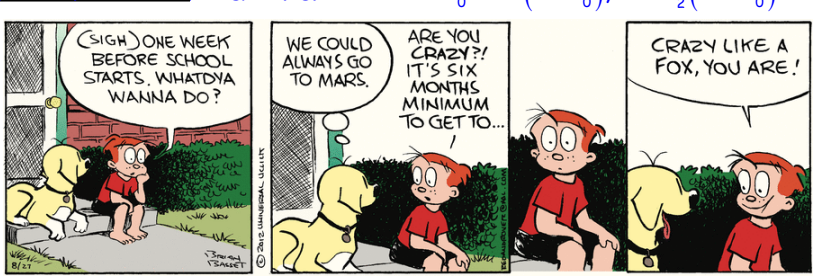
e) What was the car's initial speed? Answer: v_0 = 26.6 m/s

Sketch the tire, not the





$$s = r\theta$$
$$v = r\omega$$
$$a = r\alpha$$

Rotational Kinematics:

$$\theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha_0 t^2, \quad \omega = \omega_0 + \alpha t,$$
$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0), \quad \theta = \tfrac{1}{2}(\omega + \omega_0)t$$