

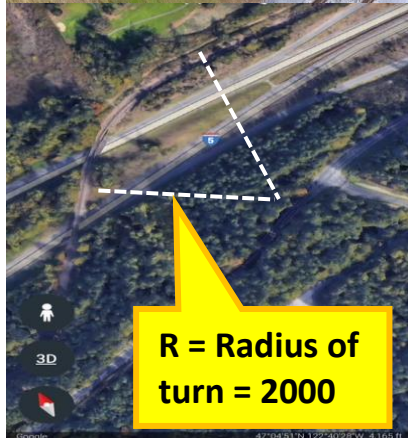
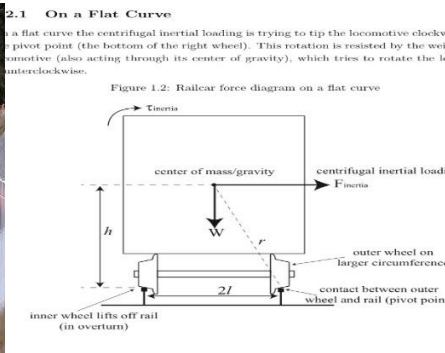
# CENTRIPETAL FORCE

Unit 14 Dr. John P. Cise, Professor of Physics, Austin

Com. College, Austin Tx. [jpcise@austincc.edu](mailto:jpcise@austincc.edu) & NYTimes Dec. 18,2017, by Kirk Johnson, Richard Perez-Pena & Niraj Chakshi

## Multiple Deaths in Amtrak Train Derailment in Washington

A passenger train on a newly opened Amtrak route jumped the tracks on an overpass south of Tacoma on Monday, slamming rail cars into a busy highway, killing at least three people and injuring about 100 others, officials said. The derailment of Amtrak Train No. 501, making the inaugural run of a new service from Seattle to Portland, dropped a **132-ton locomotive** in the southbound lanes of the Northwest's busiest travel corridor, Interstate 5. Two passenger coaches also fell partly in the traffic lanes, and two other coaches were left dangling off the bridge, one of them wedged against a tractor-trailer. On the highway below lay five crumpled cars, two semi trucks and huge chunks of concrete that were ripped away from the damaged overpass. 12 of the train's coaches and one of its two engines derailed. The National Transportation Safety Board said at a Monday night briefing that the train had been traveling more than twice the speed limit before it derailed, or at **80 miles per hour instead of the allowable 30 m.p.h.** Bella Dinh-Zarr, a member of the safety board, said at the briefing that it was unclear why the train was traveling so fast or whether the operator's unfamiliarity with the new route had caused the accident. The train derailed where the track curved onto the bridge across Interstate 5. The State Transportation Department had boasted that the new route would have a **top speed of 79 miles per hour**. Shortly before the accident, a passenger, Chris Karnes, chairman of [the advisory board](#) to Pierce County's transit agency, [took to Twitter](#) to marvel at how fast the train was moving, noting, "We are passing up traffic on I-5."



**INTRODUCTION:** This turn was rated for 30 mph and the train was going at 80 mph. Too high a speed for tracks to supply required centripetal force on train.

**QUESTIONS:** (a) Convert 30 & 80 mph to ft./s.?, (b) Find proper centripetal acceleration when train was to make this turn at 30 mph?, (c) What is the improper Centripetal acceleration this train needed to make the turn at 80 mph?. (d) Find mass (in slugs) of this 132 ton train engine?. (e) Find proper centripetal force  $F_c$  (supplied by the rails) this train needed at 30 mph?, (f) Find improper (unavailable) centripetal force from track rails (see graphic above) when train was going at excessive speed of 80 mph?, (g) How much larger was the needed improper centripetal force at 80 mph compared to proper 30 mph needed centripetal force?,

**HINTS:** weight =  $m g$ ,  $g = 32 \text{ ft./s.}^2$ ,  $a_{\text{CENTRIPETAL}} = V^2/R$ ,  $F_{\text{CENTRIPETAL}} = m V^2/R$ , 60 mph = 88 ft./s.

**ANSWERS:** (a) 44 ft./s. , 117.73 ft./s. , (b)  $a_{30 \text{ MPH}} = 0.968 \text{ ft./s.}^2$ , (c)  $a_{80 \text{ MPH}} = 6.88 \text{ ft./s.}^2$ , (d)  $m = 8250 \text{ slugs}$ , (e)  $F_{30 \text{ MPH}} = 7986 \text{ lb.}$ , (f)  $F_{80 \text{ MPH}} = 56,789 \text{ lb.}$ , (g)  $F_{80}/F_{30} = 7.111$  times larger, thus 711 % larger centripetal force was needed by the track rails ON train and cars at the excessive turn speed at 80 mph compared to proper authorized speed of 30 mph.

**COMMENT:** Centripetal force needs are not linear, but increase as the square of the speed:  $F_c = m V^2/R$