

FLUIDS: BERNOULLI CONCEPT

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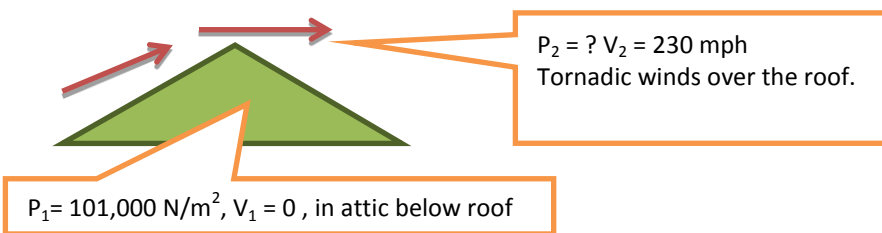
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INTRODUCTION: When Joplin's F5 Tornado(230 mph winds) blows over a 2000 ft² roof ...the roof explodes outward with a force of about 136 tons. The reason for this huge force is the air inside attic is at zero velocity($V_1=0$) and normal atmospheric pressure($P_1= 101,000$ N/m²), while the wind outside on the roof top is $V_2 = 230$ mph. Bernoulli's Principle says with increased velocity the Pressure drops. In terms of energy conservation for moving fluids(Bernoulli) $P_1 + 1/2(\rho)V_1^2 = P_2 + 1/2(\rho)V_2^2$ Where (ρ) = air density = 1.225 kg/m³

JOPLIN, Mo. — When the warning — “Execute Condition Gray!” — blared through the halls of St. John’s Regional Medical Center, nurses began rolling patients’ beds into the hallways, as they had been trained to do time and again in this tornado-prone region. But just as workers were completing the precautionary steps Sunday night, the entire nine-story building was pummeled by a tornado. Glass shards exploded from every window, doors blew open, and even patients’ IV-lines were ripped from their arms. By the time the three-quarter-mile-wide tornado — among the deadliest in the nation’s history — moved on, the hospital was a scene of stunned chaos. Nearly every patient was splashed or covered with blood from all the glass, and people in the emergency room on the first floor were sucked out of windows into the parking lot. Even a backup generator failed, leaving ventilators and other medical equipment without power in dark rooms. One panicked nurse, who had been in the intensive care unit, pleaded for help when machines stopped pumping air into the lungs of critically ill patients. “I’ve got patients dying up there!” Robert Kuhn, a hospital worker, recalled the nurse calling out. The doctors told him to go back and pump the air manually. At least 116 people were killed and hundreds more injured, city officials said Monday, as hundreds of emergency workers searched for others beneath the rubble that blanketed this southwest Missouri city. Leaders said they expected the death count to continue to rise.



QUESTIONS: (a) Convert 230 mph to m/s? Note: 1.61 km/s = 1 mph , 3600 s = 1 hr (b) Find the pressure(in N/m²) differential ($P_1 - P_2$) between inside and outside the roof? Note: Use Bernoulli’s principle listed above. (c) What is P_2 (in N/m²) on outside surface of roof as the tornado passes over the roof at 230 mph? (d) 14.7 lb/in²(PSI) = normal atmospheric pressure $P_1 = 101,000$ N/m². Convert P_2 into PSI? (e) Find $P_1 - P_2$ in PSI units ? (f) Find outward force(in pounds and tons) on 2000 ft² roof’s underside? Note: 144 in² = 1 ft² , 2000 lb = 1 ton

ANSWERS: (a) ~ 102.86 m/s , (b) ~ 6481 N/m² (c) ~ 94,519 N/m² (d) ~ 13.76 psi, (e) ~0.943 lb/in² , (f) ~ 271,584 lb. , ~ 136 tons