ME 328 – Machine Design
Quiz 3– Closed book, closed notes, NO calculator
February 24, 2020

This exam is MY work, and my work ONLY:

Signature: SOLUTION

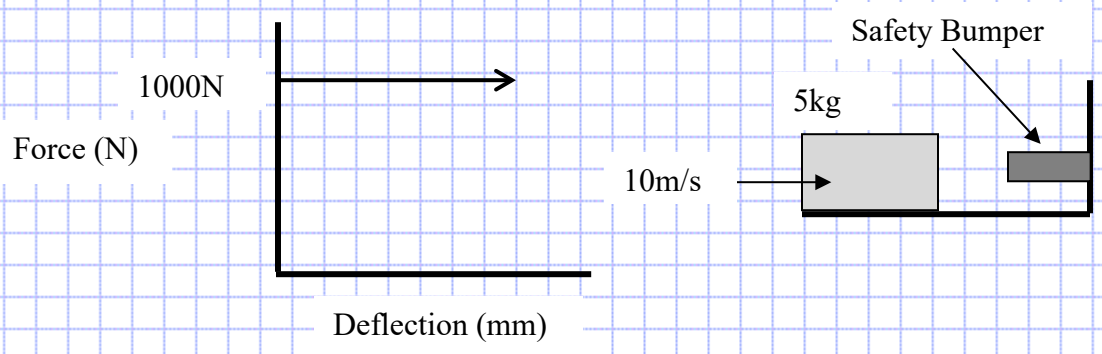
Print name:

For full credit, you must show units at every step and show variable form of equations before inserting values. Values must include units at every step. Since you do not have a calculator, you do not need to calculate the answer, but solve it symbolically (with variables only) and then include appropriate numbers so that if you had a calculator it would be a matter of simple number crunching. If you don't have values for all parameters, leave them as variables in your final equation. If you cannot calculate answers with the information provided in this exam, explain why and/or what information would be required.

Equations:

$\delta_{max} = \delta_{st} K$ $P = WK$ $K=\{ 1 + (1+ 2h/\delta_{st})^{1/2}\}$, $PE = mgh$, $KE = ½ mv^2$, $E= ½ kx^2$; $E=\int Fdx$

1. If a 5 kg object is moving horizontally at 10m/s (without friction) strikes a "safety bumper". The safety bumper immediately reacts with a 1000N force, and remains at 1000N at indefinite distance. How much will the bumper deform (deflect)? What is the peak impact force? STATE ALL CRITICAL ASSUMPTIONS.



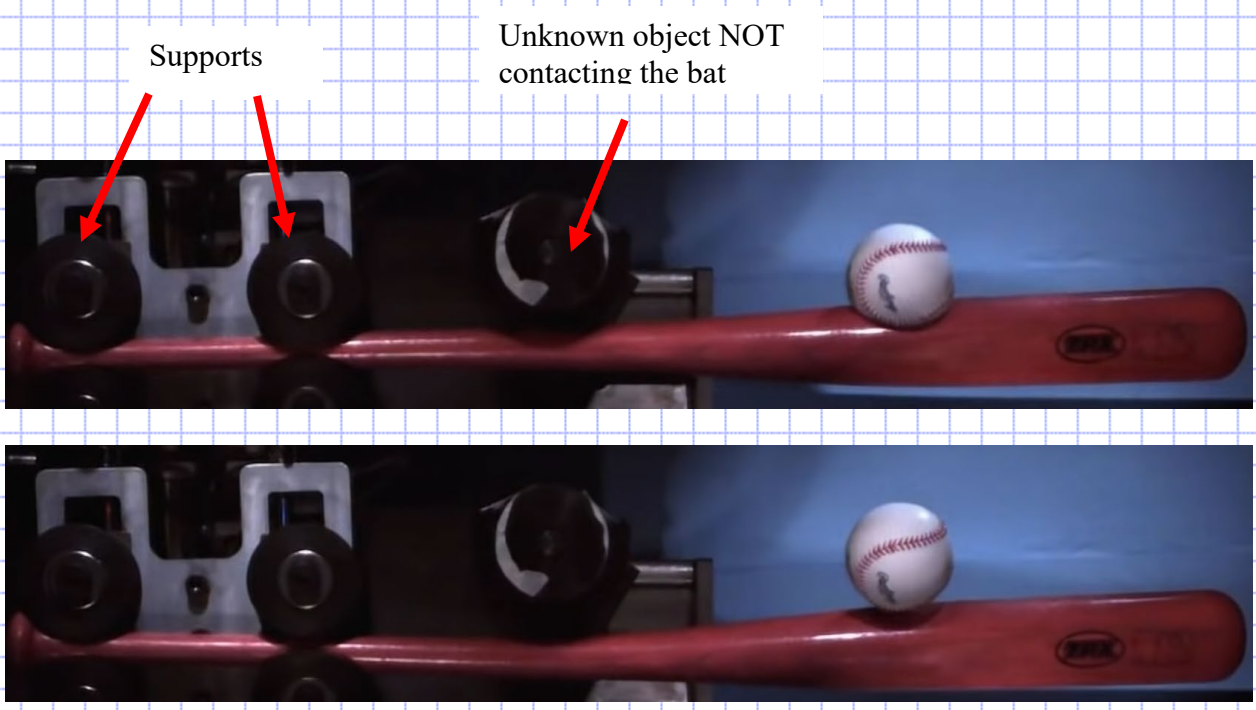
ANS:
KE goes into Spring Energy, which is the "area" under F-d curve ($\int Fdx$)

$KE = ½ mv^2 = ½ (5kg)(10m/s)^2=250Nm$

$\int Fdx$ = 1000N δ_{max} = 250Nm (the KE); therefore, δ_{max} = 250Nm/1000N = 0.25m = **250mm**

F_{max} = **1000N** (F is constant in this spring, not a function of displacement)

Continued on back…



2. In class, we watched a time-lapsed video of a baseball hitting a baseball bat (a "cantilever beam"). Based on the screen-shots above (top image is near the initial contact time, the lower image is a small fraction of time later showing the bat bending just after impact with the ball), briefly describe one important assumption we have been making with impact analysis that is evidently not valid for baseball/bat impact as demonstrated in either image above.

ANS:
The bat is the "spring", the ball is moving "object"
Assumptions:

- Massless spring: violated based on the shape of the bat in lower image, and by reason that it probably weighs more than the ball
- Deflection during impact is the same as quasi-static deflection: violated in lower image, the bat tip seems to deflect upward, whereas static loading would cause it to go downward.
- Rigid object (the ball): violated in the upper image (that ball is highly deformed)