

# Spaghetti and Gumdrops Grand Challenge

A DARPA-esque exercise in  
engineering whimsy

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# Why DARPA-esque?

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- DARPA has approaches for high-risk high-impact programs that push boundaries of current scientific understanding.
- DARPA idiosyncrasies include:
  - Heilmeier's catechism
  - Quad charts
  - Odd wording/TLA's mix with a military bent
  - Moving goalposts
  - Frequent milestones and reporting desirements
  - Phased agendas

# Agenda

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- **Phase I**
  - Why are we doing this?
  - Introductions
- **Phase II**
  - Pregame Competition
  - Review Scoring metric
- **Phase III**
  - Grand Challenge

# Heilmeyer's Catechism (7 questions)

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1. *Our problem:* Find a way to engage NSF PI meeting participants so they can learn more about each other.
2. *Past approaches:* Lightning talks, plenary & poster sessions
3. *What is new:* Competitive team activity involving engineering, dry pasta and candy
4. *If successful:* New contacts made for future collaborative work that may or may not involve pasta
5. *Risks:* Shattering noodles
6. *Costs:* \$1 per box of gumdrops, \$1.25 per box of spaghetti
7. *Milestones:* Score assessment at end of session.

# Break into teams of three

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- Introduce yourselves.
  - Which program (FRR or NRI)?
  - Where from?
  - What discipline? (Of particular value mechanical, civil, architecture)
- Find out who is left handed or right handed
- Find out who likes to eat gumdrops

# The Old Marshmallow challenge

- Build tallest tower with limited resources.
- In 18 minutes.



20 sticks of spaghetti



+ one yard tape



+ one yard string



+ one marshmallow

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TED Ideas worth spreading

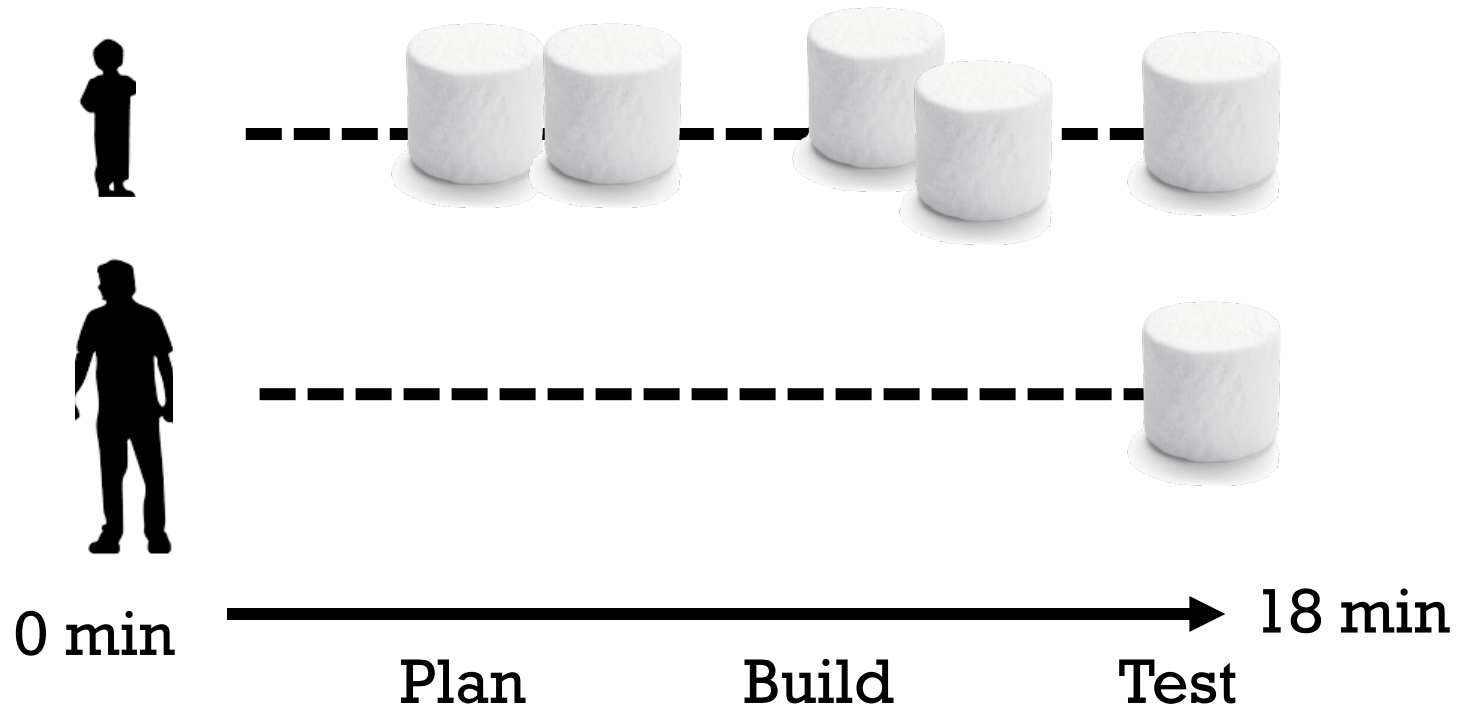


TOMWUJEC

# Who performed best?

Wujec studied 70 groups

- Kindergarten kids
- CTO's
- MBA's



- Key is prototyping and iteration



# Spaghetti Quad Chart



## Performance Goals

- Achieve highest score according to our metric.

$$P = S * C - \left[ 50 + \frac{(N - 10)^3}{20} \right]$$

## Operational constraints

- Attach gumdrops to noodles to form a tower
- Each team member must use only one hand

## Funding (resources)

- Desirement: fewer gumdrops
- Higher stability is better.
- Fewer noodles is better
- Temporary stability is okay.

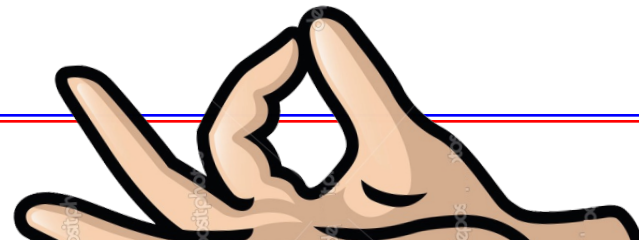
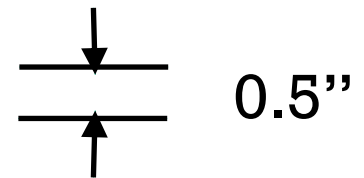
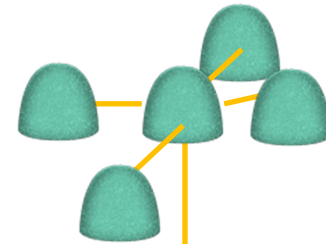
# Failure modes for this structure?

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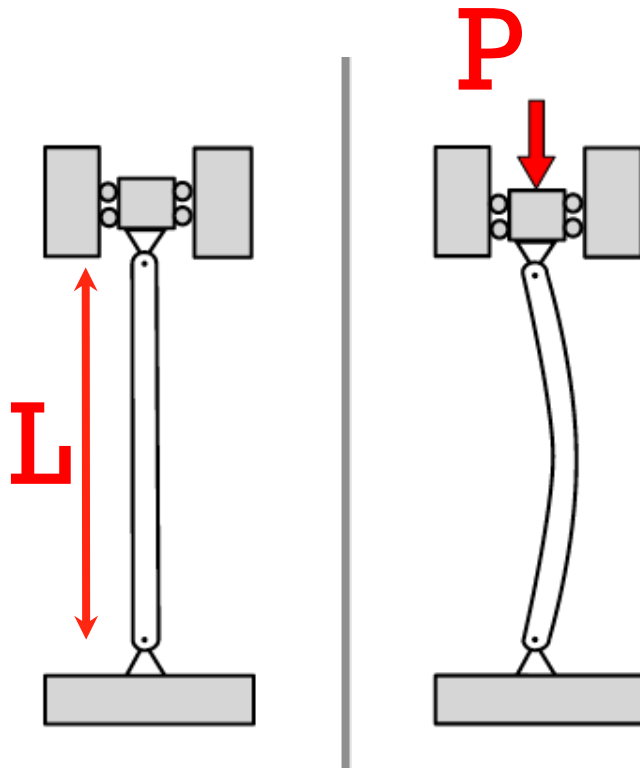


# Pre-game Spaghetti Challenge

- Take 5 gumdrops, attach them together with 4 pieces of spaghetti of any length with one in the middle
- Stick a full length noodle into the center gumdrop.
- See if you can support the structure without it breaking if you can only touch the bottom half inch.



# Buckling



Pinned-pinned end conditions  $K = 1$

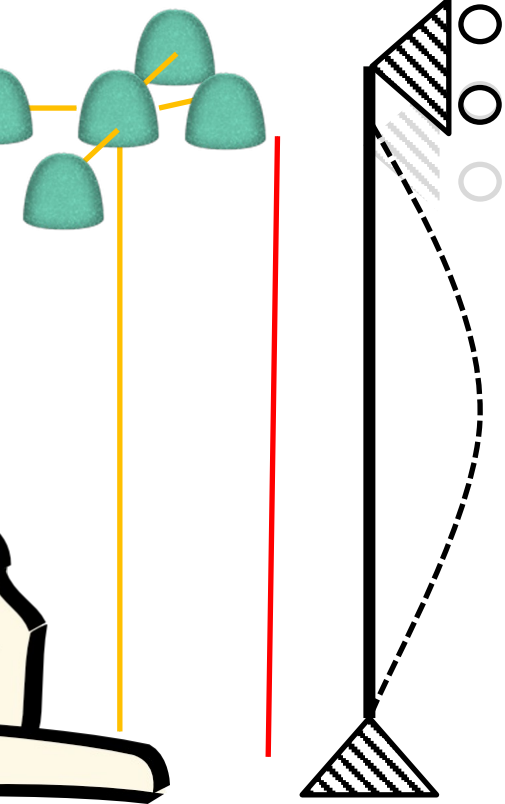
$$P_{CR} = \frac{\pi^2 EI}{(KL)^2}$$

Where  $E$  is the modulus of elasticity  
 $K$  effective length factor

# End conditions

$$P_{CR} = \frac{\pi^2 EI}{(KL)^2}$$

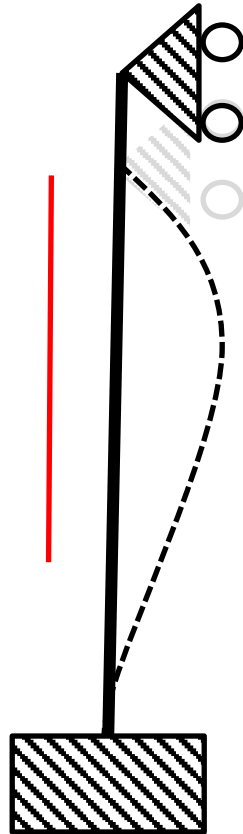
pinned



pinned

$K = 1$

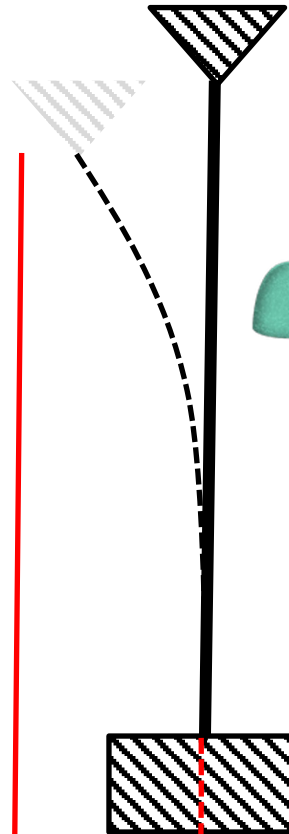
pinned



fixed

$K \sim 0.7$

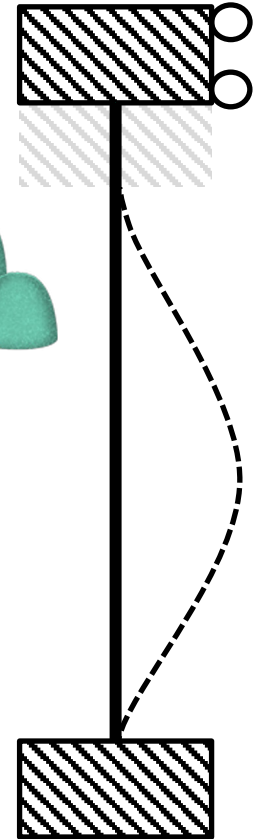
free



fixed

$K = 2$

fixed



fixed

$K = 0.5$

# Spaghetti Grand Challenge

- Time limit: ~20 mins (or end of session)
- ~20 sticks of spaghetti
- Up to 20 gumdrops
- 1 bottle of water (don't open)
- Maximize P
  - C = height of bottom of bottle in mm
  - N = number of whole spaghetti noodles (estimated)
  - S = stability modifier
    - S = 1 if support for 5 seconds
    - S = time with no visible motion / 5 seconds

$$P = S * C - \left[ 50 + \frac{(N - 10)^3}{20} \right]$$



# Example Score:

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- $\sim 1/2$  spaghetti stick tall,  $C = \sim 130\text{mm}$
- 11 spaghetti noodles used,  $N = 11$
- Mark's score =  $130 - (50 + 1/20) = 79.95$
- Stable  $S=1$

$$P = SC - \left[ 50 + \frac{(N - 10)^3}{20} \right]$$