Freshman Seminar: The Art and Science of Motorcycle Design



TIGER CUB: 2007 ('58); 2009-10 ('62); 2010-11 ('63); 2011-12 ('64); 2012-13 ('59); 2014-15 ('57); 2015-16 ('65) TERRIER: 2013-14 ('55);



Restoration Team - Princeton Class of 2017 last day of class



Restoration Team - Princeton Class of 2017 12 weeks earlier

Often, we begin with a rusty broken motorcycle We restore one each year





Students read two books that use motorcycles to explain ideas or points of view – they learn all of the motorcycle references – for example, what does it mean to choke an engine? Why use a choke? One hour in class discussion – Two hours of lab work – 2x per week

A motorcycle is an engineering system

STRUCTURE	_	Steel Tubular Frame
MACHINE	_	Valved Piston Engine
NETWORK	-	Sparked Ignition
PROCESS	_	Chemical Combustion

All components work together -- Vehicles integrate industries

CRITICAL COMPARATIVE ANALYSIS



All Triumph Cub motors have same displacement (200 cc), but the 1958 motor achieves 10 Hp, and the 1965, 14 Hp. Why are they different ? Ans: better breathing (larger intake port) and higher RPM (ball bearings)



- For wire-spoked rear driven wheel center hub rotates and stretches spokes
- Stretched spokes (half of them shown in blue) pull rim along clockwise
- Remaining half of the spokes are compressed effectively detached from rim
- In braking, the roles reverse, the gray spokes stretch so hub resists rim rotation

A good engineering question – What spoke wire diameter is needed ? Answer: using 40 spokes of mild steel -- 1/16th of an inch diameter This provides a safety factor of 2.



Caitlin and Noel (Princeton retired alum who helps with the Seminar) "true" the wheel by carefully tightening the spokes – start by plucking spokes so that they all "ring" with the same musical note – then adjust so the wheel rolls without wobble (both coaxial and out of plane)

In some cases we manufacture our own parts using modern design tools.





Rear wheel fork on sprocket side often fractures during aggressive braking – as a result, replacement forks are impossible to find – so we make our own.

Clutch Team – 2010



Triumph uses a wet clutch (oil-bathed spring-loaded friction plates) - clutch allows engine crank to attach and detach from drive train – allows for shifting gears and saves engine if transmission jams.





Kristyna Smith Megan Skalbeck Victoria Cadiz Casey Cortes

FRS 108 March 3rd, 2010



Mid-semester interlude — learn how to drive a Model T





In the Ford kitchen . . . this little trial engine sputtered into life

Ask the experts ...



Prof. Arnold (MATERIALS)



Prof. Smits (FLUID MECHANICS)



Prof. Ju (COMBUSTION)

Hard work pays off – look at those happy faces!



Key points

- 1. See the whole how do the pieces <u>work</u> together?
- 2. Fix it analytic at all scales How do all the pieces <u>fit</u> together? What is the function of the left-over part? Why won't motorcycle start? Problem might be electrical (weak or no spark), mechanical (timing valve or spark), chemical (carburetion rich / lean / none) How to sort it out? use scientific method in the toughest cases
- **3**. Do it How to take it apart? How to recover from a broken piece? How to put it together without breaking more parts?
- 4. Read about it (especially the service manual!) Many suggestions in the literature some are good and some are not.
- 5. Ask experts (those with knowledge and experience).
- 6. Write about it final report as web-posting.

MAKING can be inspirational But, RE-MAKING is better for learning

- Start with something that was once working.
- Get it working again.
- Figure out how to make it better.