

Time: _____

PHYS-113(3) (Kaldon-10717)
WMU - Fall 2001

Final Exam - 000,000 points
Sample Final Exam from Spring 1995

Name _____

Section: 3a 3b 3c 3d
 A to G H to M N to S T to Z Rev. 11/18/01

State Any Assumptions You Need To Make -- Circle Any Final Answers
Use Your Time Wisely - Work on What You Can - Be Sure to Write Down Equations
Show All Work - Feel Free to Ask Any Questions

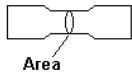
Somewhere in the Adriatic - The Navy, It's Not Just a Job, It's an Adventure (40,000 pts.)

1.) Aboard the aircraft carrier *USS Abraham Lincoln*, a 320,000 N (32,700 kg) US Navy F-14 Tomcat (star of the recent Kalamazoo Air Show) is about to be launched into the air by brute force by its two 100,000 N thrust engines and a steam catapult. Since the carrier is already heading into the wind, the F-14 will "only" have to go from 30 mph (13.0 m/s) to 200 mph (90.0 m/s) in a distance of 80.0 m.
(a) Find the acceleration of the F-14.



(b) Carefully draw a free body diagram of the F-14 as it is being launched, assuming that there is no friction. Find the force supplied by the steam catapult during the launch.

(c) In order to keep the F-14 in its place until it can safely take-off, a brittle steel pin (tensile strength = 2.00×10^9 Pa) is used that won't break under the thrust of the two engines, but will break with the thrust plus the catapult. What cross-sectional area should this pin have? *Hint: find the areas that will just break for engines alone and engines+catapult, then average.*



(d) Assuming that the F-14 was at rest on the carrier's deck to begin with, find the total change in mechanical energy when the F-14 is cruising at Mach 2.34 ($c_s = 331$ m/s) and 60,000 ft (18,300 m).

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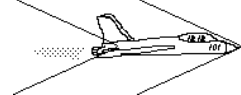
Top Gun (Part II) - Sonic Booms Over Bosnia (40,000 points)

2.) When we last saw our intrepid US Navy F-14 jet, it was cruising at Mach 2.34 ($c_s = 331$ m/s) and 60,000 ft (18,300 m). One hundred miles away (161 km), a NATO commander in Bosnia requests some air support. If the F-14 immediately heads toward him, (a) when will he see the plane overhead?

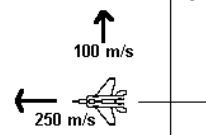


(b) ... when will he hear the plane overhead?

(c) The sonic boom is actually composed of two shock waves, 16.7 m apart, coming from the nose and the tail of the jet. How much time is there between the two parts of the double boom?



(d) On the return flight to the aircraft carrier, the F-14 is pointed due West and travelling at 250 m/s. They encounter a 100 m/s crosswind headed due North. Find the direction and speed of the F-14, using due East as our standard angle reference.



Once In A Bleu Moon (40,000 points)

3.) Given its pale, pockmarked surface, it is probably not too silly for people a long time ago to joke (or wonder) about the Moon being made of cheese. Suppose the Moon was (a) Consider a slab of Treasure Cave Blue Cheese: 0.0852 kg (85.2 g), $0.0200 \text{ m} \times 0.0600 \text{ cm} \times 0.0600 \text{ cm}$ ($2.00 \text{ cm} \times 6.00 \text{ cm} \times 6.00 \text{ cm}$). Find its density, ρ . Once you have the density of the blue cheese, find the mass of this Bleu Cheese Moon. The Volume of a sphere is $(4/3) \pi r^3$. The radius of the Moon is $1.74 \times 10^6 \text{ m}$.

(b) Find the value of " g_{Moon} " near the surface of this Bleu Cheese Moon.

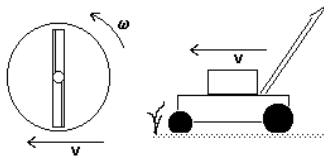
(c) Since the Moon has no atmosphere, you can safely put a satellite in an orbit about one kilometer about the surface. How fast does this satellite go around the moon?

(d) What is the period (T , the time to make one orbit) of a satellite that is orbiting 1000 km ($1.000 \times 10^6 \text{ m}$) above the surface of the Bleu Cheese Moon. *Try to use Kepler's 3rd Law; otherwise, use any legal method.*

The Lawnmower Man (40,000 points)

4.) The maker of a self-propelled gas lawnmower claims in their ad that "the cutting bar strikes each blade of grass five times as the mower moves forward at normal walking speed (1.00 m/s)".

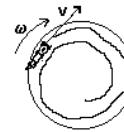
(a) Given that the blade is 0.700 m long, how many revolutions per second must the blade be turning to whack that blade of grass five times as the mower moves forward at 1.00 m/s; what is the angular velocity ω ? *NOTE: Be sure to PTPBIP, you can't just do $\omega = v/r$.*



(b) The ad continues, "to meet Federal safety standards, the blade brake will stop the blade in one revolution". Find the angular acceleration α needed to stop the blade.

(c) The 2.00 kg blade can be modeled as a solid rod or bar. Find the torque needed to stop the blade.

(d) As you mow around the yard, what happens to " v " or " ω "? Why?

**"A Hot Time In The Old Town Tonight" (40,000 points)**

5.) An engine works at 90% of the Carnot efficiency for the reservoir temperatures of 300 K and 350 K.

(a) What is the efficiency of this engine?

(b) If this engine pulls 500 J of heat out of the hot side with each cycle, how much heat is rejected to the cold side? How much work is extracted?

(c) Suppose, instead of large hot and cold reservoirs, we only had 1.00 kg of water on the hot side and 1.00 kg of water on the cold side (this is one liter for each side). Assuming that we could continue to extract heat from the hot side and reject heat to the cold side at the same rate, how many cycles would it take to bring the hot and cold sides to the same temperature? (The specific heat of water is $4200 \text{ J/kg}\cdot^\circ\text{C}$.)

(d) Suppose the work from one cycle is used to compress a gas whose original volume is 1.00 m^3 . If the pressure is held constant at 101,300 Pa and the number of moles does not change, what is the final Volume and Temperature of the gas? ($R = 8.31 \text{ J/mol}\cdot\text{K}$)