

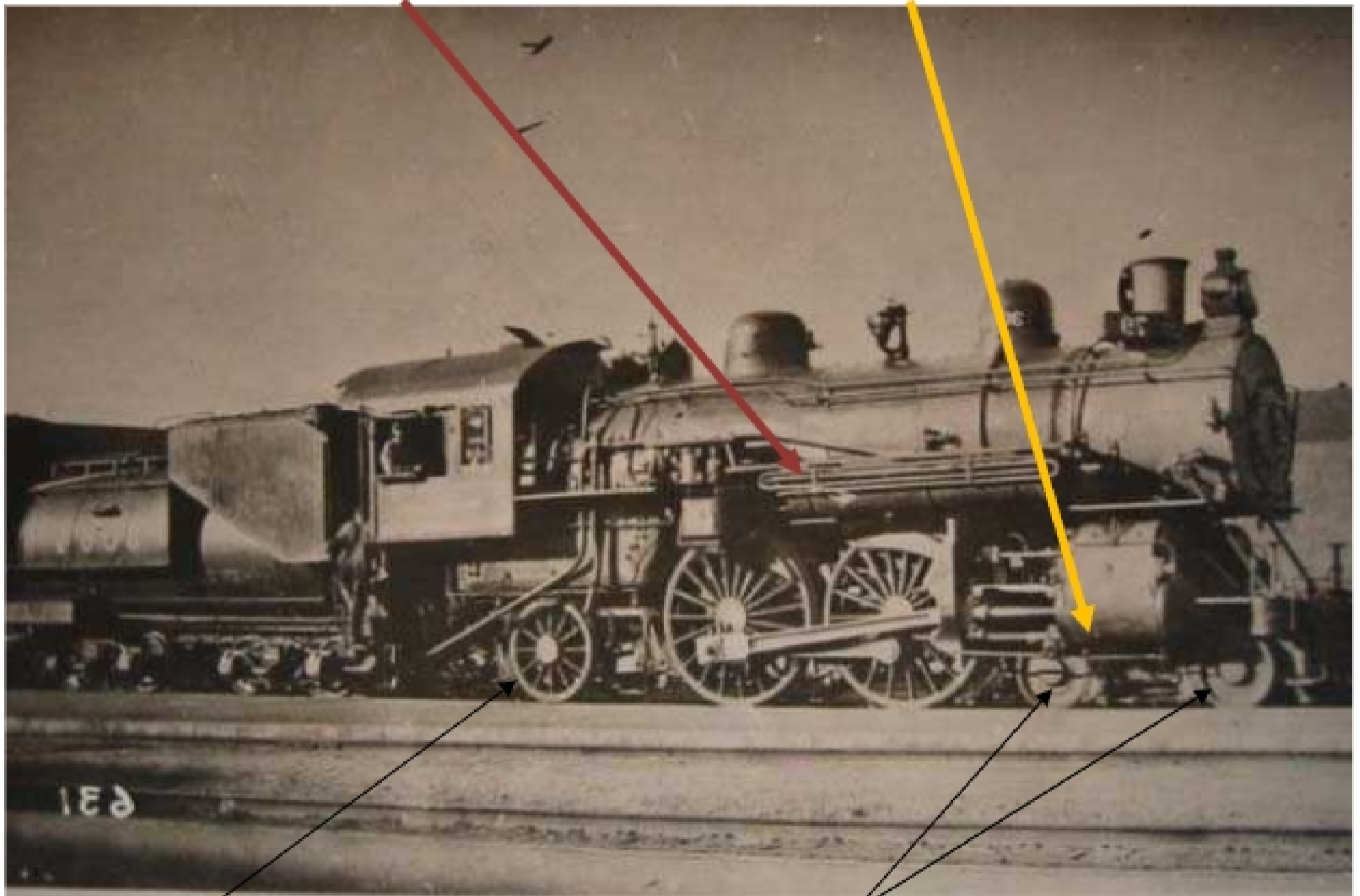
ME 200 Summer 2012

Homework 9

Assigned Thursday 21 Jun 2012

Due Friday 22 Jun 2012 @730 am in Room 1130 ME

1. Early railroads used steam locomotives. Steam locomotives are excellent examples of piston cylinder systems—steam is fed from the boiler to piston-cylinder assemblies where it causes the piston to oscillate back and forth. This oscillatory motion is transferred from the piston rod to the crosshead and on to the side rods which drove the wheels. A nice animation is shown at http://en.wikipedia.org/wiki/Steam_locomotive. A unit such as the one below had a boiler produced 185 psig steam and pistons of 21 inch diameter and 26 inch stroke. Engines are classified by their wheel arrangement. This



One is a 4-4-2: there are 4 wheels connected together at the front, four in the middle and 2 in the rear.

Assume that the pistons received saturated vapor steam at 185 psig and exhausted it at as a saturated vapor at 5 psig. This is not correct, but it's the approximation we'll use. **Pretend the piston-cylinder is a closed system and calculate the change in internal energy of the steam as it completes this process.** Report your answer in Btu/lbm. Now assume that heat transfer from the piston to the surroundings is small compared to the internal energy change and the work. **How much work does each**

piston-cylinder perform in one expansion process? Again, report your answer in Btu/lbm. **Finally, if the locomotive uses about 500 gal/hr of water to produce steam, how much power does it produce?** Report this answer in hp so you can compare it to the power produced by a modern automobile engine.

2. Locomotive boiler pressure was limited by mechanical strength concerns. The internal boiler pressure was counteracted by the combination of iron or steel strength and the local atmospheric pressure. This meant that locomotives climbing into the mountains had to reduce their boiler pressures. In Denver, for instance, the “standard” local atmospheric pressure is 12.2 psia. To the west of that, Tennessee pass, with its elevation of 10,400 feet has a “standard” local atmospheric pressure of 9.9 psia.

Estimate the loss in locomotive power production by reducing the boiler pressure to [185-(14.7-12.2)] psig for Denver and [185-(14.7-9.9)] psig for Tennessee pass.

Report your answer as a percentage of the sea-level power. Note that you will have to interpolate in the tables to complete this problem.