Answer Sheet:

A. Shaft Parameters:

$Diameter =$.743 in (rounded to the nearest 0.001”)
$Material =$ 1095 HR carbon steel SAE Designation
$S_y =$ 66 kpsi
$S_{ut} =$ 120 kpsi
$Designated\ Surface\ Finish =$ Hot Rolled
$Designated\ Reliability =$ 99.9 %
$S_e =$ 18.7 kpsi

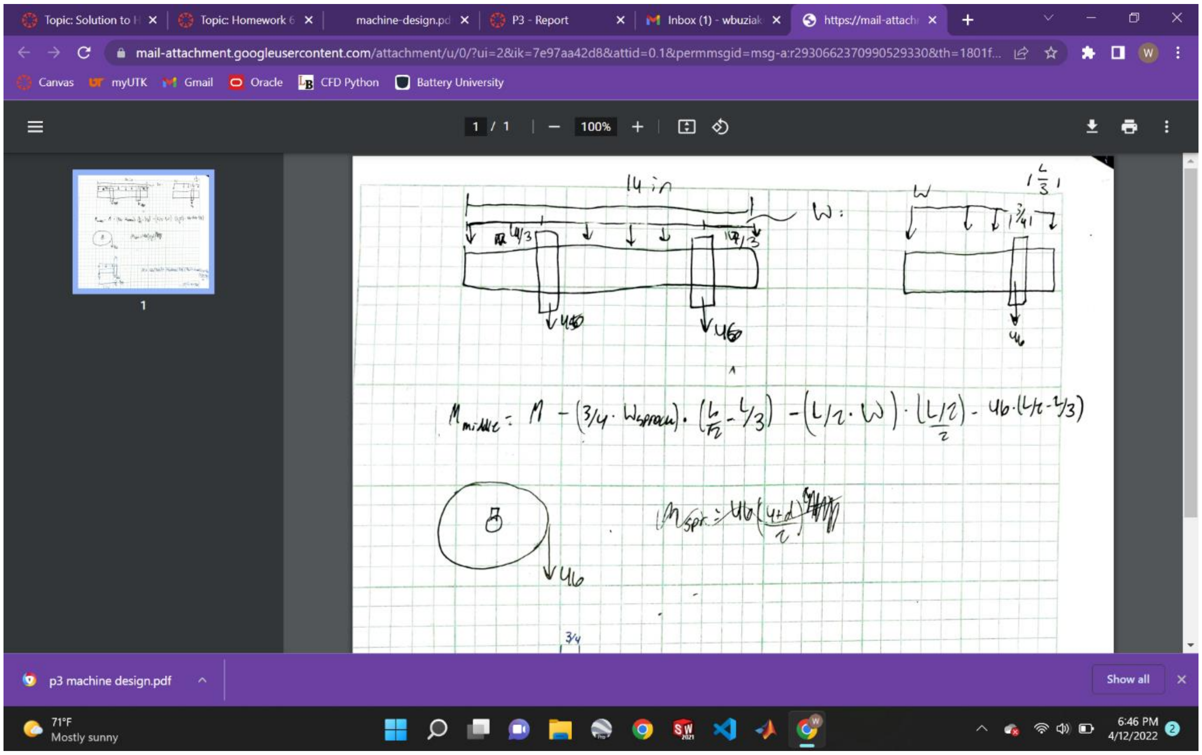
$M_m(middle) =$ 0 lb-in
$M_a(middle) =$ 227.5 lb-in
$T_m(middle) =$ 155 lb-in
$T_a(middle) =$ 45 lb-in
$FOS(middle) =$3.0

$M_m(keyway) =$ 0 lb-in
$M_a(keyway) =$ -268.8 lb-in
$T_m(keyway) =$ 155 lb-in
$T_a(keyway) =$ 45 lb-in
$FOS\ (keyway) =$ 2.0

The FOS for the shaft at the middle and the bearing is right at 3.0, specifically, 3.03 & 2.999 respectively, however, since the FOS rounds to two significant figures, it still falls into the required range. Similar to the FOS of the key-way which is precisely at 1.988, once again rounding into the appropriate range.

B. Key Parameters:

$S_e =$ 23.87 kpsi
$F_{mkey} = 415.7$ lb
$F_{akey} = 120.7$ lb
$h_{key} = .25$ in
$w_{key} = .25$ in
$A_{shear} = .0488\ in^2$
$\sigma_{ke'ya} = 4.304$ kpsi
$\sigma_{ke'ym} = 1.482$ kpsi
$FOS_{shear} = 2.8$
$F_{peakkey} = 538.4$ lb
$A_{bearing} = .0244\ in^2$
$\sigma_{peak}{'}$ = 2.201 kpsi
$FOS_{bearing} = 3.0$
$Length =$ .195 in (rounded to the nearest 0.001”)



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14 in
W:
L/3
46
M_middle = M − (3/4 · W_sprocket) · (L/2 − L/3) − (L/2 · W) · (L/2)/2 − 46 · (L/2 − L/3)
M_spr = 46 ((4+d)/2)
46
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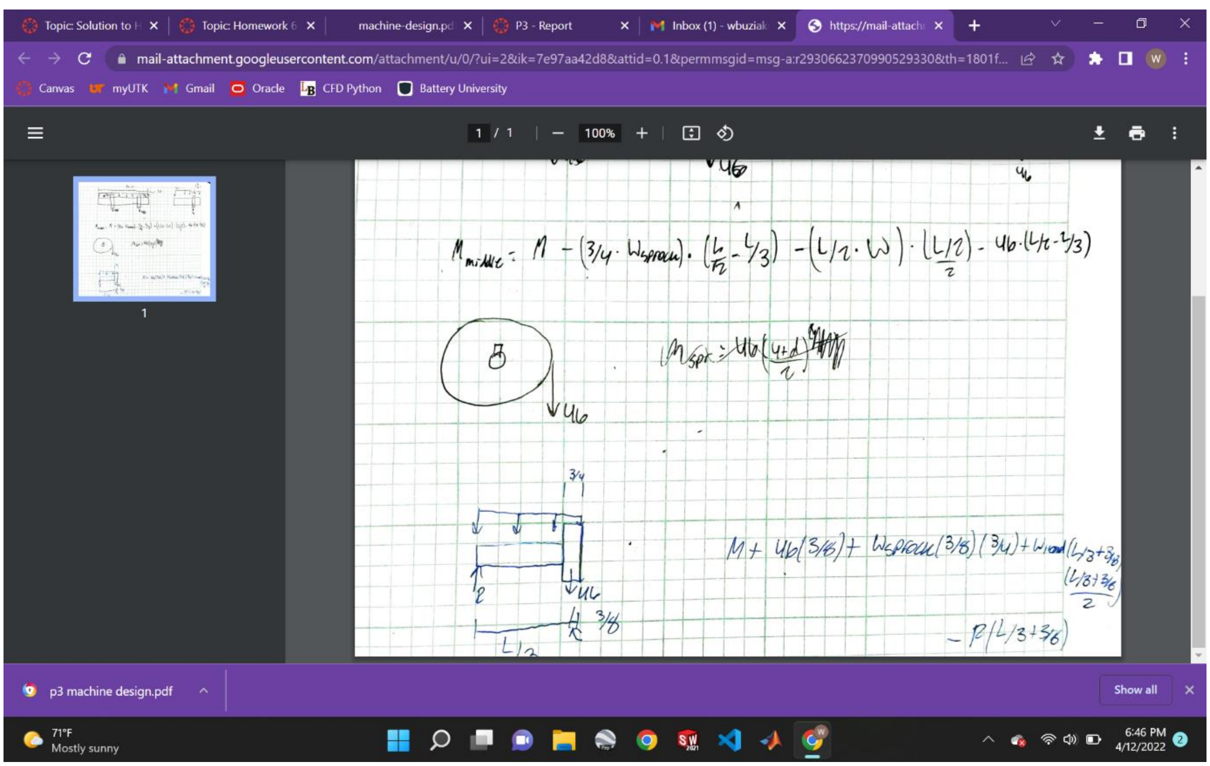

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M_middle = M − (3/4 · W_sprocket) · (L/2 − L/3) − (L/2 · W) · (L/2)/2 − 46 · (L/2 − L/3)
M_spr = 46 ((4+d)/2)
46
3/4
46
3/8
L/2
M + 46(3/8) + W_sprocket(3/8)(3/4) + W_road(L/3 + 3/8)(L/3 + 3/8)/2
− R(L/3 + 3/8)
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Important things to note: All mean moments are zero for this project due to fully reversed loading.

A. The most difficult part of section A & most prone to error is calculating the moments. It was not necessary to use a singularity function to find the internal moment at the middle, since the shaft is symmetrical about the middle it is easy to perform simple static analysis to calculate the reaction forces and the corresponding moment in the middle of the shaft.

   This was complicated merely due to using the correct distances for the distributed loads and calculating the correct distances for each moment.

   Both Kfm & Kfsm were both lower than the yield stress & therefore they were both equal to Kf & Kfm, these were vital to the FOS equation for the keyway, however, Kfm is technically not necessary due to the fact that the mean moment is zero.

B. Part B was significantly simpler to calculate relative to part A, since the bulk of the calculation was just finding the correct von mises stresses as well as ensuring you had the correct alternating and mean torques with the right corresponding forces and areas. However, since there was not any moments you had to calculate or keep track of which moment you are using for which ugly matlab calculation it was cleaner and more resilient to human error.

Conclusion:

The most important factor of safety to consider is the shaft, as shaft failure would result in complete failure of the entire system, therefore, the project had a requirement of at least one FOS to be LESS than the FOS of the shaft so that, ideally, this component would fail before the shaft would fail. If the sprocket, bearing, or key were to fail before the shaft it would result in a significantly easier and cost-efficient fix than if the entire shaft were to fail resulting in the potential for other components to break in the process.