In this laboratory, your group will develop three subroutines in the C language to implement two force process controllers for a face milling operation. The file names and contents are:

force1.h: integral (I) fixed gain force process controller
force2.h: integral (I) adaptive force process controller
paraest1.h: RLS routine to estimate $Pd^b$ term in static force process

The subroutines declarations are:

```c
double ForceController1(double F)
double ForceController2(double F, double Kde)
double ParameterEstimator1(double fe, double F)
```

The axis controllers and linear interpolator will be provided. Design the controllers such that the force process closed-loop time constant is 0.25 s. Make sure to include saturation in all three subroutines, covariance resetting in the parameter estimator, and integral antiwindup in the force controllers. The force process model is $F = 0.76d^{0.65}f^{0.63}$ where $F$ is the machining force (kN), $d$ is the depth-of-cut (mm), and $f$ is the feed (mm). If the spindle speed is 1500 rpm, the tool diameter is 50 mm, and the maximum spindle power is 1.5 hp, what is the reference cutting force? Use this value in your force control subroutines. The subroutine inputs are measured force ($F$) in N, estimated force process gain ($K_{de}$) in kN/m, and measured feed ($fe$) in m. The output of the force controller subroutines is command feed in m and the parameter estimator subroutine output is force process gain in N/m. Data that will be saved: measured force, command feed, measured feed, and force process gain estimate. Turn in the three subroutines (make sure they are well documented), the expected performances via simulation, and the experimental results. You may ignore the servomechanism dynamics in your simulations. Discuss your results.