P1 intro
instrumentation process

P2 motivation
concurrent & unified approach
terms & procedure

P3 component interconnect
impedance matching

P4 signal conditioning
op-amp
ground loop
analog filter
bridge circuit

P5. Performance spec
Reference model
Time domain specs
Freq domain specs
Linearity / Nonlinearity
Rating params / sensitivity
other rating params / signal-to-noise / dynamic range / resolution / DC offset
Data ramping / aliasing
Bandwidth design
error propagation

P6 Sensors types
Potentiometer
var-inductance transducer (LVDT)
Permanent Magnet transducer (DC Tachometer)
Eddy transducer (impedance bridge)
Var-cap transducer
piezoelectric transducer (Charge)

P7 effort sensor
strain gauge
tactile sensor
gyroscopic sensor
optical sensor
ultrasound sensor
thermo fluids sensor

$d\left(\frac{x}{y}\right) = \frac{y\,dx - x\,dy}{y^2}$

mid1 sensor perf spec
$-\omega^2 = (j\omega)^2$
mech relec loading
mass spring, forcing

mid2 impedance matching
gears deceleration

mid3 torque sensor
Sensor specs / system specs

mid4 LVDT
op amp inv amp, non-inv amp
optical potentiometer
Sensitivity derive

mid5 Sensitivity & error analysis
Sensitivity calcs
abs error calcs (lin)

mid6 opamp, inv amp & low pass
transfer fn
half power bandwidth
Sensor time const.

sensitivity bal explain
wheat stone

p8 Digital transducer
Advantage
Shaft encoder types
incremental optical encoder
direction sensing
motion/position & speed
resolution
sensing hardware
Absolute encoder, grey code
encoder error
other transducer (resolver, tachometer, hall effect, toroidal, linear enc)

p9 Types of actuator
stepper types, switch sequence
polarity reversal issue
operation
nitro stepping
stack stepper
control, feedback encoder
torque control through switching
sizing terminology.
characteristic
sizing steps
advantage/disadvantage

P10 DC motor, brush & brushless
principle of operation
torque characteristic
commutation
DC eqns
steady state
power
motor load matching
torque speed equation, shunt wound, series wound, compound wound

P10 DC control, armature, field
Stepper vs Servo
DC selection, torque speed curve
electric linear actuator

AC motors
induction motors,
characteristics
control
synchronous motors

Hydraulic motors
pump equations
control equations

P11 estimation method
least square estimate

Assign6 1. shaft encoder speed resolution, DC motor
2. shaft encoder velocity, gear ratio, speed resolution
3. inc encoder vs potentiometer
Describe function:
control processor
DAC
PWM
DC motor
encoder
part swap, encoder
4a. part selection criteria
encoder vs LVDT
b. linear encoder, photo detector
5. PM stepper
describe operation
step angle

A6 b Spec Stepper

7. Comparison

Brush DC, brushless DC, Stepper induction, AC motor

power capability, speed ctrl, speed reg, linearity, bandwidth, start torque

psu, commutation, power dissipation

method to reverse dir

8a. flow control valve

b. equations, flow ctrl valve, hydraulic

c. block diagram

sample final 1a displacement sensor spec

1b capacitive sensor, displacement

2a. aliasing error

bi. hydraulic pressure to distance change

diff eq'n, natural frequency

bii plug numbers

time constant of analog signal condition

min Hz command

min Hz ADC sample

time const max of displacement sensor

3a LVDT

b diff eq'n of system

c. op. bandwidth, damp ratio: get k ϕb

LVDT carrier frequency

4 a absolute VS square root of sum of square error

bi sketch curve

ii absolute error, non dim sensitivity

iii plug numbers