

# Laser Automation & Safety



ME 677: Laser Material Processing  
Instructor: Ramesh Singh

# Outline

- Laser Automation
- Laser Sensing
- Safety Considerations



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# Automation

- The Ford Motor Co. Introduced "automation" in the 1940s
- Machines were used to enhance speed, force or reach but the control was human
- Automatic machinery is defined as programmed movements without human intervention and the machine can be self regulating



# Adaptive or Intelligent Control

- In the future there is the prospect of "adaptive control" or "intelligent" machines
- The machine can be set a task and it teaches itself to do the task better and better according to some preset criteria

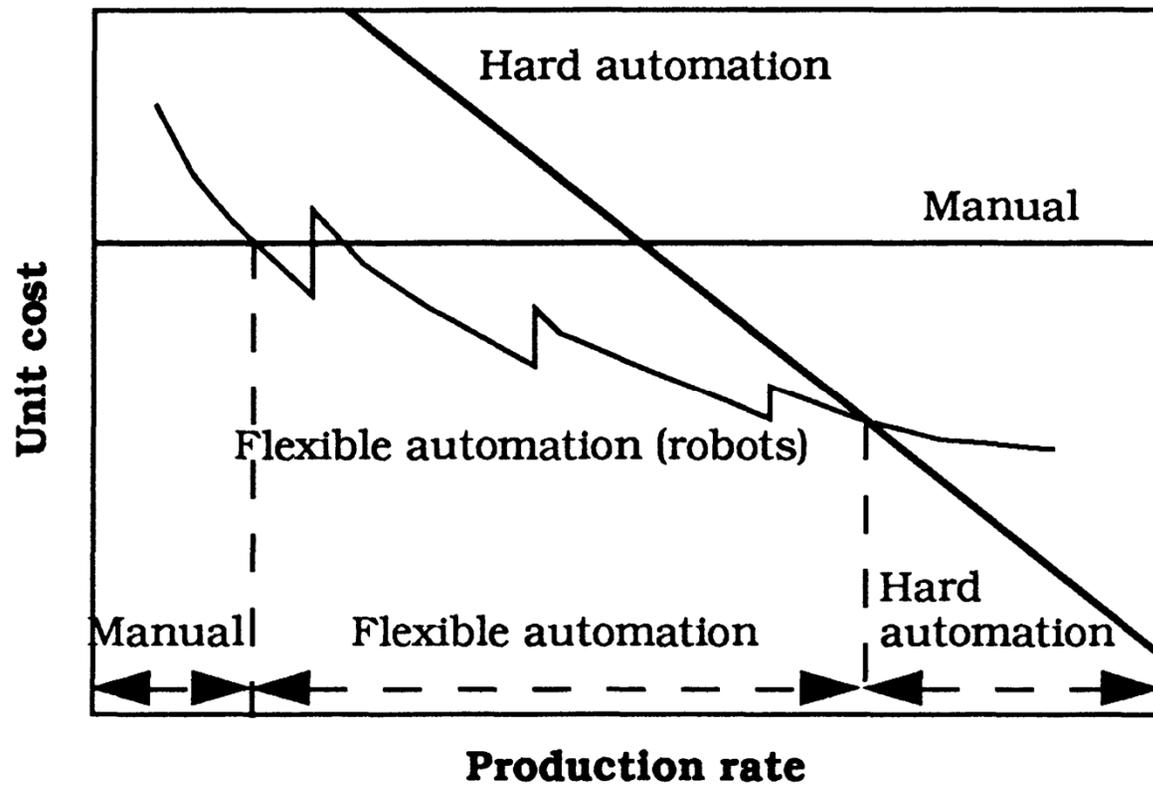


# Advantages of automation

- The drive towards automation is powered by:
  - possibility of cost reductions
  - increased productivity
  - increased accuracy
  - saving of labour
  - greater production reliability
  - longer production hours
  - Better working conditions for the staff
  - increased flexibility of production to meet the needs of changing markets
  - improved quality.

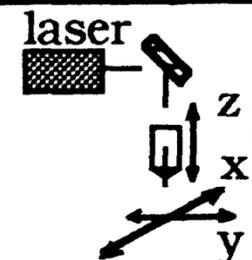
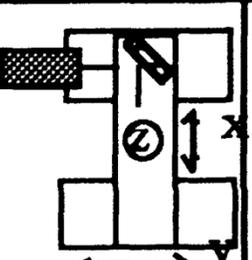
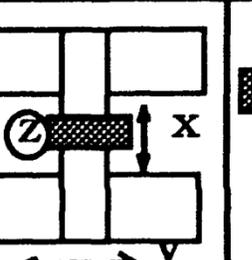
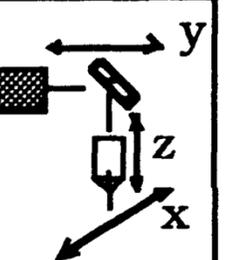
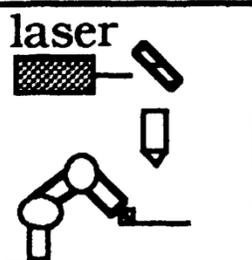
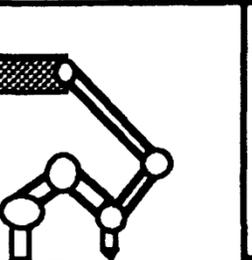
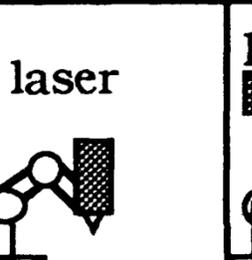
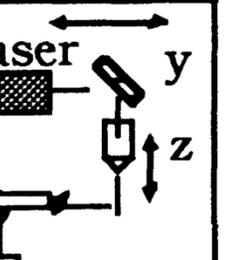


# Cost Vs. Production



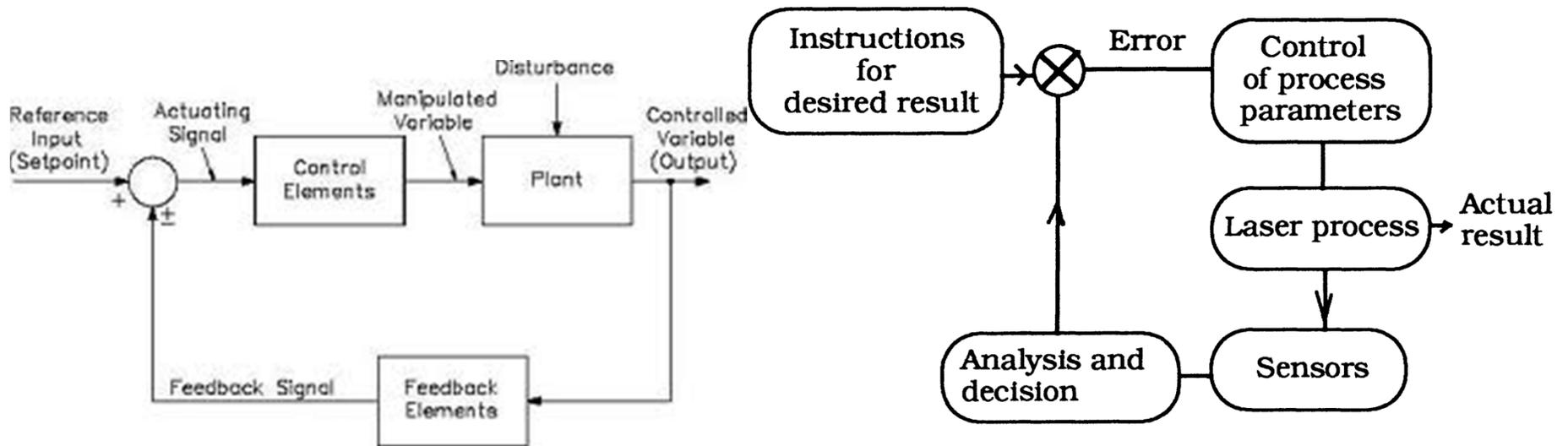
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# Automation types

Style	moving workpiece	moving optics	moving laser	hybrid
Cartesian gantry type				
Articulated robot type				



# Feedback Control



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# Laser Process Parameters

<b>Beam</b>	<b>Workstation</b>	<b>Workpiece</b>
Power	Traverse speed	Surface absorptivity
Diameter	Vibration, stability	Seam location
Mode structure	Focal position	Temperature
Location	Shroud velocity and direction	"Quality" of product



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# Instrumentation

Signal	Sensor	Commercial or Research	Sensor	Commercial or Research
Beam power	Laser Beam Analyser (LBA)	Commercial	Leakage from cavity mirror	Commercial
Beam diameter and mode	LBA Hollow needle	Commercial Commercial	Perforated mirror	Commercial
Location	Acoustic mirror LBA Edge thermocouples	Research Commercial Research	Modified LBA Scanning slot/beam splitter	Research Research
Traverse speed and table position	Encoders Tachometers Laser doppler anemometer(LDA)	Commercial Commercial Commercial	Linear Moire encoders Laser interferometer	Commercial Commercial
Vibration/stability	Accelerometers Strain gauges	Commercial Commercial	LDA	Commercial
Focal position	Infra red Capacitance Inductance	Research Commercial Commercial	Pressure Feeler Laser diode	Research Commercial Research

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# Instrumentation-Research

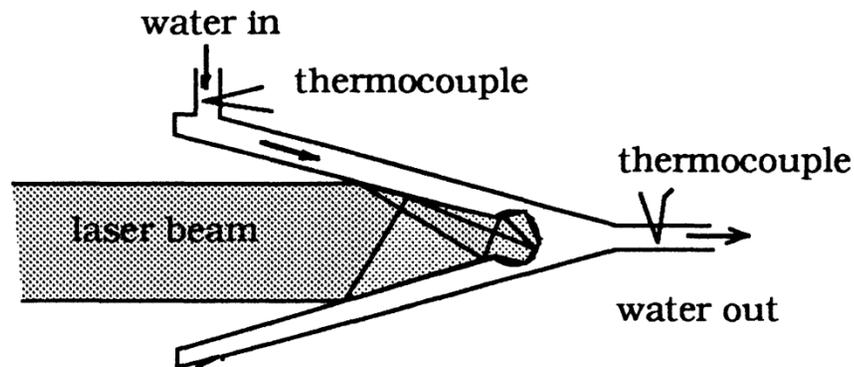
Shroud gas	Nozzle pressure	Commercial	Speckle interferometry	Research
Velocity	Schlieren	Research		
Surface absorption	Acoustic mirror	Research	Back reflection	Research
Seam location	Optical	Res/com	Acoustic	Research
	Pressure	Research		
Cutting quality	TV camera on spark discharge	Research	Acoustic mirror	Research
	Temperature of cut face	Research	Viewing down beam	Research
Welding quality	Acoustic mirror	Research	Plasma charge sensor	Research
	Acoustic workpiece	Research	Laser probe	Research
	Sonic microphone	Research	Acoustic nozzle	Research
	Optical emissions	Research	Video camera	Research
	Electric signals	Research		
Surface hardening quality	Temperature	Res/com	Acoustic	Research
	Infra red	Research		
Cladding dilution	Inductance	Research		
Powder feed rate	Pressure	Research	Vibration	Research
	Stress	Research		

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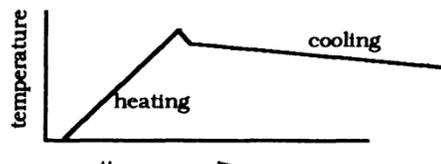
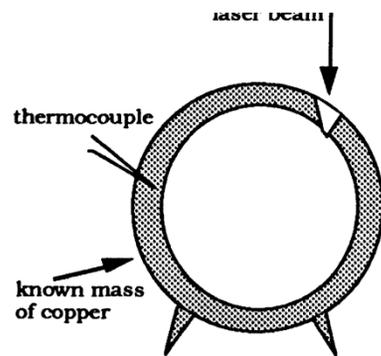
# Monitoring beam characteristic

- Lasers are fitted with a beam dump which doubles as a calorimeter. The power is measured as the rise in temperature of the flowing water



# Beam monitoring

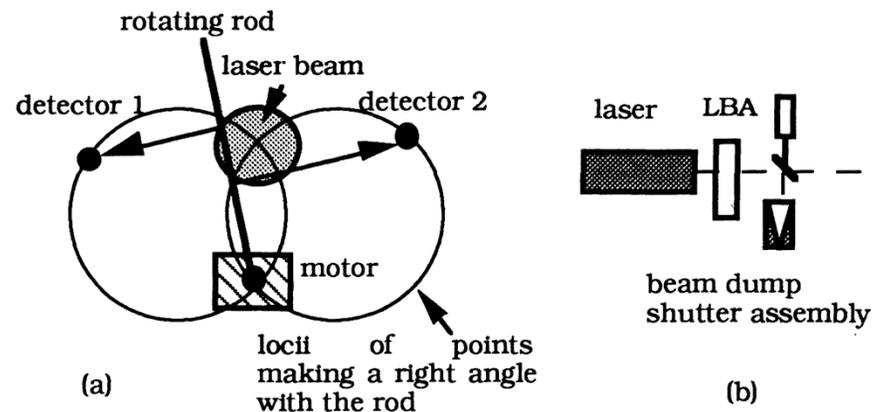
- An absolute blackbody calorimeter is highly mobile, but requires a lens to focus the beam into the spherical absorbing chamber, which is usually coated black on the inside.



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# Laser Beam Analyzer

The laser beam analyser consists of a reflecting molybdenum rod which is rotated fast through the beam. The reflections off the rod are measured by two pyroelectric detectors placed as shown in Figure below.



The two detectors pick up signals proportional to the power on two simultaneous orthogonal passes of the beam, as illustrated. It is this ability of the instrument to collect the power distribution within around 1/100th of a second in two dimensions simultaneously with only 0.1% beam interference that has made



# LBA

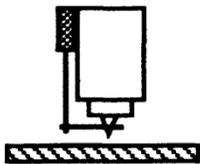
- Overall power: measured from the integral under the curve or RMS value
- Beam diameter: measured from the  $1/e^2$  position of the power rise.
- Beam wander: measured from any variation in the relative rise positions A and B of the two traces.
- Mode structure: measured from shape of curves, in particular comparison with previous mode structures can be made to check on cavity tuning, or fouling of cavity mirrors.



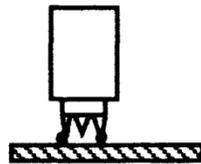
# Monitoring Work Table Characteristics

- Monitoring focal position

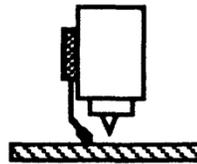
a) Capacitor, inductance



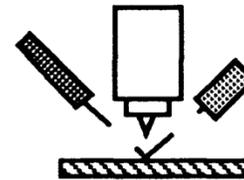
b) skids



c) Feeler devices



d) Optical sensors



# Laser Safety

- Damage to the eye.
- Damage to the skin.
- Electrical hazards.
- Hazards from fume.



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# Standards

1. American National Standard Institute ANSI  
z136.1 A986)
2. Federal Laser Product Performance Standard  
FLPPS CFR 50 A61) 33682-33702 A985)
3. British Standards Institute                      BSI 76/31221 DC
4. British Standards Institute                      BSI 4803 A983)
5. International European Convention IEC 825

A984)



# Laser Classification

Class	Definition
1	Intrinsically safe $< 0.2\mu\text{J}$ in 1ns pulse or $< 0.7\text{mJ}$ in a 1s pulse
2	Eye protection achieved by blink reflex (0.25s) $< 1\text{mW}$ CW laser
3A	Protection by blink and beam size $< 5\text{mW}$ with $25\text{W}/\text{m}^2$ (e.g. an 16mm beam diameter from a 5mW laser)
3B	Possible to view diffuse reflection $< 2.4\text{mJ}$ for 1ns pulse or $< 0.5\text{W}$ CW visible
4	All lasers of higher power Unsafe to view directly, or by diffuse reflection May cause fire Standard safety precautions must be observed (Section 8.4.)



# Class IV - Precautions

- All beam paths must be terminated with material capable of withstanding the beam for several minutes.
- Stray specular reflections must be contained.
- All personnel in Nominal Hazard Zone must wear safety goggles.
- For CO2 radiation they can be made of glass or perspex, in fact normal spectacles may do, if the lenses are large enough.
- Non involved personnel must have approval for entry.
- There should be warning lights and hazard notices so that it is difficult (impossible) to enter the area without realising that it is being entered.
- Extra care should be taken when aligning the beam.
- There should be a Laser Safety Officer to check that these guidelines are followed.



# Ocular safety

Laser Type	Wavelength $\mu\text{m}$	Biological Effects	Skin	Cornea	Lens	Retina
CO2	10.6	Thermal	X	X		
H2F2	2.7	Thermal	X	X		
Erbium-YAG	1.54	Thermal	X	X		
Nd-YAG	1.33	Thermal	X	X	X	X
Nd-YAG	1.06	Thermal	X			X
GaAs Diode	0.78-0.84	Thermal	**		X	
He/Ne	0.633	Thermal	**		X	
Argon	0.488-0.514	Thermal photochem	X			X
Excimer: XeF	0.351	Photochem	X	X	X	
XeCl	0.308	Photochem	X	X		
KrF	0.254	Photochem	X	X		

\*\* Insufficient power



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