



# Chemistry 4631

## Instrumental Analysis

### Lecture 7

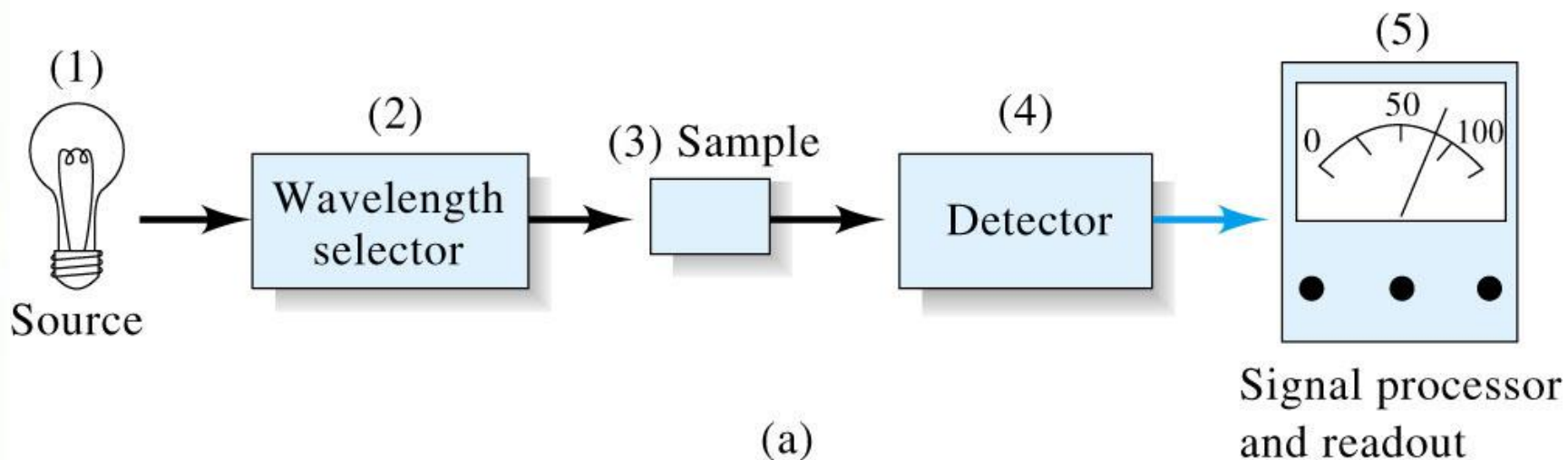
# Components of Optical Instruments

## UV to IR

### Basic components of spectroscopic instruments:

- stable source of radiant energy
- transparent container to hold sample
- device to isolate selected region of the spectrum for measurement
- detector to convert radiant energy to a signal
- signal processor and readout

# Components of Optical Instruments



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# Components of Optical Instruments

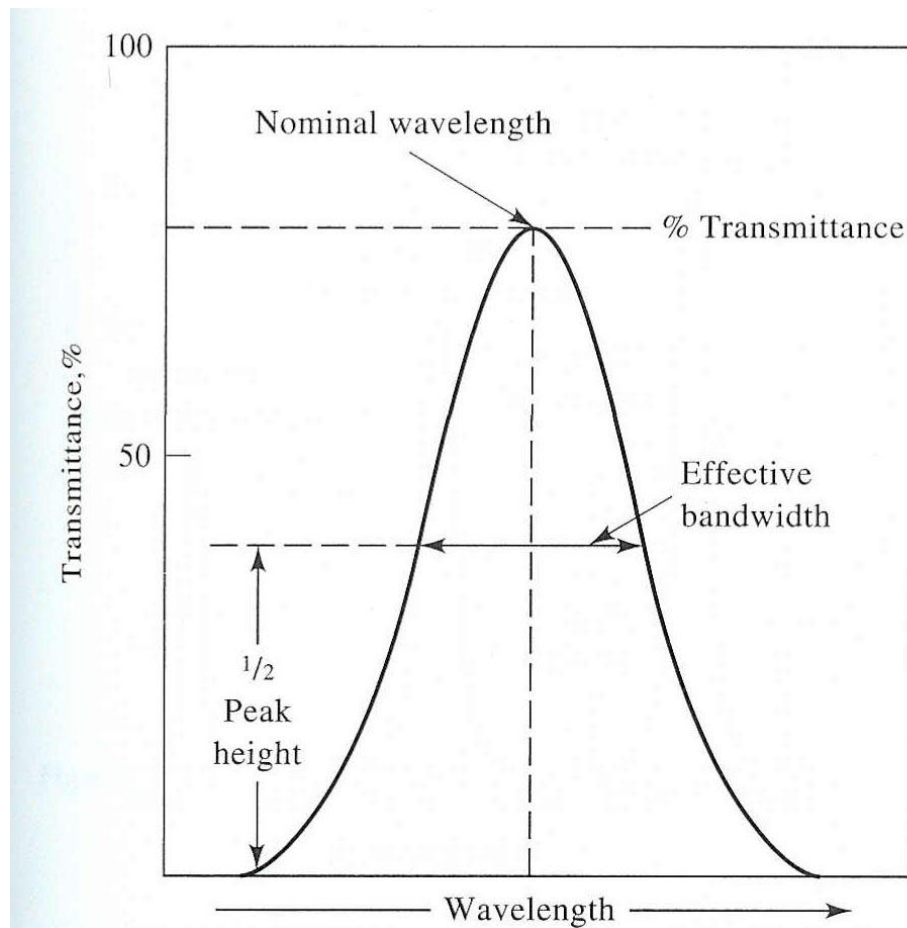
## Wavelength Selectors

Since many sources are continuum sources, need a wavelength selector to narrow the bandwidth.

This increases the sensitivity and selectivity of spectral methods.

A wavelength selector gives a band with a measurable width.

# Components of Optical Instruments



**Figure 7-11** Output of a typical wavelength selector.

# Components of Optical Instruments

## Types of wavelength selectors:

### Filters

Interference (Wedge)

Absorbance (Colored glass, plastic)

### Prisms

### Monochromators

Ruled

Holographic

# Components of Optical Instruments

## Monochromators

Vary the wavelength of radiation over a selected range. (Scan a spectrum)

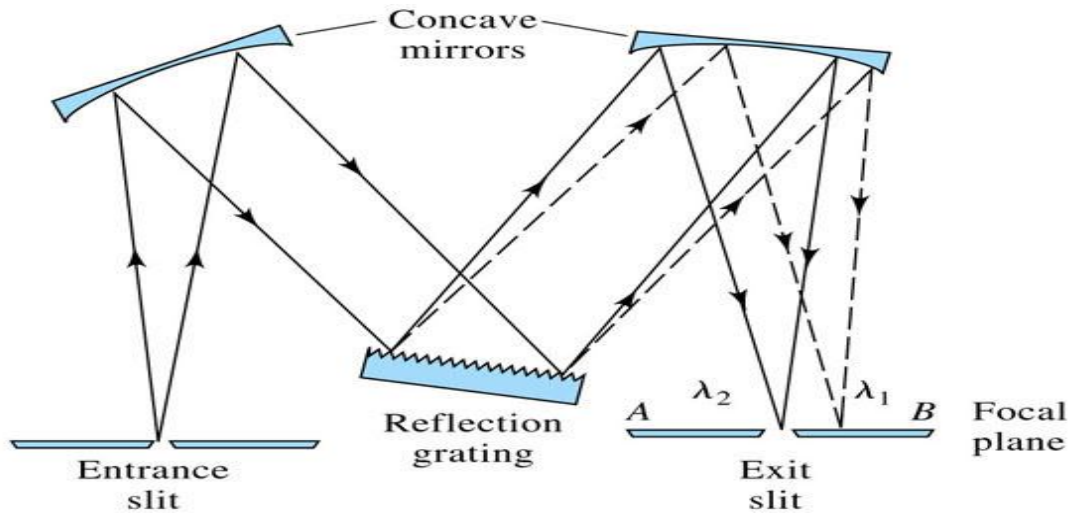
# Components of Optical Instruments

## Components of the Monochromator

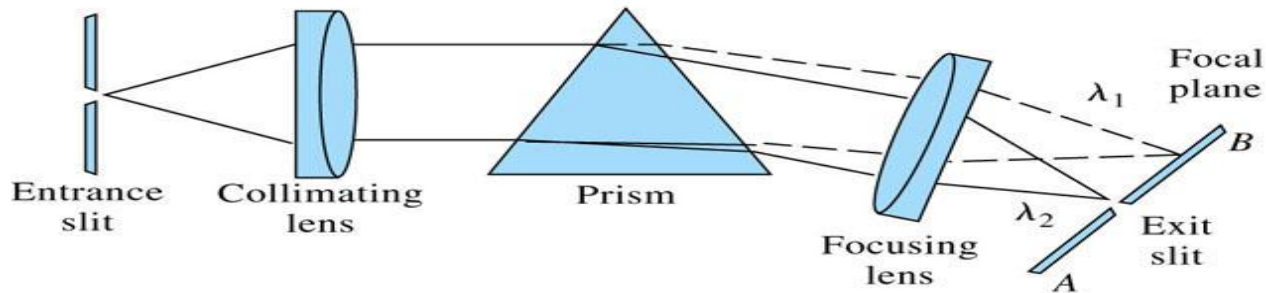
### Include:

- Entrance slit (allows a rectangular optical image)
- Collimating lens or mirror (produces a parallel beam of radiation)
- Prism or grating (disperses radiation into component wavelengths)
- Focusing element (focuses image on a focal plane)
- Exit slit (isolates desired spectral band)

# Components of Optical Instruments



(a)



(b)

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# Components of Optical Instruments

## Monochromator Slits

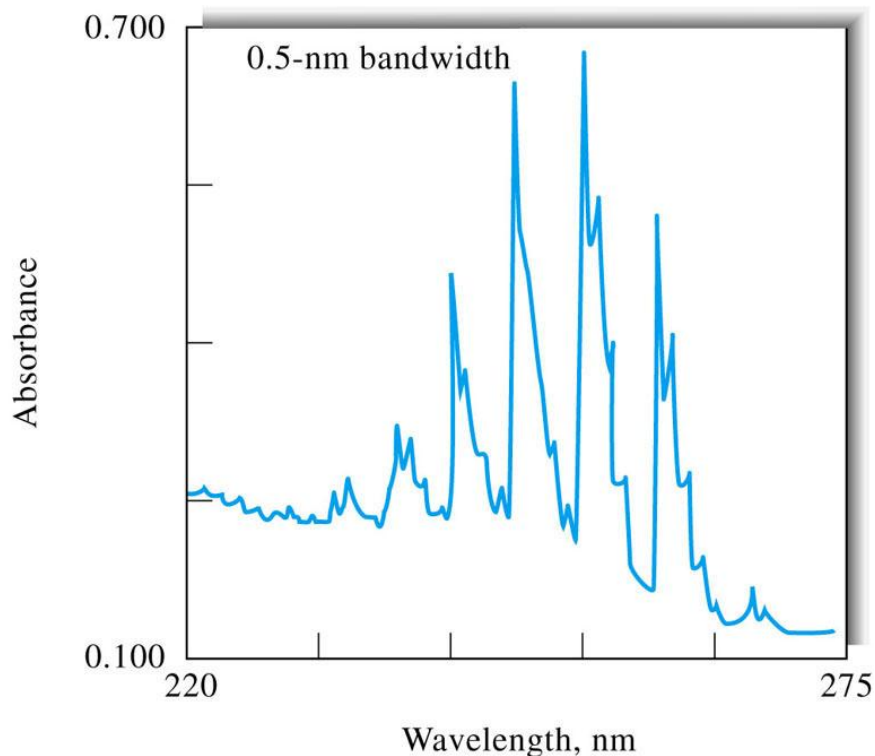
**Two pieces of metal with sharp edges.**

**Must be exactly parallel to each other and lie on the same plane.**

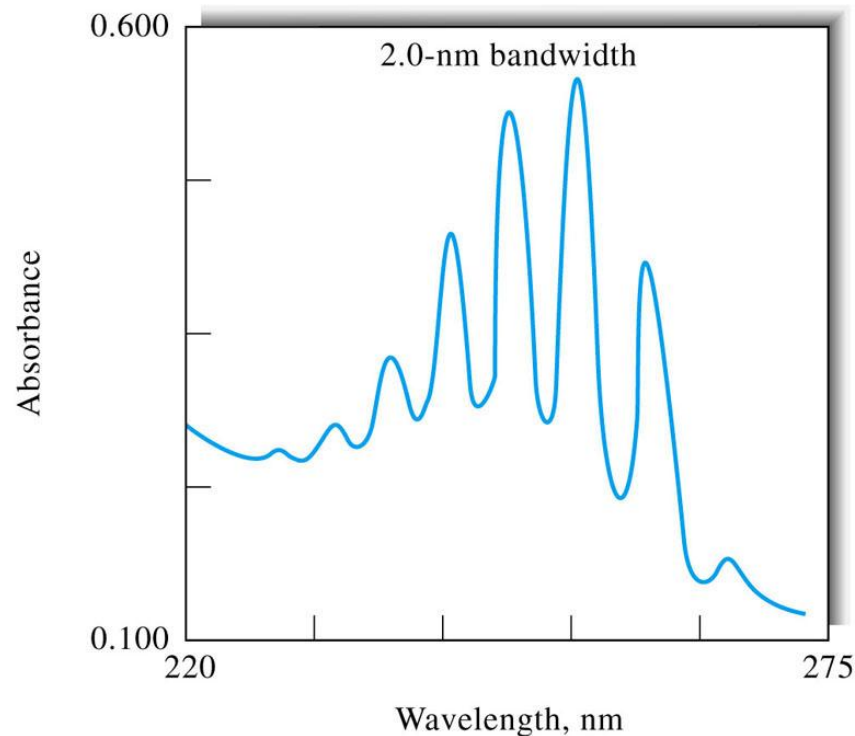
**The opening of the slit can be fixed or adjusted mechanically.**

# Components of Optical Instruments

## Monochromator Slits



(a)



(c)

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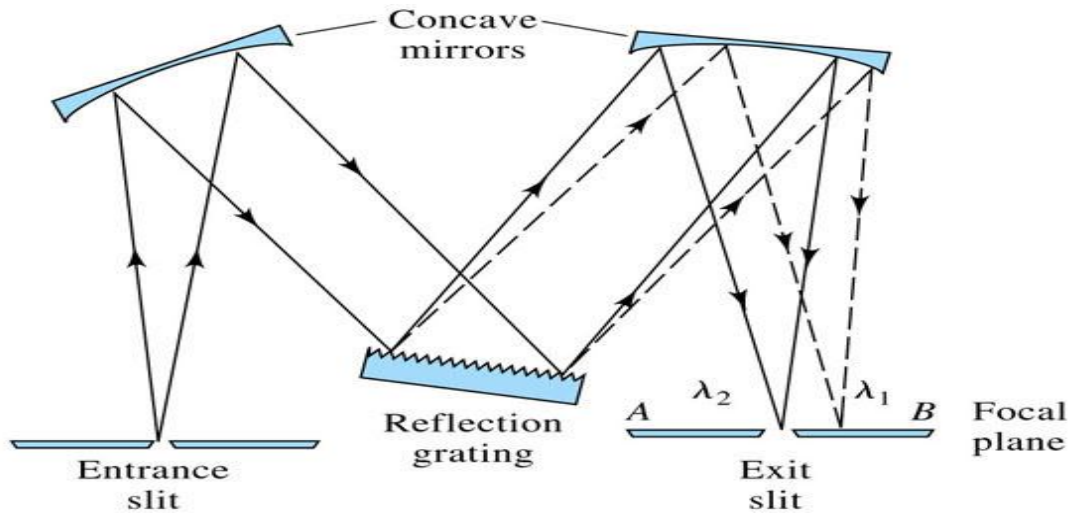
# Components of Optical Instruments

## Effect of Slit Width

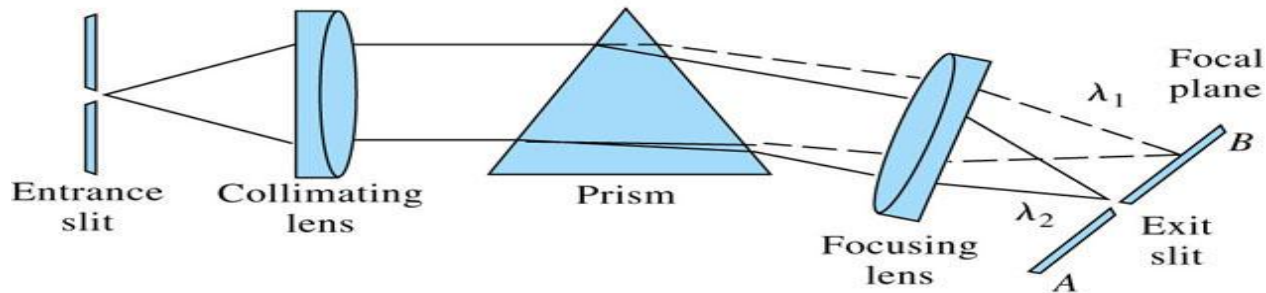
**Wider slits give poor resolution**

**A decrease in slit width gives power reduction in radiant energy and becomes a problem with low signal-to-noise ratios.**

# Components of Optical Instruments



(a)



(b)

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# Components of Optical Instruments

**Historically, monochromators were prism instruments, however today nearly all commercial monochromators use reflection gratings.**

# Components of Optical Instruments

## Grating Monochromators

### Replica gratings

Manufactured from a master grating consisting of a hard, optically flat, polished surface ruled with a diamond tool.

These gratings typically contain 10-200 grooves/mm for IR region and 300-2000 grooves/mm for UV-vis region.

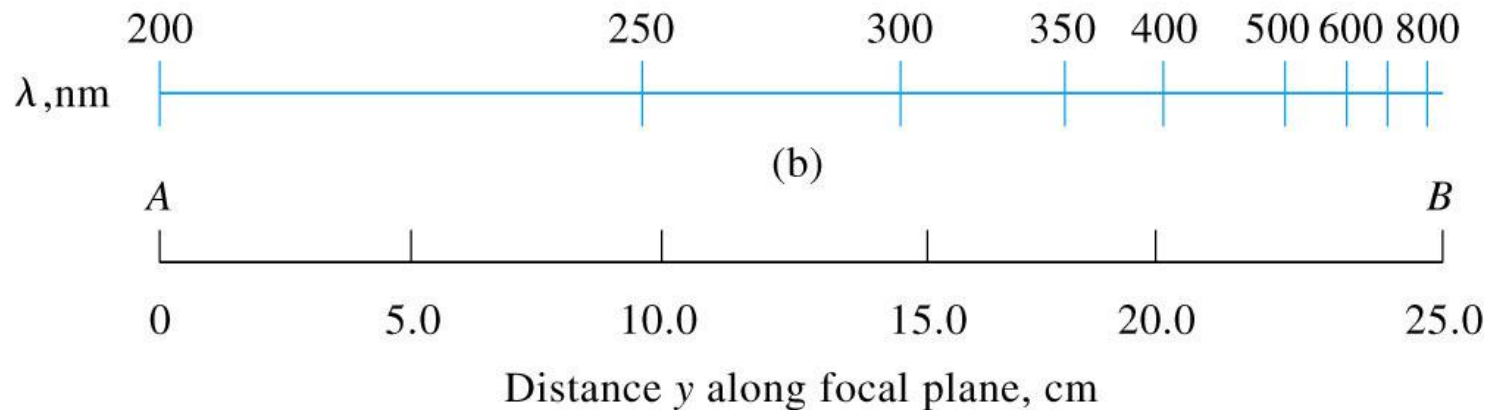
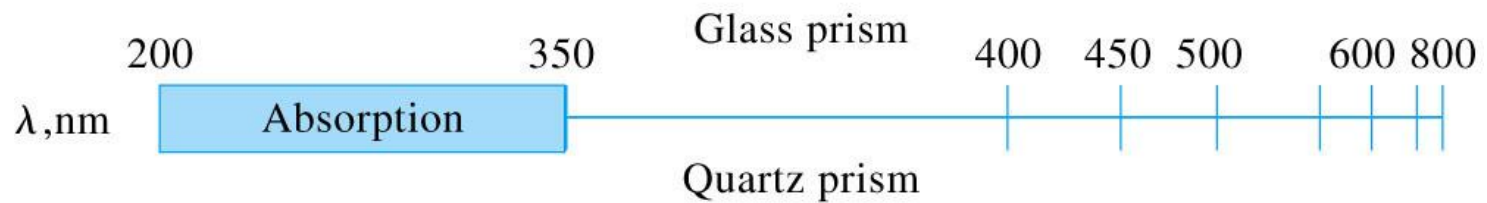
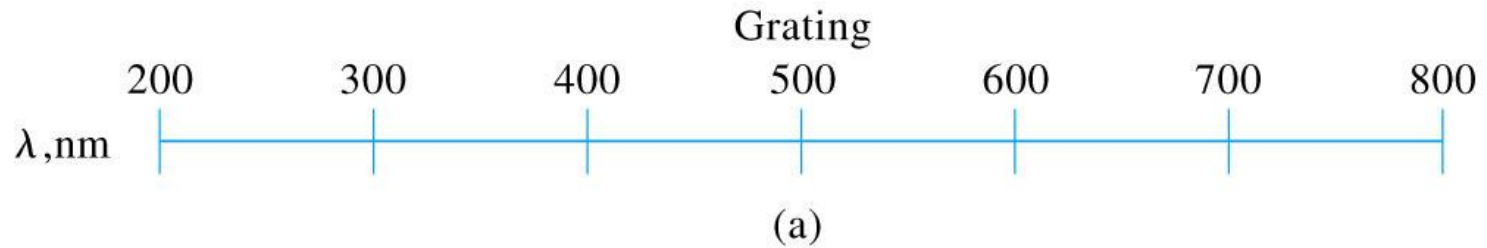
Replica gratings are formed from master gratings by a liquid resin casting process.

# Components of Optical Instruments

## Advantages of gratings:

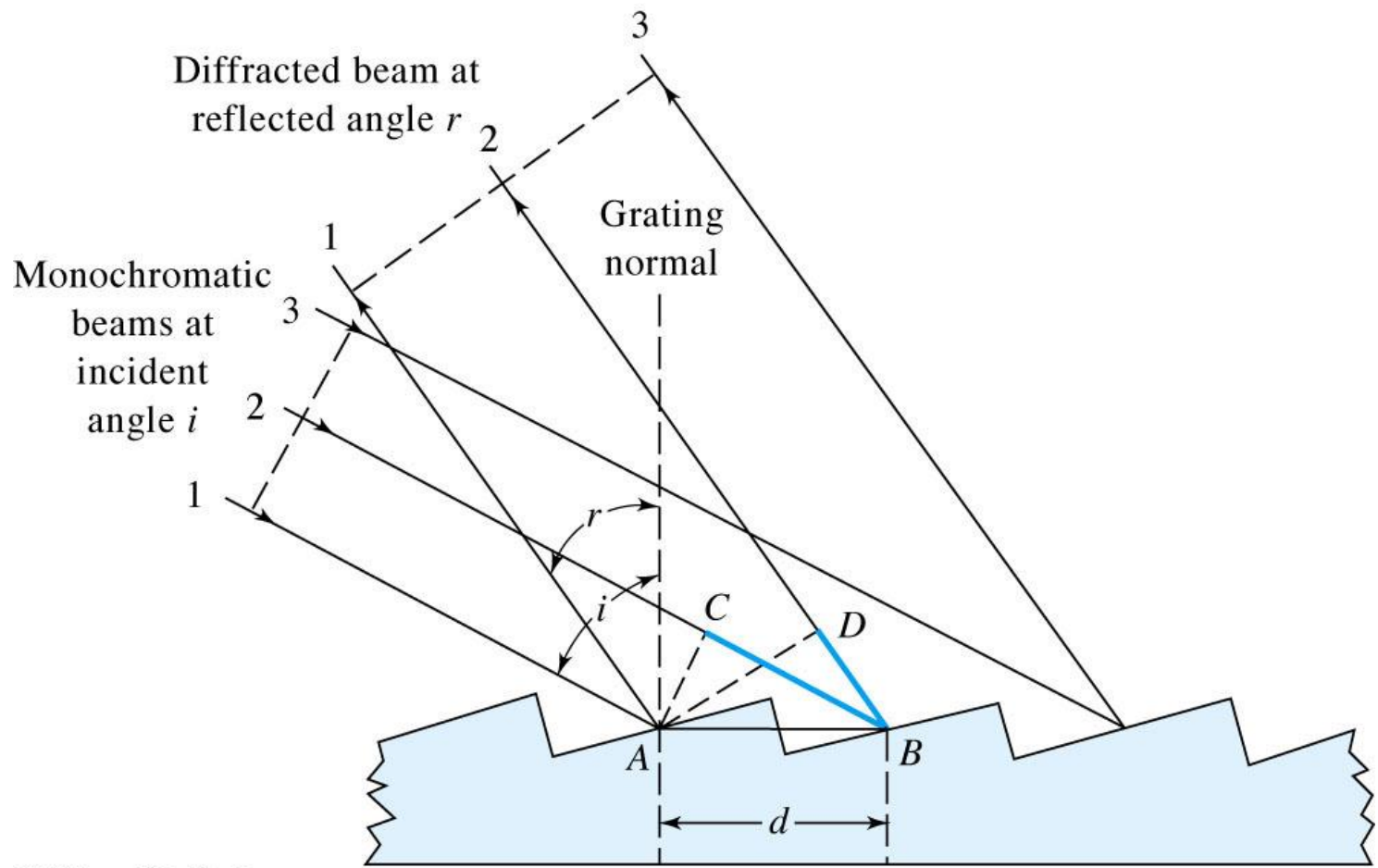
- Cheaper
- Give better wavelength separation
- Disperse radiation linearly along the focal plane

# Components of Optical Instruments



(c)

# Components of Optical Instruments

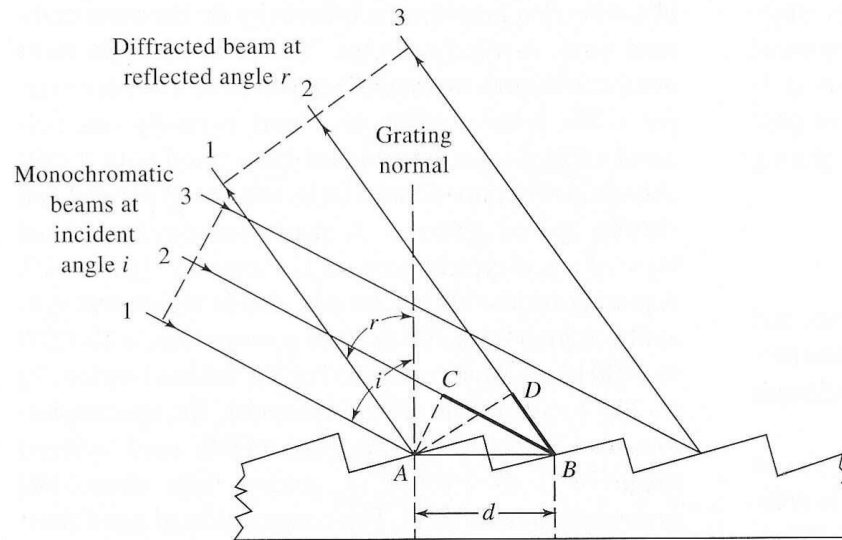


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# Components of Optical Instruments

## Echelle Grating

Grooved with broad faces for reflection and narrow faces away from reflection.



**Figure 7-19** Mechanisms of diffraction from an echellette-type grating.

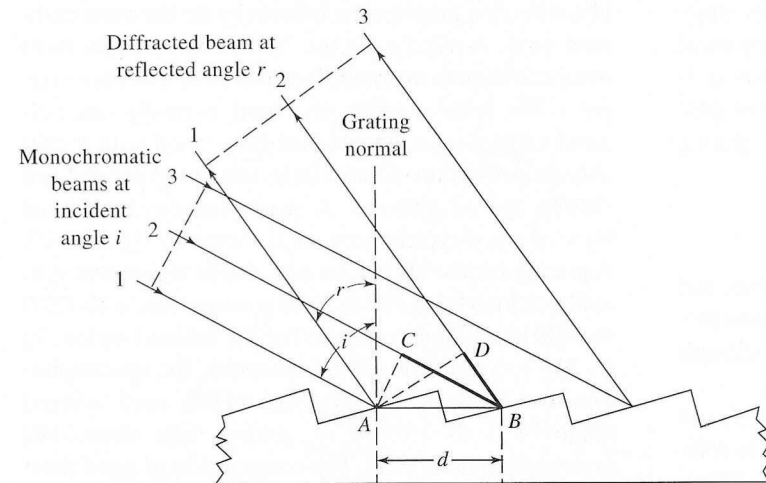
# Components of Optical Instruments

## Echelle Grating

Common geometry used to cause constructive interference so that

$$n\lambda = (\overline{CB} + \overline{BD})$$

$n$  – whole number –  
diffraction order



**Figure 7-19** Mechanisms of diffraction from an echellette-type grating.

# Components of Optical Instruments

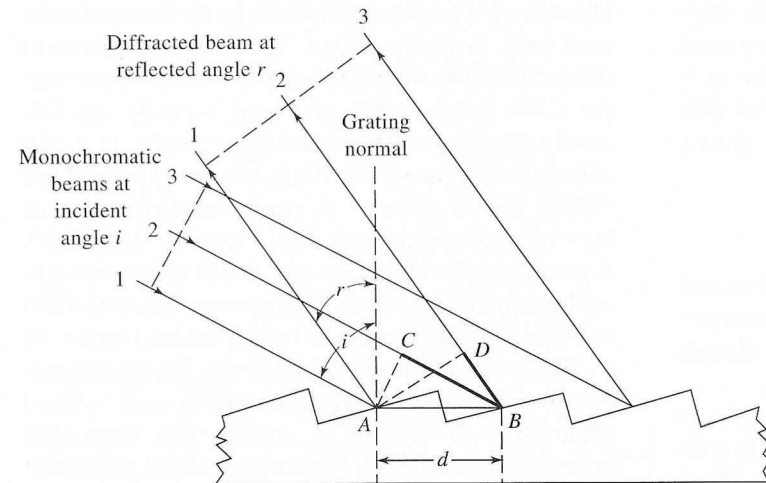
## Echelle Grating

$$CAB = i \quad \text{and} \quad DAB = r$$

$$\overline{CB} = d \sin i \quad \text{and} \quad \overline{BD} = d \sin r$$

d-spacing between reflecting surfaces

$$n\lambda = d(\sin i + \sin r)$$



**Figure 7-19** Mechanisms of diffraction from an echellette-type grating.

# Components of Optical Instruments

## Echelle Grating

Angle of reflection,  $r$ , is close to the angle of incidence,  $i$ .

$$r = i = \beta$$

$$n\lambda = 2d\sin\beta$$

# Components of Optical Instruments

## Echelle Monochromator

Contains two dispersing elements arranged in a series.

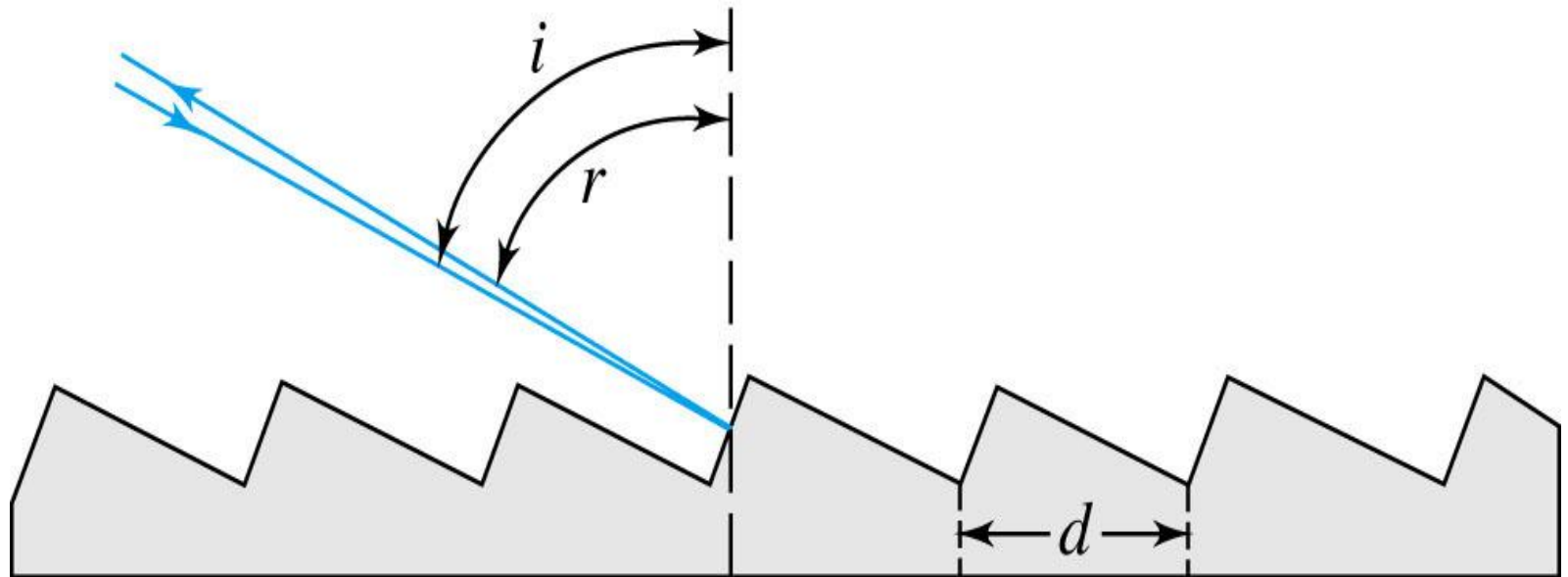
First element is the echelle grating.

This type of grating has reflection from the short face at a steep angle.

# Components of Optical Instruments

## Echelle Monochromator

Grating  
normal



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Angle of reflection,  $r$ , is close to the angle of incidence,  $i$ .

$$r = i = \beta$$

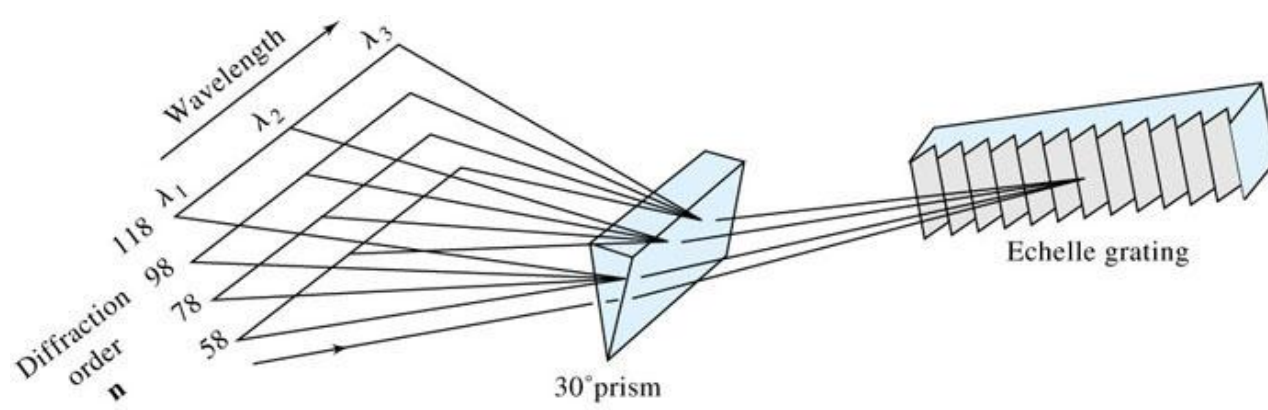
# Components of Optical Instruments

## Echelle Monochromator

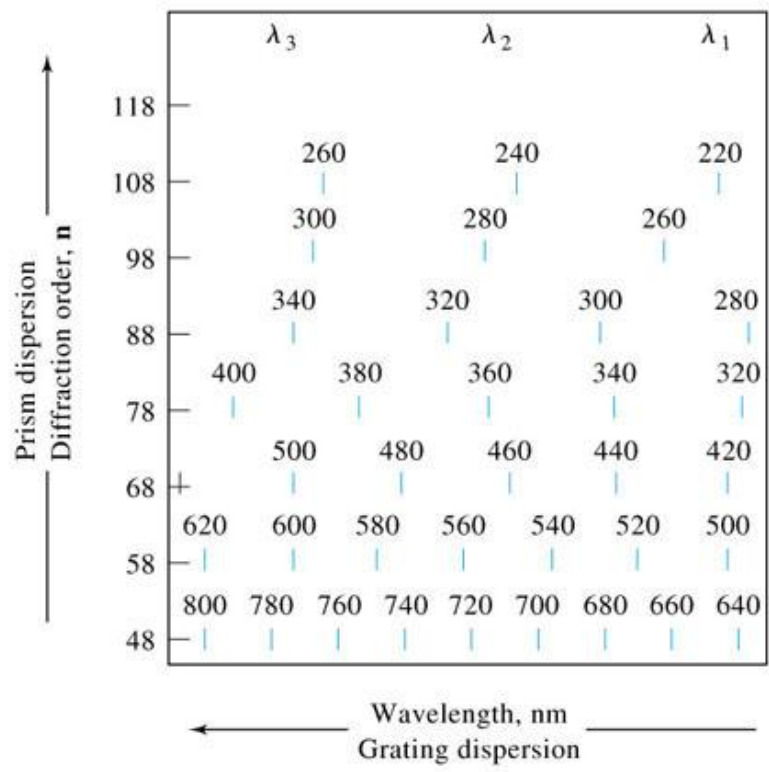
Second element is a low dispersion prism.

Advantage of an echelle grating:

- higher dispersion
- higher resolution

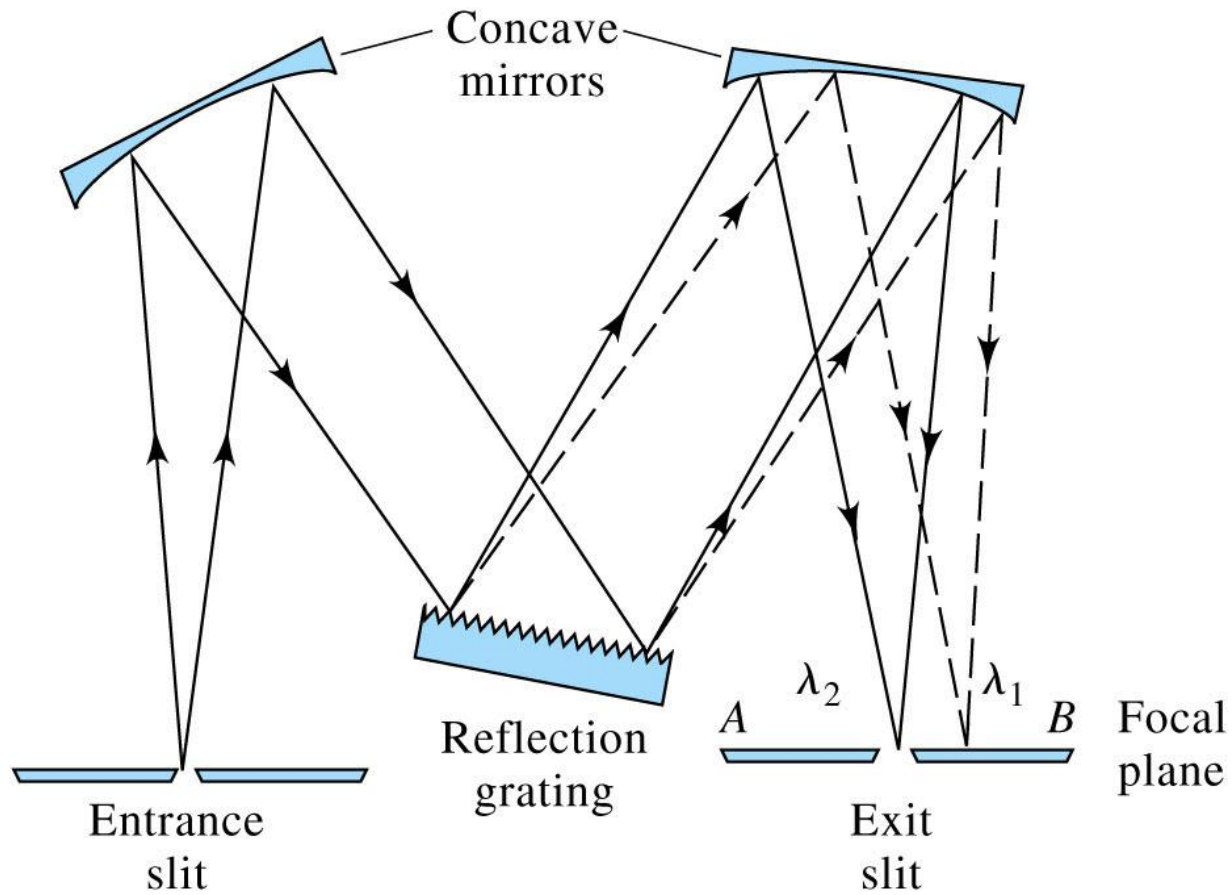


(a)



(b)

# Components of Optical Instruments



(a)

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# Assignment

- Read Chapter 7
- Read Chapter 13
  
- HW3: Chapter 7: 2-4, 8-13, and 16 (extra credit) (Due 1-30)
- HW4 Chapter 13: 1, 2, 5-8, 12, 13, 16-19
- HW4 Chapter 13 Due 2-6
  
- Exam 1- Lectures 1 to 8 - Feb 9<sup>th</sup>

