Astro 500 Spectrograph Design Project #2

[your name]

1. Summary narrative:

Here you will describe the problem you are trying to solve, your solution (in words), and what led you to this solution. Specifically, what kind of spectrograph have you designed to meet the performance requirements? What size optics and number of channels do you need? What grating types do you use? What are your camera and collimator focal-lengths and speeds? Where is the pupil in your system? If you are cross-dispersing, describe that as well and how it is done. If you are image-slicing, describe that as well. Finally summarize the performance in terms of achieved spectral resolution and summary score.

Show all work. You can discuss the problem with your classmates but your write up needs to be your own work.

2. Spectrograph geometry

Provide a simple figure of your spectrograph (using block drawings, e.g., in PowerPoint as shown in class). While everything does not need to be to scale you should point out the overall critical lengths between entrance aperture, collimator, grating(s), camera(s) and detector(s), and estimate the overall envelop of the instrument (ignoring what you don't know about, say, how large the detector cryostat is, etc.). Provide a short narrative as a caption to explain your drawing as needed.

If you are cross-dispersing consider adding two views that show both the primary and cross-dispersion planes.

If you are image-slicing consider adding a sketch of what that slicing looks like, e.g., you are reformatting some entrance aperture of a certain size and shape from the telescope into another shape of equivalent size to serve as the entrance slit. What are the shapes and dimensions?

3. Spectrograph critical design parameters

Provide information in the following Table 1 accompanied by a narrative as needed, e.g., describing motivation for pupil placement (and how this is done) as well as image slicing (and how this is done). Give all wavelengths in nm.

Table 1: Spectrograph Critical Design Parameters									
Slit height	*mm*	*arcsec*							
Slit width	*mm*	*arcsec*							
Collimator	*Focal length mm*	*Diameter mm*	*f/#*						
Pupil	*Distance from collimator mm*								
Beam size	*mm*								
Number of channels	*N*	*λ range channel 1* $(\lambda_{blue} - \lambda_{red})$	*λ range channel 2* $(\lambda_{blue} - \lambda_{red})$	*Etc.*					
Dichroic breaks		*Break λ (ch. 1-2)*	*Etc.*						

Grating 1	α *deg*	β *deg*	*Height mm*	*Width mm*	*Line density l/mm*	*Blaze angle deg*	*Order(s)*	*type*	*Distance from collimator*
Camera 1	*Focal length mm*	*Diameter mm*	*f/#*	*Angle from collimator deg*		*Distance from grating mm*			
CCD 1	*Pixel size microns*	*Number of pixels along slit*		*Number of pixels along dispersion axis*					
Etc. (Grating, Camera, CCD) for other N channels									
Cross Dispersion	*Information as required for each channel*								

4. Spectrograph performance

Provide information in the following Table 2 accompanied by a narrative as needed. Give all wavelength units in nm.

Table 2: Spectrograph Performance				
	Channel 1		Etc. for other chanels	
1-Slit loss[1]				
System Demagnification	*spatial*	*spectral*		
Dispersion	*angular (nm/rad)*	*linear (nm/mm)*		
Monochromatic slid-width	*microns*	*pixels*		
Spectral Resolution	@ start wave	@ end wave		
Number of pixels[2]	*spatial*	*spectral*		
Relative throughput[3]	*On axis*	*End wavelengths*		

Notes –

1) Slit losses refer to the amount (%) of light lost at the spectrograph entrance slit because it was smaller than the image aperture containing all of the light. Express as a percentage: (100 – loss %)
2) The number of pixels required to cover the full spectrum in a given channel over the full slit-length for a single object (including slicing)
3) The amount of light reaching the detector counting for vignetting from spectrograph optics (do not consider diffraction efficiency or optical surface transmission).

5. Evaluation

Assuming you have met the objectives in wavelength coverage the final performance metric is based on the information you will compile in the following Table 3. In this scheme bigger numbers are worse.

In addition, argue for any aspect of your design that you think is novel.

Table 3: Evaluation Rubric			
	weight	Common factors	
1) slit loss	0.05	(100 / *% (1-slit-losses)*)	
2) Collimator size	0.05	(*diameter* / 150 mm)^2	

	weight	Channel 1 factors	Etc. for other channels
3) Grating size	0.1	(*width* / 250 mm) *x* (*height* / 150 mm)	
4) Camera diameter	0.1	$(diameter / 150\ \text{mm})^2$	
5) Camera speed	0.1	1.2 / (*camera f/#*)	
6) Detector size	0.05	(*mm* / 96)	
7) Number of unbinned pixels	0.05	(*spatial* / 10) *x Ispectral* / 5)	
8) Vignetting	0.05	(100 / *% on-axis) x* (70 / *% off-axis*) *x* (100 / *% slit losses*)	

Compute your final score (this is the score of your spectrograph not the score of your project which include other factors!):

> *Sum the product of each item 1-8 with its weight in column-2. There is only one collimator and a one-time slit-loss penalty for the system, but your sum should include N products of each item 3-8 where N is the number of channels.*

Conclude in the context of Table 3 and your summary with a brief discussion of what elements contributed most to this summary score and hence what led you to your system design?