CLASSIFYING ABSORPTION SPECTRA LAB

<u>Instructions</u>: This laboratory exercise consists of classifying the absorption spectra of 30 stars. Examine the key on the right of the exercise sheet (or online), where the stars are placed top to bottom in order of decreasing surface temperature. In the absorption spectrums, the colors blue and violet are to the left; longer wavelengths are to the right. Since the image was taken using a blue-sensitive photographic plate, the red, orange, and yellow spectral regions have not been recorded.

Note that the hotter stars tend to be relatively more intense in the violet than the cooler stars. These stars will have longer trailing "tails" in the blue. In cooler stars where there is little energy emitted in the blue part of the spectrum, the light will seem to bunch to the right where the greatest amounts of energy are being produced. However, it is the dark absorption lines in each spectrum that will generally give the most information for you to successfully classify the stars in this lab. The classification will also involve assigning a decimal subscript, between $_0$ and $_9$ within each of the major letter types by interpolating the information between the provided reference spectra. The number is assigned as a subscript, A_0, F_6, K_4, etc.

The spectral lines are dark because light in the star's atmosphere is absorbing energy at specific wavelengths. At the top of the key is one Wolf-Rayet star. These stars are emitting energy in such great abundance that they drag their own atmospheres into space forming a shell of gas around the star which fluoresces and produces bright emission lines against a fainter continuum.

In spectral types B, A, and F, the pattern of hydrogen (Balmer) lines plays the dominant role in classifying the star, distinguishing these early (hotter) type stars from the later (cooler) ones. The secret for determining B and early A stars from late A and F stars is the relative strength of the Balmer series of hydrogen as well as the K line of signally ionized Calcium (Ca II). The H and K lines of singly ionized calcium (Ca II) become prominent in F, G, and K spectra. Important secondary information is given by the strength of the G band at 4307 Ångstroms (430.7 nm) with respect to hydrogen gamma or the neutral calcium line at 4227 Ångstroms (422.7 nm).

O: Temperatures are so high that helium is singly ionized and other elements are at least doubly ionized. In the visual region these spectra are almost featureless with long tails that are blue and violet.

B_0: The Balmer series is faintly visible. If the spectrum is well exposed, a few helium lines may be seen. Neutral helium is strongest at B_2 and fades rapidly towards A_0.

A_0: Hydrogen lines of the Balmer series are strong (strongest at A_3). Helium lines are no longer present. In this photograph, the singly ionized K line of Calcium becomes visible at A_2.

F_0: The Balmer lines are still conspicuous, although only half as strong as in the A_0. However, the K line of singly ionized calcium is as strong as the blend of hydrogen-epsilon (Hε) and the H line of calcium.

G_0: In this solar type spectrum, the H and K lines of singly ionized calcium (Ca II) are the strongest features visible with the Balmer lines no longer conspicuous. The continuum shows through between the numerous metal lines that are just at the limit of visibility. In G, K, and M stars, the light of the star's spectrum is brightest in the longer wavelengths (to the right) and appears bunched in these locations.

K_0: The energy maximum of the continuous spectrum lies far to the red (right) of the singly ionized calcium H and K lines which reach their greatest intensity in this class. Many metal lines are easily visible. The strongest is that of neutral calcium at 4227 Ångstroms (422.7 nm). Even stronger is the G band to the right of the calcium line.

M_0: The wide bands of the molecule TiO, shaded towards the violet, mark the spectra of the M class. The 4227 Ångstrom line of calcium (422.7 nm) is very strong, and the G band is also conspicuous. There are no M stars present in this laboratory exercise.

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Look at the full-page absorption spectrum photograph online or given to you. Here are some hints. As a trial, sort the first six numbered spectra near the top into some rough order. Notice that 1 and 5 have similar, almost featureless continua; 2 and 6 are also related, both exhibiting many hydrogen lines; 3 is an emission line star; and 4 belongs in yet another category. The intense part of 4 is bunched to the right on the longer wavelength end. This indicates a much cooler star than 5, whose spectrum is very strong in the ultraviolet light. It is evident that spectra with longer blue tails, such as 5, arise from hot early type stars, whereas 4 represent a later (cooler) type star. Compare 2 and 6 more carefully. The hydrogen lines are comparatively stronger in 2, but the most striking difference is the appearance of the H and K lines of singly ionized calcium which spoils the regular Balmer line pattern. Comparison with the key shows that 2 is an A star and 6 is an F star. You pick the decimal number which goes with each star. In star 4 the H and K lines are clearly visible, but the hydrogen series has vanished, thus ruling out type G and earlier (hotter). The dark line some distance to the right of the H and K pair is the G band. Since the 4227Å calcium line is not visible, this must be a K star. You pick the decimal. It is instructive to compare this spectrum with 26, 27, and 28, as well as with the key. Examples 1 and 5 are clearly much earlier than A_0, and 3 shows emission lines. Use these hints to help with the other stars that need identification.

NOW IT IS YOUR TURN TO CLASSIFY THE STARS

1. ______	11. ______	21. _____
2. ______	12. ______	22. _____
3. ______	13. ______	23. _____
4. ______	14. ______	24. _____
5. ______	15. ______	25. _____
6. ______	16. ______	26. _____
7. ______	17. ______	27. _____
8. ______	18. ______	28. _____
9. ______	19. ______	29. _____
10. ______	20. ______	30. _____

The written material was revised from the original exercise, “Laboratory Exercises in Astronomy-Spectral Classification,” reprinted from *Sky and Telescope* magazine, written by Owen Gingerich of the Smithsonian Astrophysical Observatory and Harvard University. “Laboratory Exercises in Astronomy” are no longer in print.