|  |  |
| --- | --- |
| **Course Title:** | **Stellar atmospheres** |
| **Course Code:** | **ASTR 352** |
| **Program:** | **ASTR-MATH** |
| **Department:** | **Astronomy** |
| **College:** | **Science** |
| **Institution:** | **King AbdulAziz University** |

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# A. Course Identification

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1. Credit hours:** | | | |  | | | | | | | | | | | | |
| **2. Course type** | | | | | | | | | | | | | | | | |
| **a.** | University | |  | | College | | |  | Department | | | | **✓** | Others |  |  |
| **b.** | | Required | | | |  | Elective | | | **✓** |  | | | | | |
| **3. Level/year at which this course is offered:** | | | | | | | | | | | | **6th Level / 3th Year** | | | | |
| **4. Pre-requisites for this course** (if any)**: ASTR 351** | | | | | | | | | | | | | | | | |
| **5. Co-requisites for this course** (if any)**: None** | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | | |

## 6. Mode of Instruction (mark all that apply)

| **No** | **Mode of Instruction** | **Contact Hours** | **Percentage** |
| --- | --- | --- | --- |
| **1** | **Traditional classroom** | **2** | **100%** |
| **2** | **Blended** |  |  |
| **3** | **E-learning** |  |  |
| **4** | **Correspondence** |  |  |
| **5** | **Other** |  |  |

**7. Actual Learning Hours** (based on academic semester)

|  |  |  |
| --- | --- | --- |
| **No** | **Activity** | **Learning Hours** |
| **Contact Hours** | | |
| **1** | **Lecture** | **30** |
| **2** | **Laboratory/Studio** |  |
| **3** | **Tutorial** |  |
| **4** | **Others** (specify) |  |
|  | **Total** | **30** |
| **Other Learning Hours\*** | | |
| **1** | **Study** | **60 (minimum)** |
| **2** | **Assignments** |  |
| **3** | **Library** |  |
| **4** | **Projects/Research Essays/Theses** |  |
| **5** | **Others** |  |
|  | **Total** | **60** |

**\*** The length of time that a learner takes to complete learning activities that lead to achievement of course learning outcomes, such as study time, homework assignments, projects, preparing presentations, library times

# B. Course Objectives and Learning Outcomes

|  |
| --- |
| 1. Course Description This course contains the following subjects: Atomic structure, Deep study of the physical properties of the radiation field. Interaction of radiation with matter. Emission and absorption. The statistical equilibrium equation. The equation of radiation transfer and its solution for continuous radiation. The stellar Gray atmosphere. Line transfer equation in stellar atmosphere - Curve of growth. Chemical abundances in stellar atmosphere. |
| 2. Course Main Objective This course aims to describe how astronomers obtain information about the properties of stars from their atmospheres. On completion of this course you should be able to:   * Understand how the interaction between the radiation and matter affects the appearance of a stellar atmosphere, including the major sources of opacity. * Understand the relation between flux and temperature for a black body emitter, and be familiar with Wien's displacement law. * You will have a knowledge of the formation of spectral lines, line broadening mechanisms, plus an appreciation of the use of stellar continua and lines as atmospheric diagnostics. * Be able to derive and use the equation of radiative transfer * Apply modern methods to evaluate relevant quantitative problems in stellar astronomy * Present the results of qualitative and quantitative analysis in stellar astronomy * Discuss links between stellar observations and physical theory * Communicate scientific work relevant to research in stellar astronomy |
|  |

## 3. Course Learning Outcomes

| **CLOs** | | **Aligned****PLOs** |
| --- | --- | --- |
| 1 | **Knowledge:** |  |
| 1.1 | Define the black body radiation, effective temperature, specific intensity, flux, optical depth, and source function. | K9 |
| 1.2 | Define limb darkening. | K9 |
| 1.3 | Outline the continuous absorption Line, bound-free, free-free opacity, Thompson and Rayleigh scattering | K8, K9 |
| 1.4 | Describe Line absorption Equivalent widths, natural line broadening, pressure broadening, thermal broadening Line absorption Equivalent widths, natural line broadening, pressure broadening, thermal broadening | K8, K9 |
| 1.5 | List the properties and observed features of chromosphere and corona | K3, K11 |
| 1.6 | Describe the local thermodynamic equilibrium and Saha-Boltzmann Equation. | K9 |
| **2** | **Skills :** |  |
| 2.1 | Compare Thompson and Rayleigh scattering. | S7 |
| 2.2 | Explain how the astronomers derive the elemental abundances. | S7, S9 |
| 2.3 | Compare between the diagnostics and mechanisms of mass-loss from late-type stars and early-type stars. | S6, S7 |
| 2.4 | Formulate the relation between the blackbody radiation and stellar opacity. | S5, S9 |
| 2.5 | Explain the radiative transfer parallel ray and plane-parallel transfer equation. | S11, S14 |
| **3** | **Competence:** |  |
| 3.1 | Ability to formulate and solve problems related to stellar atmosphere. | C3, C4 |

# C. Course Content

|  |  |  |
| --- | --- | --- |
| **No** | **List of Topics** | **Contact Hours** |
| 1 | Introduction to stellar atmospheres | 5 |
| 2 | Local Thermodynamic Equilibrium, Saha-Boltzmann Equations. | 5 |
| 3 | Radiation terms Black body radiation, Effective Temperature, Specific Intensity, Flux, Optical depth, source function. | 5 |
| 4 | Radiative Transfer Parallel ray and plane-parallel transfer equation, surface intensity, limb darkening, Eddington-Barbier relation, Eddington approximation, grey atmosphere | 5 |
| 5 | Continuous absorption Line, bound-free, free-free opacity, atomic hydrogen, H- ion, He, metals, molecules, Thompson and Rayleigh scattering | 5 |
| 6 | Blackbody radiation & stellar opacity | 4 |
| 7 | Temperatures and pressures of stars, direct determinations of radii, temperatures and pressures from discontinuities, hydrostatic equilibrium, determination of electron pressure from gas pressure using Saha equation, radiation pressure, Eddington limit | 4 |
| 8 | Line absorption Equivalent widths, natural line broadening, pressure broadening, thermal broadening, other broadening mechanisms, spectroscopic notation, allowed and forbidden lines, optically thin and thick lines, curve of growth, abundance determinations, departures from LTE | 4 |
| 9 | Solar atmosphere Granulation, properties and observed features of chromosphere and corona, origin of coronal wind | 4 |
| 10 | Stellar winds, Diagnostics and mechanisms of mass-loss from late-type stars; diagnostics and mechanisms of mass-loss from early-type stars | 4 |
| **Total** | | **45** |

# D. Teaching and Assessment

## 1. Alignment of Course Learning Outcomes with Teaching Strategies and Assessment Methods

| **Code** | **Course Learning Outcomes** | **Teaching Strategies** | **Assessment Methods** |
| --- | --- | --- | --- |
| **1.0** | **Knowledge** | | |
| 1.1 | Define the black body radiation, effective temperature, specific intensity, flux, optical depth, and source function. | Lectures | Exams & Homework & quizzes |
| 1.2 | Define limb darkening. |
| 1.3 | Outline the continuous absorption Line, bound-free, free-free opacity, Thompson and Rayleigh scattering |
| 1.4 | Describe Line absorption Equivalent widths, natural line broadening, pressure broadening, thermal broadening Line absorption Equivalent widths, natural line broadening, pressure broadening, thermal broadening |
| 1.5 | List the properties and observed features of chromosphere and corona |
| 1.6 | Describe the local thermodynamic equilibrium and Saha-Boltzmann Equation. |
| **2.0** | **Skills** | | |
| 2.1 | Compare Thompson and Rayleigh scattering. | Lectures | Exams & Homework & quizzes |
| 2.2 | Explain how the astronomers derive the elemental abundances. |
| 2.3 | Compare between the diagnostics and mechanisms of mass-loss from late-type stars and early-type stars. |
| 2.4 | Formulate the relation between the blackbody radiation and stellar opacity. |
| 2.5 | Explain the radiative transfer parallel ray and plane-parallel transfer equation. |
| **3.0** | **Competence** | | |
| 3.1 | Ability to formulate and solve problems related to stellar atmosphere. | Oral discussion | Exams |

## 

## 2. Assessment Tasks for Students

| **#** | **Assessment task\*** | **Week Due** | **Percentage of Total Assessment Score** |
| --- | --- | --- | --- |
| **1** | Exams I | 6th | 15% |
| **2** | Exams II | 12th | 15% |
| **4** | quizzes | Monthly | 20% |
| **5** | Homework | Every two weeks | 10% |
| **6** | Final Exam | 15th | 40% |

**\*Assessment task** (i.e., written test, oral test, oral presentation, group project, essay, etc.)

# E. Student Academic Counseling and Support

|  |
| --- |
| **Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice :** |
| Office hours: 3 hours per week |

# F. Learning Resources and Facilities

## 1.Learning Resources

|  |  |
| --- | --- |
| **Required Textbooks** | Lecture notes |
| **Essential References Materials** | 1. Introduction to Stellar Astrophysics, Vol 2, E. Bohm-Vitense, 1989 (CUP). 2. Observation and Analysis of Stellar Photospheres (3rd Ed)., D. Gray, 2005. 3. Theory of Stellar Atmospheres, I. Hubeny and D. Mihalas, 2015 (Princeton) 4. Stars and their spectra, J.B. Kaler, 1997 (CUP) 5. Introduction to Stellar Winds, H. Lamers and J. Cassinelli, 1999 (CUP) 6. Introduction to Stellar Atmospheres and Interiors: Eva Novotny, Oxford University press, 1973. 7. [Radiative transfer in stellar atmospheres](http://www.fys.ruu.nl/~rutten/node19.html) by R. J. Rutten 2003 |
| **Electronic Materials** | <http://www.fys.ruu.nl/~rutten/node19.html> |
| **Other Learning Materials** |  |

## 2. Facilities Required

| **Item** | **Resources** |
| --- | --- |
| **Accommodation**  (Classrooms, laboratories, demonstration rooms/labs, etc.) | * Lecture’s room with 10 seats * Library |
| **Technology Resources**  (AV, data show, Smart Board, software, etc.) | Data show |
| **Other Resources**  (Specify, e.g. if specific laboratory equipment is required, list requirements or attach a list) |  |

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# G. Course Quality Evaluation

| **Evaluation**  **Areas/Issues** | **Evaluators** | **Evaluation Methods** |
| --- | --- | --- |
| Course contents | Students | Course evaluation questionnaire (Direct) |
| Learning resources and equipment | Students | Student experience questionnaire (Direct) |
| Effectiveness of teaching and assessment | Students | Student experience questionnaire (Direct) |
| Course contents and materials | Faculty members | By department council discussion (Indirect) |

**Evaluation areas** (e.g., Effectiveness of teaching and assessment, Extent of achievement of course learning outcomes, Quality of learning resources, etc.)

**Evaluators** (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

**Assessment Methods** (Direct, Indirect)

# H. Specification Approval Data

|  |  |
| --- | --- |
| **Council / Committee** |  |
| **Reference No.** |  |
| **Date** | September 2017 |