

Pharmaceutical Engineering

A Course Book for B. Pharmacy, Semester III

*As per the new Pharmacy Council of India (PCI) syllabus 2026
(NEP 2020)*

Course Code: BP307T

Dr. Sheetal Sharma

Associate Professor
School of Pharmacy and Emerging
Sciences, Baddi University of Emerging
Sciences & Technology, Baddi, Himachal
Pradesh, India.

Jyoti Rani

Assistant Professor
School of Pharmacy and Emerging
Sciences, Baddi University of Emerging
Sciences & Technology, Baddi, Himachal
Pradesh, India.

Anupama Kumari

Assistant Professor
School of Pharmacy and Emerging
Sciences, Baddi University of Emerging
Sciences & Technology, Baddi, Himachal
Pradesh, India.



Pharmaceutical Engineering

Course Code: BP307T

A Coursebook for B.Pharmacy, Semester III

As per the new Pharmacy Council of India (PCI) Syllabus 2026 (NEP 2020)

Authors: Dr. Sheetal Sharma, Jyoti Rani, Anupama Kumari

Edition: First Edition, August 2026

Language: English

Copyright © 2026 Wiseleaf Scientific Ventures Pvt. Ltd.

All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher, except for brief quotations in reviews or scholarly works permitted by copyright law.

ISBN: 978-81-903393-2-2



MRP: 410/-

Published by: Wiseleaf Scientific Ventures Pvt. Ltd.

Address: Wework - Berger Delhi One Floor 19, C-001/A2, Sector 16b, Noida, Uttar Pradesh, 201301, India

Printed by: Patraloka | Prints and More

Immadihalli Main Rd, Immadihalli, Whitefield, Bengaluru, Karnataka 560066

Printed in India

Preface

Pharmaceutical Engineering occupies the point at which pharmaceutical science becomes pharmaceutical manufacture. A formulation that is elegant on paper reaches the patient only after a sequence of physical operations has been carried out on a scale of kilograms and tonnes, under the discipline of good manufacturing practice, and at a cost the market will bear. This book is written to teach those operations to the third-semester B. Pharmacy student in the depth the examination expects and the clarity the subject deserves.

The organising idea of the book is the unit operation: the recognition that any manufacturing process, however complex, resolves into a small set of physical operations, each governed by the transport of momentum, heat, or mass. Size reduction, size separation, mixing, filtration, crystallization, centrifugation, heat transfer, evaporation, drying, distillation, and fluid flow are treated in turn, and each is approached the same way, from the industrial task it performs, through the principle and the governing equations, to the construction and working of the equipment and its pharmaceutical application.

Three commitments shape every chapter. The first is that the equipment is always matched to the material: the hardness of a solid selects the mill, the heat sensitivity of a drug selects the dryer and the evaporator, and the viscosity of a slurry selects the filter. The second is that operations are quantified, not merely described, so the laws of size reduction, the heat-transfer rate equation, the moisture and energy balances, and the Reynolds and Bernoulli relations are carried through to worked numerical examples in consistent units. The third is that modern manufacture is governed by quality and safety, so good manufacturing practice, containment, corrosion control, waste management, and the newer disciplines of Process Analytical Technology and automation are given their due.

Each chapter opens with its learning outcomes, develops the topic in a formal and definition-led manner supported by original figures and comparison tables, works through numerical examples where the subject is quantitative, and closes with a summary and a graded self-assessment that includes questions in the style of the end-semester paper. The five units of the syllabus are gathered into review grids so that the thermal operations, in particular, can be compared side by side as the course outcomes require.

The book aims to serve the first-time learner, the reviser, and the examinee from the same pages. It is offered in the hope that the student who works through it will not only describe an item of pharmaceutical plant but understand why it is built as it is, and be able to compute what it will do.

Authors

Dr. Sheetal Sharma

Jyoti Rani

Anupama Kumari

Syllabus: BP307T Pharmaceutical Engineering (Theory)

Course code	BP307T
Course title	Pharmaceutical Engineering (Theory)
Course type	Core
Hours per week (L-T-P)	3-0-0
Maximum lecture hours	45

Course Outcomes

CO1: Explain the principles and pharmaceutical applications of unit operations such as size reduction, mixing, size separation, and fluid flow.

CO2: Identify and describe the construction, working, and utility of various pharmaceutical engineering equipment.

CO3: Compare and evaluate different thermal processes such as drying, evaporation, distillation, and heat transfer based on operational efficiency.

CO4: Apply principles of safe and efficient material handling and understand the impact of corrosion and waste management in pharmaceutical industries.

CO5: Examine the relevance of contemporary technological trends such as PAT and automation for enhancing pharmaceutical manufacturing processes.

Detailed Syllabus

Unit I (12 h) — Unit operations associated with solids

Principle, construction, working, advantages and disadvantages, and pharmaceutical applications of size reduction, size separation, and mixing equipment.

Unit II (12 h) — Unit operations associated with liquids

Principle, construction, working, advantages and disadvantages, and pharmaceutical applications of filtration, crystallization, and centrifugation equipment.

Unit III (12 h) — Unit operations associated with heat transfer

Principle, construction, working, advantages and disadvantages, and pharmaceutical applications of evaporation, drying, distillation, and heat-transfer equipment.

Unit IV (5 h) — Materials and material handling

Introduction to material handling equipment and techniques; conveyors, hoists, and automated guided vehicles (AGVs); storage systems (bins, silos in warehouses); safety considerations in material handling and waste management; types of corrosion and their impact on pharmaceutical processes and the environment.

Unit V (4 h) — Flow of fluids

Types and measurement of flow; manometers; Reynolds number and its significance; Bernoulli's theorem and its applications; orifice meter, venturimeter, pitot tube, and rotameter.

Table of Contents

Preface	3
Syllabus: BP307T Pharmaceutical Engineering (Theory)	4
Course Outcomes.....	4
Detailed Syllabus	4
Abbreviations and Symbols	13
Chapter 1: Introduction to Pharmaceutical Engineering and Unit Operations.....	14
Learning Outcomes.....	14
1.1 What Pharmaceutical Engineering Is	14
1.2 The Unit-Operations Concept.....	15
Classification of unit operations relevant to pharmacy.....	15
1.3 The Three Transport Phenomena	17
1.4 Material and Energy Balances	18
1.5 The Sequence of a Manufacturing Line	19
1.6 Engineering Constraints Specific to Pharmacy	20
1.7 Contemporary Direction: PAT and Automation	20
Self-Assessment.....	21
Chapter 2: Size Reduction.....	22
Learning Outcomes.....	22
2.1 Definition and objectives.....	22
2.2 Mechanisms and forces of size reduction.....	23
2.3 Factors affecting size reduction.....	25
2.4 Laws of size reduction.....	26
2.5 Size-reduction equipment	27
2.5.1 Hammer mill	27
2.5.2 Ball mill	29
2.5.3 Fluid-energy (jet) mill.....	30
2.5.4 Edge-runner and end-runner mills	31
2.5.5 Roller mill	32
2.5.6 Cutter mill	32
2.5.7 Colloid mill	32
2.6 Reduction ratio, feeding, and circuit	33
Worked Examples.....	34

Self-Assessment.....	35
Chapter 3: Size Separation	36
Learning Outcomes.....	36
3.1 Definition and Objectives	36
3.2 Particle Size and Particle Size Distribution	37
3.3 Standard Sieves.....	38
3.4 Methods and Equipment of Size Separation.....	40
3.4.1 Sieving with a Sieve Shaker	41
3.4.2 Separation by Sedimentation and Elutriation	41
3.4.3 The Cyclone Separator.....	42
3.4.4 The Air Separator (Air Classifier)	42
3.4.5 The Bag Filter	43
3.5 Mechanism and Efficiency of Sieving.....	43
Worked Examples.....	44
Self-Assessment.....	45
Chapter 4: Mixing	47
Learning Outcomes.....	47
4.1 Definition, objectives, and pharmaceutical importance	47
4.2 Types of mixtures	48
4.3 Mechanisms of mixing	48
4.3.1 Solid-solid mixing.....	48
4.4 Segregation (demixing) of solids.....	50
4.5 Degree of mixing, mixing index, and scale of scrutiny.....	51
4.6 Equipment for mixing solids	52
4.6.1 Double-cone blender	53
4.6.2 Twin-shell (V) blender.....	54
4.6.3 Ribbon blender.....	55
4.6.4 Cube and drum blenders	56
4.6.5 Planetary mixer	56
4.7 Equipment for mixing liquids.....	57
4.7.1 Propeller (axial-flow) agitator.....	58
4.7.2 Turbine (radial-flow) agitator	58
4.7.3 Paddle agitator	58
4.7.4 Flow patterns, baffles, and the vortex	59

4.8 Equipment for mixing semisolids.....	60
4.8.1 Sigma-blade mixer	60
4.8.2 Planetary mixer (semisolid duty)	60
4.8.3 Triple-roller mill	61
4.8.4 Colloid mill	62
4.9 Factors affecting mixing efficiency	62
Worked Examples.....	63
Self-Assessment.....	64
Chapter 5: Filtration	65
Learning Outcomes.....	65
5.1 Definition, terminology, and pharmaceutical applications.....	65
5.2 Theory of filtration	66
5.2.1 Darcy's law and the general rate equation.....	66
5.2.2 Specific cake resistance	67
5.2.3 Compressible and incompressible cakes.....	68
5.2.4 The Kozeny-Carman relation.....	68
5.3 Factors affecting the rate of filtration	68
5.4 Filter media and filter aids.....	69
5.5 Classification of filters.....	70
5.6 Equipment: pressure and vacuum filters	71
5.6.1 Plate-and-frame filter press.....	71
5.6.2 Filter leaf (Sweetland filter).....	72
5.6.3 Rotary drum vacuum filter.....	73
5.6.4 Meta filter (sparkler filter)	75
5.6.5 Edge filter.....	76
5.7 Equipment: cartridge and membrane filters	76
5.7.1 Cartridge filter.....	76
5.7.2 Membrane filters and membrane processes	77
5.8 Cake washing.....	78
Worked Examples.....	79
Self-Assessment.....	80
Chapter 6: Crystallization.....	81
Learning Outcomes.....	81
6.1 Definition, objectives, and the importance of crystal form	81

6.2 Solubility and supersaturation	82
6.3 Mechanism: nucleation, crystal growth, and their control	84
6.3.1 Nucleation	85
6.3.2 Crystal growth.....	85
6.3.3 The degree of supersaturation controls crystal size	85
6.3.4 Factors affecting crystal size, shape, and purity	86
6.3.5 Caking of crystals and its prevention.....	87
6.4 Yield of crystals.....	87
6.5 Crystallization equipment.....	87
6.5.1 Agitated batch (tank) crystallizer.....	88
6.5.2 Swenson-Walker crystallizer	88
6.5.3 Forced-circulation (Oslo/Krystal) crystallizer	89
6.5.4 Vacuum crystallizer	90
Worked Examples.....	92
Self-Assessment.....	93
Chapter 7: Centrifugation.....	94
Learning Outcomes.....	94
7.1 Definition and Principle.....	94
7.2 Classification of Centrifuges	95
7.3 Sedimentation Centrifuges	96
7.3.1 Tubular-bowl centrifuge	96
7.3.2 Disc-bowl (disc-stack) centrifuge	97
7.3.3 Non-perforated basket centrifuge	99
7.3.4 Supercentrifuge and ultracentrifuge.....	99
7.4 Filtration Centrifuges.....	100
7.4.1 Perforated-basket centrifuge	100
7.5 Pharmaceutical Applications	101
Worked Examples.....	102
Self-Assessment.....	103
Chapter 8: Heat Transfer	104
Learning Outcomes.....	104
8.1 Heat transfer as a rate process	104
8.2 Conduction.....	105
8.2.1 Fourier's law.....	106

8.2.2 Composite walls: resistances in series	106
8.3 Convection.....	107
8.3.1 Newton's law of cooling and the film coefficient	107
8.3.2 Factors affecting h.....	107
8.4 Radiation.....	108
8.5 The overall heat-transfer coefficient U.....	108
8.6 Heat transfer in process equipment	109
8.6.1 Steam-jacketed vessels and coils	109
8.6.2 Heat exchangers	109
8.6.3 Co-current and counter-current flow	111
8.6.4 The log mean temperature difference	111
8.7 Pharmaceutical applications	112
Worked Examples.....	112
Self-Assessment.....	114
Chapter 9: Evaporation.....	115
Learning Outcomes.....	115
9.1 Definition and scope	115
9.2 Factors affecting evaporation	116
9.3 Heat and mass balance, capacity and economy	117
9.4 Single-effect and multiple-effect evaporation	118
9.4.1 Feeding arrangements	119
9.5 Vapour recompression.....	120
9.6 Evaporation equipment.....	120
9.6.1 Steam-jacketed pan	120
9.6.2 Horizontal-tube evaporator	121
9.6.3 Climbing-film (long-tube vertical) evaporator	122
9.6.4 Forced-circulation evaporator.....	122
9.6.5 Falling-film evaporator	123
Worked Examples.....	124
Self-Assessment.....	125
Chapter 10: Drying.....	127
Learning Outcomes.....	127
10.1 Definition and scope	127
10.2 Moisture content and its several forms.....	128

10.3 The rate-of-drying curve.....	128
10.4 Classification of dryers.....	130
10.5 Drying equipment.....	131
10.5.1 Tray (shelf) dryer.....	131
10.5.2 Fluidised-bed dryer.....	132
10.5.3 Spray dryer.....	133
10.5.4 Drum (roller) dryer.....	134
10.5.5 Freeze dryer (lyophilisation).....	135
10.5.6 Vacuum (tray) dryer.....	136
10.5.7 Tunnel and rotary dryers.....	137
Worked Examples.....	138
Self-Assessment.....	138
Chapter 11: Distillation.....	140
Learning Outcomes.....	140
11.1 Definition and the basis of separation.....	140
11.2 Vapour pressure, boiling point, and Raoult's law.....	140
11.3 Vapour-liquid equilibrium and the two diagrams.....	141
11.4 Relative volatility.....	142
11.5 Simple (differential) distillation.....	142
11.6 Flash (equilibrium) distillation.....	144
11.7 Fractional distillation (rectification).....	145
11.8 Steam distillation.....	147
11.9 Distillation under reduced pressure, azeotropic, and extractive distillation.....	148
11.10 Molecular distillation.....	150
Worked Examples.....	152
Self-Assessment.....	152
Chapter 12: Materials, Material Handling, Corrosion and Waste Management.....	154
Learning Outcomes.....	154
12.1 Materials of construction.....	154
12.2 Material handling.....	155
12.3 Storage of materials.....	157
12.4 Safety considerations in material handling.....	158
12.5 Corrosion.....	158
12.5.1 The electrochemical mechanism.....	158