Adult Basic Education

Science

Physics 3104A

Force, Motion and Energy

Study Guide

Prerequisite: Physics 2104B or Physics 2204

Credit Value: 1

Text: *Physics: Concepts and Connections*. Irwin, 2002

Physics Concentration

Physics 1104
Physics 2104A
Physics 2104B
Physics 2104C
Physics 3104A
Physics 3104B
Physics 3104C

Table of Contents

To the Student

I. Introduction to Physics 3104A

This course will involve further study of motion. In Physics 2104A and Physics 2104B, you studied kinematics and were introduced to dynamics. Dynamics will be studied further in this course with more advanced applications of Newton's Laws and more advanced analysis of forces. The study of statics, which is the physics of keeping things still, will be covered at the end of the course.

Like all previous courses, you will need a scientific calculator. You will also need a good understanding of trigonometry. In this course you will be need to find components of vectors to solve problems. It is strongly recommended that a course in trigonometry be completed before you start this course.

II. Use of Science Study Guides

Before beginning this course, ensure you have the text and any other resources needed *(see the information in the Introduction to this course for specifics)*.

As you work through the Study Guide, you will see that it is divided according to the Units listed in the Table of Contents. When you open a unit it will have the following components:

To the Student

Reading for this Unit:
Here you will find the chapters, sections and pages of the text you will use to cover the material for this unit. Skim the sections of the textbook, look at the titles of the sections, scan the figures and read any material in the margins. Once you have this overview of the unit, you are ready to begin. Do not be intimidated by the content. You will work through the text, section by section, gaining knowledge and understanding of the material as you go.

References and Notes	Work to Submit
This left hand column guides you through the material to read from the text. Read any highlighted notes that follow the reading instructions. The symbols ▶▶ direct you to the questions that you should complete when finished a reading assignment..	You come across three (3) headings in this right hand column. **Writing:** This section comprises your notes for the unit. Here you will find either written questions or references to specific questions or problems from your text. You may want to write out each question followed by the answer. This material should be checked by your instructor before moving on to the next unit. Mathematical problems should have their solutions checked as you go. **Laboratory:** This section indicates if there is a Lab that should be completed for the unit. Let the instructor know in advance that you will be ready for the lab. A lab report should be submitted for each Lab. Your instructor will provide guidelines as to how s/he wants the report written. **Assignment:** This section indicates if there is an assignment that should be completed for the Unit. The information in the "References and Notes" column will indicate how you obtain the assignment. These assignments frequently relate the science content to technology, society and the environment.

III. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam *(entire course)*	50%
	100%

The overall pass mark for the course is 50%.

Unit 1 - Motion in Two Dimensions

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*

Chapter 3:
- Section 3.1: pages 79 - 84
- Section 3.2: pages 84 -86
- Section 3.3: pages 87 - 95
- Lab 3.1: page 119

References and Notes	Work to Submit
	Writing:
Read pages 79 to 84 of Section 3.1.▶▶ *Vectors are reviewed but emphasis will be on finding the components of a vector.*	1.1 Complete Questions 1 and 2 on page 84.
Read pages 84 to 86 of Section 3.2▶▶	1.2 Explain what is meant by projectile motion. 1.3 How is parabolic motion produced? 1.4 What is meant by the term *range* in parabolic motion? 1.5 Sketch diagrams to show the effect on the distance travelled in a horizontal direction if the vertical velocity is: (a) zero (b) downward (c) upward 1.6 For which conditions in 1.5 will the time be: (a) shortest (b) longest

Unit 1 - Motion in Two Dimensions

References and Notes	Work to Submit
	1.7 Complete Questions 1 and 2 on page 86.
	1.8 Complete Questions 18 and 19 on page 114.
Read page 87 Section 3.3 up to Example 2 ▶▶	1.9 What is the key to solving two dimensional motion problems?
Study Examples 2 and 3 on pages 87 and 88 ▶▶	1.10 Complete Questions 20 to 24 on page 115.
Study Example 4 on page 89 to 90 ▶▶	1.11 Complete Question 29 on page 115.
Study Examples 5 on page 91 ▶▶	1.12 Complete Problems 30 to 31 on pages 115 and 116.
Read page 91 and study Examples 6 on page 92 to 93 ▶▶	1.13 Complete Problem 33 on page116.
	Laboratory:
Let your instructor know you are ready to complete Lab #1. ▶▶	1.14 Complete and submit Core Lab #1: Initial Velocity of a Projectile on page 119.

Unit 2 - Applications of Newton's Laws I

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*

Chapter 4:
- Section 4.3: pages 131-136
- Section 4.4: pages 53-64
- Section 5.5: pages 172 -179
- Section 6.1: pages 194 -196
- Section 6.2: pages 197 -202

References and Notes	Work to Submit
	Writing:
Review Section 4.3 and then read pages 137 to 141 of Section 4.4 ▶▶	2.1 Complete Problem 1 on page 141.
Review pages 173 to 178 of Section 5.5. Carefully study Examples 8 to 10 ▶▶	2.2 Complete Problem 3 on page 179.
Read pages 194 and 195 of Section 6.1 up to and including Example 1 ▶▶.	2.3 Complete Problem 7(a) and (b) on page 224.
Notice that the angle of the inclined plane is the angle you will use to solve your parallel and perpendicular components.	
Study Example 2 on pages 195 and 196 ▶▶	2.4 Complete Problems 3 and 4 on page 196.
Watch your signs. When the example changes from using the vector notation ($\vec{F}_f$) to the notation F_f, the sign on the force (as it is to the left) is negative.	

Unit 2 - Applications of Newton's Laws I

References and Notes	Work to Submit
Read page 197 up to Example 3. ▶▶	2.5 What is needed to solve string-and-pulley problems?
Study Example 3 on pages 197 to 198. ▶▶	2.6 Complete Problem 11(a) on page 225.
You are solving three problems in 11(a). Your text solves these problems by using letters and solving for an unknown. If you have trouble with this, try substituting numerical values into the equations in place of mg etc.	
Study Example 4 on pages 198 to 199. ▶▶	2.7 Complete Problem 11(b).
In 11(b) you will have the same string and pulleys, but now the force of friction must be included in your calculations.	
Study Example 5 on pages 200 to 201. ▶▶	2.8 Complete Problem 11(c) and 13 on page 225.
If $\vec{F}_{\parallel} > \vec{F}_g$ then Jane goes up. Remember that $\vec{F}_{\parallel}$ is found from the horizontal component of $\vec{F}_g$. Also note that your text changes $F_{\parallel}$ to F_x in this example.	

Unit 3 - Applications of Newton's Laws II

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit:	*Physics: Concepts and Connections:*	
	Chapter 6:	Section 6.3: pages 202 - 206
		Section 6.4: pages 207 - 214
		Lab 6.1: pages 228-229

References and Notes	Work to Submit
	Writing:
Read pages 202 to 206 of Section 6.3. ▶▶	3.1 Define uniform circular motion.
By period (T) it is meant how long it takes for 1 cycle around the face of the watch.	3.2 Regarding the example: the speed of the hand doesn't change, why is there acceleration?
	3.3 What does centripetal mean?
Subtracting vectors is illustrated on page 105.	3.4 What are the equations for the magnitude of centripetal acceleration? Explain what each variable represents.
In problem 17 you have to change your 365 day period to seconds.	3.5 Complete Problems 17 and 18 on page 226.
	3.6 Complete Problems 1 to 5 on page 206.
Read page 207 and 208 of Section 6.4 to the end of Example 7 ▶▶	3.7 What is centripetal force?
In Example 7, 77 rpm is converted to Hz. Hz is cycles per second. You convert 77 cycles/min x 1 min/60s = 1.28 cycles/s or 1.28 Hz.	3.8 What happens when the net force on an object traveling in a circle at constant speed is zero?
	3.9 What are the three equations for centripetal force? Explain what each variable represents.

Unit 3 - Applications of Newton's Laws II

References and Notes	Work to Submit
Study from Example 8 on page 208 to "Centripetal Force and Banked Curves" on page 210. ▶▶ *Watch the signs of the forces **very** carefully in this example.* *Use the information on where the tension is greatest and least for these problems.*	3.10 Where is the tension in the shoelace (a) smallest and (b) greatest? 3.11 Complete Problems 21 and 22 on page 226.
Read page 210: "Centripetal Force and Banked Curves". Study Example 9 on page 210 to 211. ▶▶	3.12 How is centripetal force provided when a car travels along a curve? 3.13 How can you reduce reliance on friction? 3.14 When a car doesn't rely on the force of friction to keep it on track, what provides the centripetal force? 3.15 Calculate the angle at which a frictionless curve must be banked if a car is to round it safely at a speed of 75 km/h. The radius of the curve is 5.0×10^2 m.
Read "Satellites in Orbit" and study Example 10 on pages 212 to 214. ▶▶	3.16 Complete Problems 1 to 5 on page 214.
Let your instructor know that you are ready to complete the lab. You will be required to submit a report. ▶▶	**Laboratory:** 3.17 Complete and submit Core Lab #2: Centripetal Force and Centripetal Acceleration on pages 228 to 229.

Unit 4 - Introduction to Statics

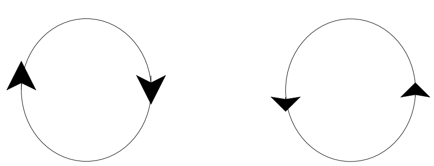
To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 7: Section 7.1: page 232
Section 7.2: pages 232-233
Section 7.3: pages 234-238
Section 7.4: pages 238-265
Section 7.5: pages 265-251
Lab 7.1: pages 272-273

References and Notes	Work to Submit
	Writing:
Read Section 7.1 on page 232. ▶▶	4.1 Define statics.
	4.2 State Newton's First Law.
	4.3 When will an object stay at rest?
	4.4 What is *static* equilibrium?
	4.5 What is *dynamic* equilibrium?
Read pages 232 to 233 of Section 7.2 ▶▶	4.6 What is translation?
	4.7 What forces must be balanced for static equilibrium?
	4.8 What is the center of mass (center of gravity)?

Unit 4 - Introduction to Statics

References and Notes	Work to Submit
	4.9 How do you find the center of mass of an object?
	4.10 Complete Problem 17 on page 267.
Read pages 234 to 237 of Section 7.3 and carefully study Example 1. ▶▶	4.11 What two circumstances allow an object to be in a state of translational static equilibrium?
In solving these problems you will need to use trig functions. Set the forces as sides of right triangles. In solving #4, find the angle first and use that angle to solve for the forces.	4.12 Complete Problems 1 to 4 on page 237.
Read pages 238 to 239 of Section 7.4 up to Example 2 ▶▶	4.13 What happens when a force is not directed through an object's center of mass?
Try opening and closing the textbook as suggested in Section 7.4 to get an understanding of the relationship between torque, force and angle.	4.14 What is torque and what symbol is used to represent it?
	4.15 What are the equations for torque? Explain what each variable represents.
Clockwise torques can be considered to move in the direction of the hands of a clock while counterclockwise torques move in a direction opposite that of the hands of a clock.	4.16 What signs are given to clockwise and counterclockwise torques?



Clockwise   Counterclockwise

Unit 4 - Introduction to Statics

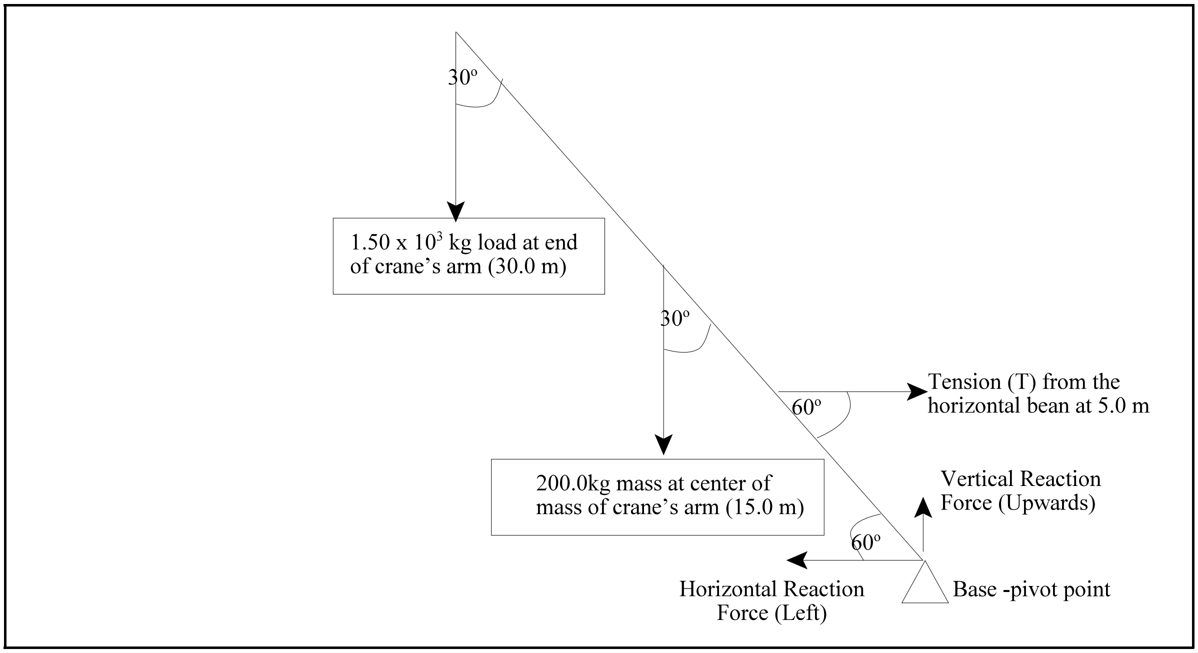
References and Notes	Work to Submit
Study Example 2 on pages 239 to 240. ▶▶	4.17 Complete Problem 1 on page 242.
The text does not provide a diagram for the Example. Use the Figure on page 241 for drawing a free-body diagram for solving this problem. Remember you are trying to get the perpendicular force component and this is found using right triangle trig i.e. sin θ and θ will be 85º not 5º.	
Again in the problem on page 242, draw a diagram and watch for the angle to use to solve the problem. Note that the angle between the applied force and the trunk is not 50º - what is it ?	
Study Example 3 on page 240 ▶▶	4.18 Complete Problems 2 and 3 on page 242.
Draw a diagram. Note both girls are turning the wheel in the same direction - clockwise. Also they are rotating about the center of the wheel so r is half the diameter and don't forget to convert cm to m for units.	
*For Problem **3**, remember that the density of water is 1g/ml. Also for 3(b) think about the angles of A, B, C.*	

References and Notes	Work to Submit
Read page 243 of Section 7.5 to Example 4. ▶▶	4.19 How is translation avoided? 4.20 How is rotation avoided?
Study Example 4 and 5 on pages 243 to 246 ▶▶ *It may help to think about zero rotation to be when the clockwise torque (CC) equals the counterclockwise torque (CCW).* *In Problem 28 let $r = x$ for CC and $r = 2.0^{-} x$ for CCW.*	4.21 Complete Problem 28 on page 268.
Study Example 6 on pages 246 to 248. *At the end of this Study Guide is a diagram that shows the forces acting on the crane's arm. It is assumed that the arm is uniform so the mass of the arm is acting halfway on the arm. The problem is solved slightly differently and the answer is a little different because of rounding.*	

References and Notes	Work to Submit
Study Example 7 on page 249 to 250. ▶▶	4.22 Complete Problems 1 to 4 on pages 251 and 252.
Again choose one end as a pivot point and the CW torque can be the product of each weight exerted times the distance from the pivot point. At one end the distance is zero so one torque disappears. Now the CCW torque is the weight of the person (the total of the two spring scale forces) times the distance (r).	
Let your instructor know you are ready for Core Lab #3	**Laboratory:** 4.23 Complete and submit Lab 7.1: Equilibrium in Forces on pages 272 to 273.

Appendix A

Example 6 on page 246 of Physics: Concepts and Connections



Counterclockwise torques (CCW) $\tau_{CCW} = F_{load}$ **xsin 30º x 30m +** F_{beam} **x sin 30º x 15 m**

$F_{load} = 1.50 \times 10^3$ **kg x 9.8 m/s²** $= 1.47 \times 10^4$ **N ;** $F_{beam} = 200.0$ **kg x 9.8 m/s²** $= 2.0 \times 10^3$ **N**

sin 30º = 0.5

Clockwise torques (CC) τ_{CC} **=T x sin 60º x 5m ; sin 60º = 0.866**

$$\tau_{CC} = \tau_{CCW}$$

$$T \times 0.87 \times 5.0 \text{ m} = 1.47 \times 10^4 \text{ N} \times 0.5 \times 30 \text{ m} + 2.0 \times 10^3 \text{ N} \times 0.5 \times 15 \text{ m}$$

$$T = 2.36 \times 10^5 \text{ N·m}/4.3 \text{ m} = 5.48 \times 10^5 \text{ N}$$

Now there are two horizontal force components: The tension (T) operating in a right direction and the horizontal reaction forces of equal magnitude operating in the left direction. Therefore $F_{r(H)} = 5.48 \times 10^5$ N (left) or (west)

There are three vertical force components: The weights of the load and beam (both down) and the vertical reaction force (up).

Therefore

$F_{load} + F_{beam} = 1.47 \times 10^4 \text{ N} + 2.0 \times 10^3 \text{ N}$

$= 1.67 \times 10^4$ N (down) and $F_{r(V)} = 1.67 \times 10^4$ N (up)