

### LON-CAPA-based Test Printing and Scoring

C. Rosenfeld, Dept. of Physics and Astronomy Univ. of South Carolina <u>LCR@sc.edu</u>

- Historical background and objectives
- Test printing procedure
- Test scoring procedure
- Equipment and cost
- Tips





- USC started with CAPA-based automated assessment in 1998-99.
- The process was less labor intensive than hand grading, but it was far from quick and easy, and it was high-maintenance.
- In 2007 we started afresh with new tools, and our present system is an evolutionary descendant.
- No single overarching concept. The benefits accrue from a constellation of many features, many details.
- If you are not fully satisfied with your present assessment system, you may hear about one or two ideas that you would consider adopting.
- Otherwise, now might be a fine time to go on coffee break.

### LON-CAPA Assessment System Objectives



- Ease of scoring
- Rapid and comprehensive reporting to students
- Objectivity of scoring
- Suppression of cheating
- Answers via hardcopy to prevent disputes
- Rapid distribution of tests at test time
- Redundancy as a defense against catastrophe

# The External Loop





## **Assessment Cycle**



<ul> <li>Preparation of test questions</li> </ul>	Instructor
<ul> <li>Preparation of ancillary materials</li> </ul>	TA
– Bubble forms	
- Test-taking instructions	
– Formula sheets	
<ul> <li>Scratch sheets</li> </ul>	
<ul> <li>Printing test packets</li> </ul>	TA
<ul> <li>"Stuffing" test packets</li> </ul>	TA
<ul> <li>Administration of the test</li> </ul>	Instructor
<ul> <li>Unstuffing bubble forms</li> </ul>	TA
<ul> <li>Scanning bubble forms</li> </ul>	TA
<ul> <li>Processing scanned images</li> </ul>	TA
<ul> <li>Uploading scores to LON-CAPA</li> </ul>	TA

# **Test characteristics**



- LON-CAPA algorithmically generates tests individualized for each student (anti-cheating).
- A six-digit code uniquely identifies each test.
- Typically questions come from a LON-CAPA library.
- Questions may come straight from the homework sets (at the instructor's discretion).
- Typically questions are 2/3 numeric, 1/3 qualitative
- Questions frequently include figures.
- LON-CAPA invokes LaTeX to generate printer-ready documents.
- Example:

### **Example Test**

3



**CODE - 010755** - Essentials of Physics II - Ph $Test\ 2$ 

A very long solenoid with a circular cross section and radius  $r_1 = 1.00$  cm with  $n_s = 130$  turns/cm lies inside a short coil of radius  $r_2 = 3.60$  cm and  $N_c = 29$  turns.



 $\fbox{8 pt}$  What is the mutual inductance between the solenoid and the short coil?

(in H)  
**6.A** 
$$\otimes 8.08 \times 10^{-5}$$
 **B**  $\otimes 9.13 \times 10^{-5}$  **C**  $\otimes 1.03 \times 10^{-4}$   
**D**  $\otimes 1.17 \times 10^{-4}$  **E**  $\otimes 1.32 \times 10^{-4}$  **F**  $\otimes 1.49 \times 10^{-4}$   
**G**  $\otimes 1.68 \times 10^{-4}$  **H**  $\otimes 1.90 \times 10^{-4}$  **I**  $\otimes 2.15 \times 10^{-4}$   
**J**  $\otimes 2.43 \times 10^{-4}$   
**8** pt





Consider the sections of two circuits illustrated above. Select True or False for all statements.

 $\label{eq:rescaled} \begin{array}{ll} \triangleright \mbox{ After connecting } \mathbf{c} \mbox{ and } \mathbf{d} \mbox{ to a battery, the current through } \mathbf{R}_3 \mbox{ always equals the current through } \mathbf{R}_4. \\ \mathbf{12.} \ \ \mathbf{A} \bigcirc \ \mbox{ True } \ \ \mathbf{B} \bigcirc \ \mbox{ False} \end{array}$ 

 $\triangleright$  After connecting **a** and **b** to a battery, the voltage across  $R_1$  always equals the voltage across  $R_2$ .

**13**. **A** $\bigcirc$  True **B** $\bigcirc$  False

 $\label{eq:Rab} \begin{array}{l} \triangleright \ R_{ab} \mbox{ is always less than or equal to } R_1. \\ \textbf{15. } \textbf{A} \bigcirc \mbox{ True } \textbf{B} \bigcirc \mbox{ False} \end{array}$ 

C. Rosenfeld, South Carolina Physics and Astronomy 16th LON-CAPA Conference and Workshop, 24 May 2014





- When we started CAPA-based testing, we bought a Scantron machine for about \$3000.
- After a few years (~eight?) it was moribund.
- A replacement from Scantron would have cost about \$7000.
- We rebelled and set off in a new direction:
  - Commodity raster image scanner and
  - Image processing software
- Disadvantages of Scantron forms
  - High cost
  - Need for inventory
  - No opportunity to choose the color of the paper
- We never looked back.

USC PHYSICS ANSWER SHEET	1														
Family name First	1		E F G H	) () ()	16	(A) (B) (C)		•) <b>(G</b> (H)		31	A B	© (	) (E) (I	) (G	$H \cup J$
	2		E E G H		17	(A) (B) (C)		•) <b>(</b> ) (H)		32	A B	0	) (	) ( <b>G</b>	$H \cup J$
(ABC style)	3		È F G H	) () ()	18	(A) (B) (C)		• <b>G H</b>	() (J	33	A B	© (	) (E) (	) <b>(</b>	$H \cup J$
Student ID Number	4		E E G H		19	(A) (B) (C)		) <b>(</b> ) ()		34	A B	<b>©</b>		) ( <b>G</b>	$\mathbf{H}$ () ()
	5	A B C D (	ĒĒGH		20	(A) (B) (C)		•) <b>(</b> ) (H)		35	A B	© (	) (E) (	) ( <b>G</b>	$H \cup J$
	6		È È Ġ H		21	(A) (B) (C)		) <b>(</b>		36	A B	<b>(</b> )	) (	) ( <b>G</b>	$\mathbf{H}$ () ()
	7		È F G H		22	(A) (B) (C)		• <b>G H</b>		37	A B	© (	) (E) (	) ( <b>G</b> )	$H \cup J$
	8		Ē   (Ē	) () ()	23	(A) (B) (C)		• <b>G</b> H	() (J	38	A B	© (	) (	) <b>(</b>	$H \cup J$
	9		E F G H	) () ()	24	(A) (B) (C)		•) <b>(</b> ) (H)	() (J	39	A B	© (	) (	) ( <b>G</b>	$\mathbf{H}$ () ()
	10		È F G H	) () ()	25	<b>A B C</b>	(D) (E) (F	•) <b>(G</b> (H)	() (J	40	A B	© (	) (E) (	) (G	$H \cup J$
	11		È È Ġ H		26	(A) (B) (C)		) <b>(</b>		41	A B	<b>©</b>	) (	) ( <b>G</b> )	$\mathbf{H}$ () ()
	12		È È G H	) () ()	27	(A) (B) (C)		• <b>G H</b>		42	A B	© (	) (E) (	) ( <b>G</b> )	$\mathbf{H}$ () ()
	13		E E G H		28	(A) (B) (C)		) <b>G</b> H		43	A B	© (	) (	) ( <b>G</b> )	$\mathbf{H}$ () ()
	14		E F G H	) 🕕 🜙	29	(A) (B) (C)		• <b>G</b> H		44	A B	© (	) (E) (	) (G	₽ () ()
	15		È F G H	) () ()	30	(A) (B) (C)	(D) (E) (F	•) (G) (H)		45	A B	© (	) 🖲 (	) (G	H () ()
CODE from top of problem sheet	46		e e G H		61	(A) (B) (C)	D E F	) <b>G</b> H		76	A B	0	) 🖲 (	6	₽ 🕕 🤳
CODE from top of problem sheet	46 47		E E G H E E G H		61 62	<ul><li>A B C</li><li>A B C</li></ul>	0 E E	) G H		76 77	A B A B	© 0 © 0	) (E) ((	) (G ) (G	
CODE from top of problem sheet	46 47 48	A       B       C       D       (         A       B       C       D       (         A       B       C       D       (	e e g q e e g q e g q		61 62 63	<ul> <li>A B C</li> <li>A B C</li> <li>A B C</li> </ul>	0 E F 0 E F	) G H ) G H		76 77 78	A B A B A B	0 0 0 0 0 0	) (E) (( ) (E) (( ) (E) ((	) (j) (j) (j) (j) (j) (j)	
CODE from top of problem sheet         Image: Imag	46 47 48 49	A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (	e e g q e e g q e g q e g q e g q		61 62 63 64	<ul> <li>A B C</li> <li>A B C</li> <li>A B C</li> <li>A B C</li> </ul>	<ul> <li>D E E</li> <li>D E E</li> <li>D E E</li> </ul>	) G H		76 77 78 79	<ul> <li>A</li> <li>B</li> <li>A</li> <li>B</li> <li>A</li> <li>B</li> <li>A</li> <li>B</li> </ul>		) (E) (( ) (E) (( ) (E) (( ) (E) ((		
CODE from top of problem sheet         0       0       0       0         1       1       1       1         2       2       2       2       2	46 47 48 49 50				61 62 63 64 65	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>		5 G H 5 G H 5 G H 5 G H 5 G H		76 77 78 79 80	<ul> <li>A</li> <li>B</li> <li>A</li> <li>B</li> <li>A</li> <li>B</li> <li>A</li> <li>B</li> <li>A</li> <li>B</li> </ul>	0 0 0 0 0 0 0 0			
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3	46 47 48 49 50 51	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C			61 62 63 64 65 66	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>		5 G H 5 G H 5 G H 5 G H 5 G H 5 G H		76 77 78 79 80 81	A 8 A 8 A 8 A 8 A 8 A 8		) E ( ) E ( ) E ( ) E ( ) E (		
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3         4       4       4       4       4	46 47 48 49 50 51 52	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C			61 62 63 64 65 66 67	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82	A 8 A 8 A 8 A 8 A 8 A 8 A 8				
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         1       1       1       1       1         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3         4       4       4       4       4         5       5       5       5       5       5	46 47 48 49 50 51 52 53	A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (			61 62 63 64 65 66 67 68	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82 83	A 8 A 8 A 8 A 8 A 8 A 8 A 8 A 8 A 8				
CODE       from       top       of       problem       sheet         0       0       0       0       0       0       0         1       1       1       1       1       1       1         1       1       1       1       1       1       1         2       2       2       2       2       2       2         3       3       3       3       3       3       3         4       4       4       4       4       4       4       6	46 47 48 49 50 51 52 53 53 54	A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (			61 62 63 64 65 66 67 68 69	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82 83 84	A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B         A       B				
CODE       from       top       of       problem       sheet         0       0       0       0       0       0       0         1       1       1       1       1       1         1       1       1       1       1       1         2       2       2       2       2       2         3       3       3       3       3       3         4       4       4       4       4       4         5       6       6       6       6       6       6       9         7       7       7       7       7       7       7       9	46 47 48 49 50 51 52 53 54 55	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C			61 62 63 64 65 66 67 68 69 70	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82 83 84	A       B         A       B				
CODE       from       top       of       problem       sheet         0       0       0       0       0       0       0         1       1       1       1       1       1         1       1       1       1       1       1         2       2       2       2       2       2         3       3       3       3       3       3         4       4       4       4       4       4         5       5       5       5       5       5         6       6       6       6       6       6         7       7       7       7       7       7         8       8       8       8       8       8       8	46 47 48 49 50 51 52 53 54 55 56	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C <td></td> <td></td> <td>61 62 63 64 65 66 67 68 69 70 70 71</td> <td><ul> <li>A</li> <li>B</li> <li>C</li> </ul></td> <td></td> <td></td> <td></td> <td>76 77 78 79 80 81 82 83 84 85 86</td> <td>A       B         A       B</td> <td></td> <td></td> <td></td> <td></td>			61 62 63 64 65 66 67 68 69 70 70 71	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82 83 84 85 86	A       B         A       B				
CODE       from       top       of       problem       sheet         0       0       0       0       0       0       0         1       1       1       1       1       1         1       1       1       1       1       1         2       2       2       2       2       2         3       3       3       3       3       3         4       4       4       4       4       4         5       5       5       5       5       5         6       6       6       6       6       6         7       7       7       7       7       7         8       8       8       8       8       8       8         9       9       9       9       9       9       9	46 47 48 49 50 51 52 53 54 55 56 57	A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C       D       (         A       B       C <td></td> <td></td> <td>61 62 63 64 65 66 67 68 69 70 71 72</td> <td><ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul></td> <td></td> <td></td> <td></td> <td>76 77 78 79 80 81 82 83 84 85 86 87</td> <td>A       B         A       B</td> <td></td> <td></td> <td></td> <td></td>			61 62 63 64 65 66 67 68 69 70 71 72	<ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul>				76 77 78 79 80 81 82 83 84 85 86 87	A       B         A       B				
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0       0         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3         4       4       4       4         5       5       5       5         6       6       6       6         7       7       7       7         8       8       8       8         9       9       9       9       9	46 47 48 49 50 51 52 53 54 55 56 57 58	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C <td></td> <td></td> <td>61 62 63 64 65 66 67 68 69 70 71 72 73</td> <td><ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul></td> <td>D       E       f         D       E       f</td> <td></td> <td></td> <td>76 77 78 79 80 81 82 83 84 85 86 87 88</td> <td>A       B         A       B</td> <td></td> <td></td> <td></td> <td></td>			61 62 63 64 65 66 67 68 69 70 71 72 73	<ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul>	D       E       f         D       E       f			76 77 78 79 80 81 82 83 84 85 86 87 88	A       B         A       B				
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3         4       4       4       4         5       5       5       5         6       6       6       6         7       7       7       7         8       8       8       8         9       9       9       9       9	46 47 48 49 50 51 52 53 54 55 56 57 58 59	A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C       D       C         A       B       C <td></td> <td></td> <td>61 62 63 64 65 66 67 68 69 70 71 72 73 74</td> <td><ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul></td> <td></td> <td></td> <td></td> <td>76 77 78 79 80 81 82 83 84 85 86 87 88 89</td> <td>A       B         A       B</td> <td></td> <td></td> <td></td> <td></td>			61 62 63 64 65 66 67 68 69 70 71 72 73 74	<ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul>				76 77 78 79 80 81 82 83 84 85 86 87 88 89	A       B         A       B				
CODE from top of problem sheet         0       0       0       0       0         1       1       1       1       1         1       1       1       1       1         2       2       2       2       2         3       3       3       3       3         4       4       4       4         5       5       5       5         6       6       6       6         7       7       7       7         8       8       8       8         9       9       9       9       9	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60				61 62 63 64 65 66 67 68 69 70 71 72 73 74 75	<ul> <li>A</li> <li>B</li> <li>C</li> <li>A</li> <li>A&lt;</li></ul>				76 77 78 79 80 81 82 83 84 85 86 87 88 89 90	A       B         A       B				





- Custom design(s), printed in house.
  - Less expensive than commercial Scantron forms.
  - Created on a Mac using commodity software (Numbers and EazyDraw).
- Printed as part of test packet preparation no inventory.
- Designed for compatibility with Remark Office OMR software.
- Form includes corner fiducials used in the image processing to register the form.
- Bubble labels are internal to the bubbles.
  - Allows high bubble density.
  - Physics form has 90 rows of 10 bubbles for answers.
- Forms are printed on a color printer. Labels are magenta or cyan.
   Image processing depends on color to "erase" the labels.
- Printed on colored paper with color selected for each test "randomly" from a universe of ten colors (anti-cheating).
- Forms are oversize, 8.5x11.375 in, to facilitate post-test separation from the packet.

# **Printing the Test Packets**





- Printing utilizes a custom script (AppleScript) that collates the pages of a packet and sends the packets to a paused print queue at a rate of around one per second.
- The printer draws stock paper from a cassette and preprinted bubble forms from the multi-purpose feed slot.
- At packet print time a barcode representation of the test ID code is added to the bubble form.
- The TA redistributes the print jobs to four active print queues.
- The four printers are low-cost (~\$400) HP models.
  - Individually they print at about 10 s/page, collectively at 2.5 s/page.
  - A 100-packet eight-page test prints in about 35 min.
- The TA stuffs finished packets into custom envelopes, and at that point they are ready for deployment. No other collating required.



C. Rosenfeld, South Carolina Physics and Astronomy 16th LON-CAPA Conference and Workshop, 24 May 2014



C. Rosenfeld, South Carolina Physics and Astronomy 16th LON-CAPA Conference and Workshop, 24 May 2014







- The students return their tests in the original envelopes.
   Between semesters we return the envelopes to stock for reuse.
- The TA removes the bubble forms from the envelopes (aided by the extra length of the forms) and orients them.
- The TA loads the forms on a commodity scanner and scans them to 24-bit/300-dpi TIFF files. These files are each 25 MB.
- The desirable properties of the scanner are
  - At least 300 dpi,
  - At least USB 2 connectivity,
  - A capacious input hopper,
  - High speed.

#### **Scan Specifications**

Scanner Type: Flatbed color image scanner with ADF

Optical Sensor: 1200 dpi 4 line color line sensor (RGB & Black)

#### Optical Resolution.

- Flatbed: 1200 dpi
- ADF: 600 dpi

#### Hardware Resolution:

- Flatbed: 1200 x 1200 dpi with Micro Step Drive™ technology
- ADF: 600 x 600 dpi Micro Step Drive™ technology

Color Bit Depth: 48-bits per pixel internal / external

Grayscale Bit Depth: 16-bits per pixel internal / external

#### Maximum Scan Area:

- Flatbed: 8.5" x 11.7"
- ADF: 8.5" x 40"

Light Source: ReadyScan LED

#### Scanning Speed:

#### <u>200 dpi</u>

- B/W: Up to 40 ppm / 80 ipm with ADF
- Color: Up to 40 ppm / 80 ipm with ADF
   <u>300 dpi</u>
- B/W: Up to 40 ppm / 80 ipm with ADF
- Color: Up to 40 ppm / 80 ipm with ADF
   <u>600 dpi</u>
- B/W: Up to 8 ppm / 16 ipm with ADF
- Color: Up to 8 ppm / 16 ipm with ADF



EPSON

#### Software:

- Epson Scan
- EPSON Event Manager (Mac only,
- ABBYY FineReader Sprint
- Document Capture Pro (Windows only)
- ISIS Driver (Web Distribution)

#### Connectivity

#### Scanner Interface:

- Hi-Speed USB 2.0
- Optional Network Module(RJ45, 10BaseT / 100Base TX)



#### Scantron iNSIGHT 4ES

Much higher cost than the Epson DS-7500.

Much worse performance for raster image scanning (as opposed to OMR).

iecnnical Specifica	ITIONS
Physical Description	Length: 21.25" Width: 14.5" Height: 9" Weight: 17 lbs
Environment	Operating Temperature: 60° to 85°F (16°C to 29°C) Humidity: 40% to 60%, non-condensating
Power	100-240 volt operation: 100-240 volts AC (-10%, +6%): 50-60 Hz; US 3-prong plug; 15 amp dedicated circuit
Communications	USB 2.0 connection—Image or OMR processing
Operation	<ul> <li>Dual Read Heads: 200 dots per inch (dpi) resolution, up to 256 levels of grayscale per pixel; pencil and ink read capabilities</li> <li>Pencil or ink forms may be used</li> <li>Scanning Rate: 2,800 sheets per hour in OMR mode, 2,300 sheets per hour in OMR with imaging mode.</li> <li>Forms: 2.5" x 5" to 9" x 14" (60-100 lb. Offset). Uses both Mark Reflex B and Trans-Optic<sup>®</sup> forms</li> <li>Form Input Capacity: Auto-feed, 100 sheets main stacker, 100 sheets select stacker (if present)</li> <li>Controls: Two Push button programmable switches</li> <li>Message Display: 40 character, alphanumeric</li> <li>Multi-feed detection</li> <li>Integrated ES/ScanMark<sup>™</sup> Emulation Mode</li> </ul>
Options	<ul> <li>A programmable interactive printer</li> <li>Select stacker separates forms that fail edit checks</li> <li>Bar code reader</li> <li>SelfScore<sup>®</sup> option for classroom test scoring and surveys</li> </ul>

e and Workshop, 24 May 2014

16

USC PHYSICS ANSWER SHEET										~ ~	21	~			0	0	
Family name First	1	(A) (B) (C)		ÐGO	B () ()	16		0 E F	GH		31						
Rudd Ka	2	(A) (B) (O)		Ð G (	B O O	17		O E E	GE		32	(A) (	B) (C)	O E	) (E) (	GW	00
(ABC., style)	3	(A) (B) (C)	0 © (	ÐG(	Ð 🔍 🛈	18	(A) (B) (C)	• • •	GE		33	(A) (	B ©	0 C	) () ()	GH	() $()$
TO Number	4			Ð @ (		19	(A) (B) (C)	O E E	GE		34		B ©	0 C	) () ()	G ®	$\bigcirc$ $\bigcirc$
Student ID Number	5	(A) (B) (C)	0 0 0	ÐG	B O O	20		O E E	GE		35		D C	0 @	) 🕑 (	GH	0 0
1103	6	A B C			BOO	21		0 © ©	GE		36		B ©	0 6		6 B	$\bigcirc$
000000000	7	() () () () () () () () () () () () () (	() (E) (	Ê G (	ÐOO	22	A B O	O E E	GE		37		B ©	0 6		6 B	•
00000000	8		M E (	F G (	D D A	23	A B C	O E E	G	000	38		BC	0 6	Œ	GH	0 0
000000000	9					24		O E F	GE	$\bigcirc \bigcirc \bigcirc \bigcirc$	39		BC	0 @	Ð	G H	0 0
0 0 0 0 0 0 0 0 0	10				9 0 0	25	A B O	0 C C	GA	00	40	A	BO	0 6	Ð	GÐ	0 0
(A)	11					26		O E E		ົດ	41	A	BC	0 0	D (D	G H	0 0
6 6 6 6 6 6 6 6	12					27				ົດ	42	A	B (C)	00	Ð	G H	0 0
66666666	12					27					43		® @	00	D (F)	© ®	00
000000000	13	@ @ ©				20					44		80	6	Ð	6 A	00
000000000000	14	(A) (B) (O)	0 C	EG		29					45			00		തെന	00
000000000	15	(A) (B) (C)	O E	() ()	$\oplus \bigcirc \bigcirc$	30					45	0					
-			0.0	~ ~		<b>C1</b>	000	000			76	0	<b>a a</b>	6		<b>@ M</b>	00
CODE from top of problem sheet	46	@ ® ©	0 C	© ©		61		© © @			76	(A)	© @	00		© ®	
CODE from top of problem sheet	46 47	8 8 C 8 8 C	0 © 0 ©	0 0 0 0		61 62					76 77	<ul><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li><li></li></ul>				© Ð © Ð	
CODE from top of problem sheet	46 47 48	0 8 0 0 8 0 0 8 0	0 E 0 E 0 E	00 00 00	® O O ® O O	61 62 63					76 77 78					6 8 6 8 6 8	
CODE from top of problem sheet 220407 00000000 0000000	46 47 48 49	A B C A B C A B C A B C	0 E 0 E 0 E	© © © © © © © ©		61 62 63 64					76 77 78 79						
CODE from top of problem sheet 2 2 0 4 0 7 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	46 47 48 49 50	A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C	0 E 0 E 0 E 0 E	6 6 6 6 6 6 6 6 6 6		61 62 63 64 65	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80	<ul><li>S</li><li>S</li><li>S</li><li>S</li><li>S</li></ul>					
CODE from top of problem sheet 2 2 0 4 0 7 0 0 0 0 0 0 0 1 0	46 47 48 49 50 51					61 62 63 64 65 66	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81	<ul><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><l< td=""><td></td><td></td><td></td><td></td><td></td></l<></ul>					
CODE from top of problem sheet         2       2       4       7         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0         1       1       1       1       1         0       0       2       2       2         3       3       3       3       3         4       4       4       4       4	46 47 48 49 50 51 52					61 62 63 64 65 66 67	<ul> <li>A</li> <li>B</li> <li>C</li> </ul>				76 77 78 79 80 81 82	<ul><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><li>A</li><l< td=""><td></td><td></td><td></td><td></td><td></td></l<></ul>					
CODE from top of problem sheet         2       2       0       1         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0         1       1       1       1       1         0       0       0       0       0         1       1       1       1       1         0       0       2       2       2       2         3       3       3       3       3       3         4       4       4       4       4       4         5       5       5       5       5       5	46 47 48 49 50 51 52 53					61 62 63 64 65 66 67 68					76 77 78 79 80 81 82 83	<ul> <li>A</li> <li>A&lt;</li></ul>					
CODE from top of problem sheet         2       2       0       0       0         0       0       0       0       0       0         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1       1         1       1       1       1       1       1       1       1         1       1       1       1       1       1       1       1       1         1       1       1 <td< td=""><td>46 47 48 49 50 51 52 53 54</td><td>A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C</td><td></td><td></td><td></td><td>61 62 63 64 65 66 67 68 69</td><td></td><td></td><td></td><td></td><td>76 77 78 79 80 81 82 83 83</td><td><ul> <li>A</li> <li>A&lt;</li></ul></td><td></td><td></td><td></td><td></td><td></td></td<>	46 47 48 49 50 51 52 53 54	A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C				61 62 63 64 65 66 67 68 69					76 77 78 79 80 81 82 83 83	<ul> <li>A</li> <li>A&lt;</li></ul>					
CODE from top of problem sheet         2       2       0       0       0         0       0       0       0       0       0         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       1       1       1       1         1       1       <	46 47 48 49 50 51 52 53 54 55	A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C         A       B       C				61 62 63 64 65 66 67 68 69 70					76 77 78 79 80 81 82 83 83 84 85						
CODE from top of problem sheet         2       2       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       <	46 47 48 49 50 51 52 53 54 55 56					61 62 63 64 65 66 67 68 69 70 71					76 77 78 79 80 81 82 83 84 85 86						
CODE from top of problem sheet         2       2       4       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0	46 47 48 49 50 51 52 53 54 55 56 57					61 62 63 64 65 66 67 68 69 70 71 72					76 77 78 79 80 81 82 83 84 85 86 87						
CODE from top of problem sheet         2       2       4       7         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0       0       0       0       0         0       0       0	46 47 48 49 50 51 52 53 54 55 56 57 58					<ul> <li>61</li> <li>62</li> <li>63</li> <li>64</li> <li>65</li> <li>66</li> <li>67</li> <li>68</li> <li>69</li> <li>70</li> <li>71</li> <li>72</li> <li>73</li> </ul>					76 77 78 79 80 81 82 83 84 85 86 87 88						
CODE from top of problem sheet         2       2       4       7         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0	46 47 48 49 50 51 52 53 54 55 56 57 58 59					<ul> <li>61</li> <li>62</li> <li>63</li> <li>64</li> <li>65</li> <li>66</li> <li>67</li> <li>68</li> <li>69</li> <li>70</li> <li>71</li> <li>72</li> <li>73</li> <li>74</li> </ul>					76 77 78 79 80 81 82 83 84 85 86 87 88 89						
CODE from top of problem sheet         2       2       4       7         0       0       0       0       0         1       1       1       0       0         1       1       1       0       0         0       0       0       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       1       0       0         1       1       1       0       0       0         1       1       1       0       0       0         1       1       0       0       0       0         1       0       0       0       0       0       0         1       0       0       0       0       0       <	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60					<ul> <li>61</li> <li>62</li> <li>63</li> <li>64</li> <li>65</li> <li>66</li> <li>67</li> <li>68</li> <li>69</li> <li>70</li> <li>71</li> <li>72</li> <li>73</li> <li>74</li> <li>75</li> </ul>					76 77 78 79 80 81 82 83 84 85 86 87 88 87 88 89 90						

407-4036-P212Morawiec

10.1

# Image Processing A



- Phase 1: Registration and color reduction by application of custom macros in ImageJ. (ImageJ began life as NIH Image and is maintained by a staff member at NIH.)
- Requires about 3 s per form.
- The grayscale format of the output allocates eight bits to each pixel notwithstanding that each pixel takes one of just two values.
   – Output files are 8.4 MB.

USC PHYSICS ANSWER SHEET						
Family name First	1	$\bigcirc \bigcirc $	16	$\bigcirc \bigcirc $	31	00000000000
Budding	2	000000000000	17	• • • • • • • • • • • • • • • • • • • •	32	00000000000
(ABC style)	3	000000000000000000000000000000000000000	18	000000000000	33	0000000000
Student ID Number	4	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	19	00000000000	34	0000000000
	5	00000000000	20	$\circ$	35	0000000000
	6	00000000000	21	$\circ$	36	0000000000
$\bigcirc \bigcirc $	7	••••••	22	000000000000000000000000000000000000000	37	0000000000
$\bigcirc \bigcirc $	8	00000000000000	23	0000000000	38	0000000000
0 0 0 0 0 0 0 0 0 0	9	000000000000000000000000000000000000000	24	0000000000	39	0000000000
$\circ \circ \circ \circ \circ \circ \circ \circ \bullet$	10	00000000000	25	0000000000	40	0000000000
0 0 0 0 0 0 0 0 0	11	00000000000	26	0000000000	41	0000000000
000000000	12	••••••	27	0000000000	42	0000000000
000000000	13	000000000000	28	0000000000	43	0000000000
	14	000000000000000000000000000000000000000	29	0000000000	44	0000000000
	15	00000000000	30	0000000000	45	0000000000
	I					
CODE from top of problem sheet	46	0000000000	61	0000000000	76	0000000000
CODE from top of problem sheet	46 47	000000000000000000000000000000000000000	61 62	000000000000000000000000000000000000000	76 77	000000000000000000000000000000000000000
CODE from top of problem sheet	46 47 48	0000000000 0000000000 0000000000	61 62 63	0000000000 0000000000 0000000000	76 77 78	000000000000000000000000000000000000000
$\begin{array}{c} \text{CODE from top of problem sheet} \\ \hline 2 2 0 4 0 7 \\ \hline 0 0 0 0 0 0 0 \\ \hline \end{array}$	46 47 48 49	0000000000 0000000000 0000000000 000000	61 62 63 64	0000000000 0000000000 0000000000 000000	76 77 78 79	0000000000 0000000000 0000000000000000
$\begin{array}{c cccc} \textbf{CODE from top of problem sheet} \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline \end{array}$	46 47 48 49 50	0000000000 0000000000 0000000000 000000	61 62 63 64 65	0000000000 0000000000 0000000000 000000	76 77 78 79 80	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	46 47 48 49 50 51		61 62 63 64 65 66	0000000000 000000000 0000000000 0000000	76 77 78 79 80 81	
CODE from top of problem sheet 220407 $0 0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$ $0 0 0 0 0$	46 47 48 49 50 51 52		61 62 63 64 65 66 67		76 77 78 79 80 81 82	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	46 47 48 49 50 51 52 53		61 62 63 64 65 66 67 68		76 77 78 79 80 81 82 83	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	46 47 48 49 50 51 52 53 54		61 62 63 64 65 66 67 68 69		76 77 78 79 80 81 82 83 84	
$\begin{array}{c ccccc} \text{CODE from top of problem sheet} \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 0 & 4 & 0 & 7 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline \end{array}$	46 47 48 49 50 51 52 53 54 55		61 62 63 64 65 66 67 68 69 70		76 77 78 79 80 81 82 83 83 84 85	
$\begin{array}{c ccccc} CODE & from top of problem sheet \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 & 0 \\ \hline 1 \\ 8 \end{array}$	46 47 48 49 50 51 52 53 54 55 56		61 62 63 64 65 66 67 68 69 70 70 71		76 77 78 79 80 81 82 83 84 85 86	
$\begin{array}{c cccc} CODE & from top of problem sheet \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 2 & 0 & 4 & 0 & 7 \\ \hline 2 & 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \\ \hline$	46 47 48 49 50 51 52 53 54 55 56 57		61 62 63 64 65 66 67 68 69 70 70 71 72		76 77 78 79 80 81 82 83 84 85 86 87	
CODE       from       top       of       problem       sheet         2       2       0       4       0       1         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0       0         1       1       1       1       1       1       1	46 47 48 49 50 51 52 53 54 55 56 57 58		61 62 63 64 65 66 67 68 69 70 71 72 73		76 77 78 79 80 81 82 83 84 85 86 87 88	
CODE       from       top       of       problem       sheet         2       2       0       4       0       1         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0       0         0	46 47 48 49 50 51 52 53 54 55 56 57 58 59		61 62 63 64 65 66 67 68 69 70 71 72 73 74		76 77 78 79 80 81 82 83 84 85 86 87 88 89	
CODE       from       top       of       problem       sheet         2       2       0       4       0       1         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0       0       0       0       0       0         0	46 47 48 49 50 51 52 53 54 55 56 57 58 59 60		61 62 63 64 65 66 67 68 69 70 71 72 73 74 75		76 77 78 79 80 81 82 83 84 85 86 87 88 87 88 89 90	

407-4036-P212Morawiec

# Image Processing B



- Phase 2: Recompression via GraphicConverter.
  - Reduces the final image file to one bit per pixel.
  - 8.4 MB -> 1.0 MB.
  - Remark Office copes better with B/W than with grayscale.
- Phase 3: Processing by Remark Office OMR.
  - Runs on a Mac in a MS Windows Virtual Box VM.
  - USC Physics is still using Ver. 6 (2005); current is Ver. 8.
  - Result is an Excel worksheet containing for all students
    - Student ID info
    - Test ID
    - Student's answers

### **Remark Office Template**

000		Remark_	Office [Running]				
Remark Office OMR Ter	nplate Editor - bubble_sheet_F_t	emplate.om	r				- 7 🛛
File Edit Page View Too	ols Help						
2 💣 🔒 🖕 🏠	× 9 @ <b>2 2 2</b> ∞ ∞	ə 🐉 🔣	💞 🎤 🏓 🗓	<b>₽</b>	🛃 😳		
3 💢 Page 1						-	
💢 Record ID							
📜 Date	USC PHYSICS ANSWER SHEET	1		16		21	000000000
📜 Student ID	Family name First	2 0 0	00000000	17	0000000000	32	00000000000
💢 Code	(ABC., style)	3 0 0	00000000	18	00000000000	33	0000000000
🖂 💢 barcode	Student ID Number	4 0 10	00000000	19	0000000000	34	0000000000
🛁 💢 ansr (1)	065821722	5 0 0	00000000	20	0000000000	35	0000000000
💢 ansr (2)		,⊗6 €O	000000000	21	0000000000	36	0000000000
📜 💢 ansr (3)	• 0 0 0 0 0 0 0 0 0	7 0 0	0000000	22	0000000000	37	0000000000
💢 ansr (4)		8 0 0 0	000000000	23	0000000000	38	0000000000
💢 ansr (5)	00000000000	9 0 0 0	0000000	24	0000000000	39	0000000000
💢 ansr (6)	000000000	10 0 0 0	00000000	25	00000000000	40	0000000000
	$\circ \circ \bullet \circ \circ \circ \circ \circ \circ$	12 0.00		20	00000000000	42	0000000000
	0 • 0 0 0 0 0 0 0	13 0 € 0	000000000	28	00000000000	43	00000000000
	00000000000	14 0 0 0	0000000	29	0000000000	44	000000000
	000000000	15 00	0000000000	30	0000000000	45	0000000000
	000000000						
	CODE from top of problem sheet	46 0 0 0	000000000	61	00000000000	76	000000000
	501935	47 0 0 0	00000000	62	0000000000	77	0000000000
Form	0 0 0 0 0 0	48 0 0 0	000000000	63	00000000000	78	000000000
TOTIT	000000	49 000	000000000	64	0000000000	79	000000000
	000000	5000	000000000	60 66	00000000000	81	0000000000
Define		52 0 0 0	000000000	67	00000000000	82	00000000000
regions to	• • • • • • • • • • • • • • • • • • • •	53 000	00000000	68	00000000000	83	0000000000
be	0 0 0 0 0 0	54 000	00000000	69	0000000000	84	000000000
on the		55 0 0 0	00000000	70	00000000000	85	0000000000
specified	00000	56 0 0 0	00000000	71	0000000000	86	000000000
page.	000000	57 0 0 0	00000000	72	0000000000	87	000000000
Save		58 0 0 0	00000000	73	0000000000	88	000000000
Form		59 0 0 0		74	0000000000	89	000000000
Court ha	933-4083-P212Petti	0000	00000000	/5	00000000000	90	000000000
form							
template.	•						-
etart Sine		OMD T					2 0 1240 PM
		OMR T.					12:19 PM
						90	🕗 🥟 🚍 🛄 \mid 🐼 💽 Left 🕷 🏼 🎵

C. Rosenfeld, South Carolina Physics and Astronomy 16th LON-CAPA Conference and Workshop, 24 May 2014

## **Remark Office Processing**



Edit View Tools Help		0.00											
	Record ID	Date	Student ID	Code	barcode	ansr1		insr2 a	iosr3	ansr4	ansr5	apsró	
mpiaces Data Analysis	1 Rec: 1	5/30/2013	249894322	786489	¥ 7777777	BACBEDEBAJEGIA	~	~~~~~~	< NONNON	Y NNNNN	V NNNNN	Y NNNNN	-
	2 Rec: 2	5/30/2013	¥ 7456~~	~ 359128	359128	K BCHBFBICDG	HGC~~	~ ~~~~~	r nonne	* nono	* nonno	× mmmm	
Data Options 🙁 🛞	3 Rec: 3	5/30/2013	163748292	528896	528896	CDDCADJDCE	AIJ~~ \	< nonno	< nnnnn	* nnnnn	* nnnnn	* mono	
🛃 Read Wizard	4 Rec: 4	5/30/2013	K NNNNN	~ 382620	382620	V DAIHDFFCFA	BDE~~	< nonnon	NUNNI	* NNNNN	K NUNNI	K vvvvvv	
Sustamize your data collection tasks by	5 Rec: 5	5/30/2013	241710112	059267	059267	ECFGCBAGGE	EFB~~	~~~~~~	NUNNI	Y NNNNN	NNNNN	Y NONNO	
stepping through the Read Wizard.	5 Rec: 5	5/30/2013	¥ ~~~~~	1226640	226640			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	~~~~~~	× ~~~~~	× ~~~~~~	P 000000	
Design and the second se	8 Rec: 8	5/30/2013	400452192	518120	518120		FGB~~ V	NNNNN	NONNON	V NNNNN	V NNNNN	V NNNNN	
Exerceptions	9 Rec: 9	5/30/2013	V NNNNN	457445	457445	DEFCICBBIFE	GF~~	NNNNN	< nonno	* NNNNN	* NNNNNI	Y NUNNIN	
Perform data validation.	10 Rec: 10	5/30/2013	249795211	644285	644285	K BCJIEDGDBIH	ED~~	~~~~~	~ ~~~~	Y NNNNN	× ~~~~	Y NONN	
逽 Open data file	11 Rec: 11	5/30/2013	249914013	529547	529547	BBGCAHIEHD	BBB~~ Y	< nonno	* nnnnn	× ~~~~	× ~~~~	K www.ww	
Search the file system for a data file to	12												
open into the [bubble_sheet_F_template]	13				_								
orm template.	14	-	-		-	-	_						-
Save data	H + H bu	bble_sheet_F	_template [Ur	n /	1	1		1					
Save the form template data.	Image Viewer -	test_1001.	tif [page 1]								<b>B</b>	🔶 🏓 🌶	×
🕺 Save data as		HVSTCS ANS	WER SHEET									•	^
Save the form template data to another file	Famil	v name	Firs	t	1 0000	000000	16 O	00000	00000	31 O C	00000	0000	-
name.	IT A		IC I	7	1 0000	0000000	17 ()	00000	00000	32 O C	00000	0000	
	(A	BC. style)		1	3 0000	0000000	16 ()	00000	00000	33 0 0	00000	0000	
	Stude	nt ID Numb	er		4 0 • 0 0	0000000	19 O	00000	00000	34 O C	00000	0000	
Evcentions Legend	2.	4989	432	2	1 0000	000000	20 C	00000	0000	35 () G	00000	0000	
checkions regent	1 53	0.0.0.0		~	6 0006	1000000	21 O	00000	0000	36 O C	00000	0000	
W Multiple responses	G A	0000	0000	0	1 0000	00000000	22 C	00000	0000	37 0.0	00000	0000	
🍸 Blank responses	0	0000	000		\$ 0 • C C	000000	23 C	00000	0000	38 O C	00000	0000	
Recognition errors				0	• • • • • •	0000000	24 0	00000	0000	39 () ()	00000	0000	
🛜 Image region	0	• e o e		0	0000	000000	25 0	00000	0000	40 0 0	00000	0000	
🖗 Database lookup region	- O	0000	000	c l	1 0000	000000	26 ()	00000	0000	41 O G	00000	0000	
Barcode region	0	0000	000	0	0000	0000000	27 ()	00000	00000	47 00	00000	1000	
	0	0 0 0 0	000	0	0000	0000000	26 0	00000	00000	43 O C	00000	1000	
	c	00.00	000	0	4 0000	000000	29 ()	00000	00000	44 OC	00000	0000	
	C ·	0 • 0 •	000	0	0000	000000	300 O	00000	00000	45 O C	00000	0000	
				-	- Harris and St	and the second second	11.1 M		Contraction and		The Property of		20





- Phase 4: Conversion of spreadsheet data to a text file meeting the requirements for upload to LON-CAPA.
  - Done by conventional formulae in an Excel spreadsheet.
  - Matches the Student IDs from the bubble forms to the Student IDs of enrollees in the course.
  - Corrects single-digit errors in the Student ID.

# **Printing Components**



- Mac with two displays and HD backup, \$1300.
- One color laser printer, \$1000.
- Four low-cost monochrome printers, \$1600.
- Custom envelopes, 6000 for \$3000.
- Adobe Acrobat X or later, \$120.
- MS Excel, \$\$?
- Custom scripts (priceless).
- User manual (priceless).

# **Scoring Components**



- Computer with HD backup, \$1200.
  - But printing computer can serve at no additional cost.
- Commodity color scanner, \$1100.
- ImageJ (no cost).
- GraphicConverter, \$40.
- Remark Office OMR, \$600 (edu price in 2007).
- MS Excel.
- Custom ImageJ macros (priceless).
- User manual (priceless).

# **Test-making Tips**



#### • The first question of a test provides bonus points for good faith bubblers.

**CODE - 022271** - 2014 Sp, Phys 212H(Rosenfeld) 1 *Test 2* 

Name:

3 ptDid you enter your name at the top of this sheet?Did you enter your name and VIP ID on the answer sheetand bubble in your VIP ID with opaque marks?Did you enter the six-digit CODE at the top of this sheet inthe CODE field on the answer sheet and bubble it in withopaque marks?

1.  $A \bigcirc I \text{ did}, I \text{ did}, I \text{ did}.$  $B \bigcirc \text{ Not yet.}$ 

- On numeric problems award one point for no answer. (A correct answer earns eight points.) Very effectively suppresses guessing, which tends to undermine the utility of difficult questions.
- On T/F problems score as Value<sup>\*</sup> (# correct # wrong)/(# of leaves) but never < 0. Likewise suppresses guessing.</li>
- The above two strategies require the LON-CAPA "spreadsheet" for calculating scores.



- The system we describe above has been evolving at U South Carolina for 16 years.
- It processes about 4000 tests / semester.
- It has now reached a state of near perfection, and needs only occasional maintenance.
- Perhaps some features will be of interest to other domains.

