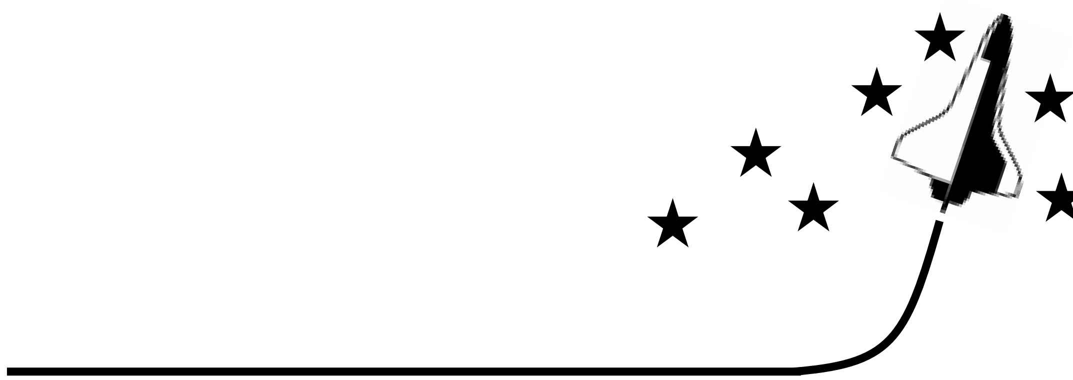
FACULTY NOTES

The LTAs and Spinoffs are designed so that each professor can implement them in a way that is consistent with his/her teaching style and course objectives. This may range from using the materials as out-of-class projects with minimal in-class guidance to doing most of the work in class. The LTAs and Spinoffs are amenable to small group cooperative work and typically benefit from the use of some learning technology. Since the objective of the LTAs and Spinoffs is to support the specific academic goals you have set for your students, the Faculty Notes are not intended to be prescriptive. The purpose of the Faculty Notes is to provide information that assists you to take full advantage of the LTAs and Spinoffs. This includes suggestions for instruction as well as answers for the exercises.



FACULTY NOTES

LTA 12

Mission Control: We Have Energy Savings

Background Information

Math Prerequisites:
- Arithmetic Skills
- Averages
- Reading and reasoning
- Graphing

Learning Technologies Suggested:
- Scientific Calculator, Graphing Calculator

Approximate Class Time required for LTA 12: 2 hours

Comments

Students will gain experience with mathematical reasoning and problem solving as they meet the following objectives:

- Collect numerical data.
- Estimate data from personal life.
- Calculate sums of data.
- Measure rectangles and calculate areas.
- Calculate ratios.
- Calculate total cost given the unit cost and the number of units.
- Find to what fiscal year a given month belongs.
- Find the average of a set of numbers.
- Draw conclusions from data.
- Graph data.
- Draw conclusions from graphs.

Section I

Utilities and Energy Use

Comments

Typical home and office treatments to protect against bad weather include:

- installing wall, ceiling, and pipe insulation
- replacing windows or adding storm windows
- insulating pipes
- wrapping water heaters
- providing tint or shade for windows (awnings)
- buying more energy efficient air conditioners, water heaters, refrigerators, and clothes washers and dryers
- installing motion detectors as light switches
- changing habits for using water
- using low or reduced water flow plumbing fixtures

Note: In completing the tables, students will need to multiply watts by hours per day to get watt-hours per day. While the units are watt-hours per day in this Section, larger amounts of electricity used in later parts of the LTA will require kilowatt-hours (kWh). A brief discussion of the meaning of this unit of measurement may help avoid confusion later.

It may be helpful to review the formulas for the area of a rectangle, triangle, and circle.

Solutions

Part A Reflecting on Energy Use

1-7) Answers will vary.

8-12) It is anticipated that students will suggest a number of types of buildings and related energy savings items. Answers will vary.

Part B Light Fixtures and Lamps

13) The answers in columns 1 and 2 of the following table should be the same for all students. The estimated daily usage in column 3 will differ from student to student.

Table 1: Light Fixtures and Lamp Information

Light Fixture or Lamp	Watts	Hours/Day	(Watt-Hours Per Day)
Kitchen: Fluorescent Light (4 bulbs @ 40 W)	160	4	640
Kitchen: Ceiling Fixture: (4 bulbs @ 60 W)	240	5	1200
Living Room (LR): Ceiling Fixture (4 bulbs @ 60 W)	240	3	720
Living Room: 2 Floor Lamps (1 bulb @ 150 W)	300	5	1500
First floor Bathroom: Recessed Light (4 bulbs @ 75 W)	300	1.5	450
First floor Hallway: Table Lamp (3 bulbs @ 60 W)	180	2.5	450
Family Room: 2 Reading Lamps (1 bulb @ 75 W)	150	6	900
Bedroom 1: Reading Lamp (1 bulb @ 75 W)	75	3	225
Bedroom 1: Ceiling Fixture (4 bulbs @ 60 W)	240	2.5	600
Bedroom 2: 2 Reading Lamps (1 bulb @ 75 W)	150	1	150
Bedroom 2: Ceiling Fixture (4 bulbs @ 60 W)	240	1	240
Second floor Hall: Reading Lamp (1 bulb @ 75 W)	75	3	225
Second floor Hall: Ceiling Fixture (4 bulbs @ 60 W)	240	3	720
Second floor Bathroom: Fluorescent Light (4 bulbs @ 40 W)	160	1.5	240
Bedroom 3: Table Lamp (3 bulbs @ 60 W)	180	4	720
Bedroom 3: Floor Lamp (1 bulb @ 150 W)	150	3	450
Bedroom 3: Ceiling Fixture (4 bulbs @ 60 W)	240	2.5	600
TOTAL	---	---	10,030 watt-hours

14. a) The prefix, kilo, means one thousand (1000)
    b) Divide watt-hours by 1000. Note: 1000 watt-hours = 1 kilowatt-hour. With reference to Exercise 13, 10,030 watt-hours = 10.030 kilowatt-hours.
    c) Multiply the number of kilowatt hours by \$0.05. With reference to Exercise 13, the total cost is equal to (\$0.05 per kWh)(10.030 kWh) = \$0.5015.
    d) Answers vary. They should include the cost of electricity as well as a comparison to \$0.05 used by NASA.
    e) Answers will vary.
    f) Answers will vary. An example of an assumption that may be used is that the year is not a leap year, and therefore the year has 365 days.

Part C Window to Wall Ratio

15) Students follow the example of Table 2 to complete a table of window and wall dimensions. Students' answers may vary slightly.

Window and wall information for House A

House A Front Wall	Window Dimension	Window Area	Exterior Wall Dimensions	Exterior Wall Area
windows (5)	8 mm by 20 mm	5·160 sq mm = 800 sq mm	113 mm by 33 mm	3,729 sq mm
door	13 mm by 29 mm			
Totals	---	800 sq mm	---	3,729 sq mm

Window and wall information for House B

<table>
<tr><th>House B Front Wall</th><th>Window Dimension</th><th>Window Area</th><th>Exterior Wall Dimensions</th><th>Exterior Wall Area</th></tr>
<tr><td>Left double window</td><td>12 mm by 8mm</td><td>96 sq mm</td><td rowspan="2">Rectangular part of front wall: 118 mm by 25 mm</td><td rowspan="2">2,950 sq mm</td></tr>
<tr><td>Rectangular windows (4)</td><td>8 mm by 21 mm</td><td>4·168 mm = 672 sq mm</td></tr>
<tr><td>Triangular windows (2)</td><td>Triangle
b = 7 mm, h = 11 mm</td><td>2·(77/2) = 77 sq mm</td><td rowspan="2">Triangular gable end: base = 60 mm, altitude = 45 mm</td><td rowspan="2">1,350 sq mm</td></tr>
<tr><td>Trapezoidal windows (2)</td><td>altitude = 8 mm
side 1 = 17 mm
side 2 = 29 mm</td><td>2·(8·46/2) = 368 sq mm</td></tr>
<tr><td>Door</td><td>10 mm by 21 mm</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>Totals</td><td>---</td><td>1,213 sq mm</td><td>---</td><td>4,300 sq mm</td></tr>
</table>

Window and wall information for House C

House C Front Wall	Window Dimensions	Window Area	Exterior Wall Dimensions	Exterior Wall Area
Rectangular part of triple window	32 mm by 20 mm	640 sq mm	Rectangular part of front wall: 130 mm by 33 mm	4,290 sq mm
Half disk above triple window	Radius = 6mm	$(1/2)\cdot p\cdot(6\text{ mm})^2$ = 57 sq mm		
Rectangular part of right side windows (2)	19 mm by 11 mm	418 sq mm	Triangular part of front wall: Base = 51 mm, altitude = 18 mm	$(1/2)\cdot 51\cdot 18$ = 459 sq mm
Half disc part of right side windows (2)	Radius = 6 mm	$2\cdot(1/2)\ p\cdot(6\text{ mm})^2$ = 113 sq mm		
Half disc window above door	Radius = 7 mm	$(1/2)\ p\cdot(7\text{ mm})^2$ = 77 sq mm		
Door	13 mm by 23 mm	---	---	---
Totals	---	1,305 sq mm	---	4,749 sq mm

16) House A: $\text{WWR} = \dfrac{800\text{ sq mm}}{3729\text{ sq mm}} = 0.215 = 21.5\%$

House B: $\text{WWR} = \dfrac{1{,}213\text{ sq mm}}{4300\text{ sq mm}} = 0.280 = 28.0\%$

House C: $\text{WWR} = \dfrac{1{,}305\text{ sq mm}}{4{,}749\text{ sq mm}} = 0.275 = 27.5\%$

Part D Energy Savings Features - Building Types - Climate

17. a) Both might need reflecting tints for snow or bright sun. Both locations use double thicknesses to reduce heat transfer, but in opposite directions.
 b) Answers will vary.
 c) Answers will vary.
 d) Answers will vary.

18. a) The units of area cancelled out.
    b) The WWR would not have changed.
    c) If k is the scaling factor for inches and if c is the conversion factor from square millimeters to square inches, then we have the following.
    The true area of the windows = k^2(area of the windows in the diagram in square inches) = $k^2 \cdot c$ (area of the windows in the diagram in square millimeters)

    The true area of the wall = k^2(area of the wall in the diagram in square inches) = $k^2 \cdot c$ (area of the wall in the diagram in square millimeters)

    Since constant factors cancel when we form the WWR ratio, it is not necessary to know the actual dimensions of the house. Any drawing done to scale is sufficient.

19. a) Answers will vary.
    b) Answers will vary.
    c) Answers will vary.
    d) Wall W: Approximately 50%
    Wall X: Approximately 20%
    Wall Y: Approximately 30%

Part E Follow Up Exercises Related to NASA

20) 3,010 hours per year which is obtained by solving the equation, (20.89kW)x = 62,878kWh.
21) ($0.071)/kWh; calculation: ($4,471)/(62,878 kWh) = ($0.0711)/kWh
22) 4,400 square feet; calculation: (88,000 sq ft)(0.05) = 4,400 sq ft
23) $0.0481 per kWh; calculation: $96.00/1995kWh = $0.0481/kWh
24) 31 years; calculation: $3,000.00/$96.00 per year = 31.25 years

Section 2

Establishing a Baseline for Energy Use

Comments

The contractor invests $12,000,000 in work and is paid back $23,000,000. The difference of $11,000,000 can be considered a return on the contractor's investment. The government obtained the money to pay the contractor from savings created by reduced energy consumption and deferred maintenance. Deferred maintenance means that by installing new equipment, replacement of the old equipment is delayed for the life of the new equipment.

The finance option on some calculators permits finding interest rates or present values. For a more detailed discussion about rate of return on investment, see the Faculty Notes section for Spinoff 12 A.

Part B Fiscal Year and Calendar Year - Baseline For Electricity Use

1) January 1 and December 31
2) Expenses such as instructor contracts are between August and June. Also, most tuition is paid at the beginning of the fall and winter terms. Thus, the major financial expenses for schools occur in the same fiscal year if the fiscal year is chosen to be July 1 to June 30.
3) September 30, 1998
4) FY 1998
5) 1995
6) 1997
7) Answers are found in the far right column of each of the following tables.

Table 3 E & O (Engineering and Operations) Building Electricity Use in kWh

Month	FY96 (kWh)	FY97 (kWh)	FY98 (kWh)	Baseline (Monthly Average) (kWh rounded to nearest hundred)
Oct	79,130	70,320	87,120	78,900
Nov	67,910	61,920	60,720	63,500
Dec	58,010	56,280	60,650	58,300
Jan	51,870	80,720	56,280	63,000
Feb	50,990	52,560	47,880	50,500
Mar	55,570	69,000	47,040	57,200
Apr	64,500	58,560	59,020	60,700
May	75,600	71,760	69,210	72,200
Jun	75,600	77,520	80,400	77,800
Jul	86,140	90,240	89,870	88,800
Aug	93,550	93,240	95,290	94,000
Sep	96,010	97,920	95,330	96,400

Table 4 Hangar S Electricity Use in kWh

Month	FY96 (kWh)	FY97 (kWh)	FY98 (kWh)	Baseline (Monthly Average) (kWh rounded to nearest hundred)
Oct	92,890	116,360	97,520	102,300
Nov	81,200	100,000	82,080	87,800
Dec	69,940	80,180	71,280	73,800
Jan	61,890	84,320	67,800	71,300
Feb	59,000	77,520	61,760	66,100
Mar	61,990	101,440	59,480	74,300
Apr	70,120	94,600	64,980	76,600
May	81,410	87,840	74,780	81,300
Jun	93,080	95,240	86,600	91,600
Jul	102,290	103,440	97,530	101,100
Aug	106,780	92,240	104,910	101,300
Sep	105,440	101,240	106,920	104,500

Table 5 Hangar AF Electricity Use in kWh

Month	FY96 (kWh)	FY97 (kWh)	FY98 (kWh)	Baseline (Monthly Average) (kWh rounded to nearest hundred)
Oct	120,230	288,000	139,520	182,600
Nov	134,270	218,880	103,680	152,300
Dec	166,850	229,120	125,440	173,800
Jan	210,000	236,800	122,880	189,900
Feb	253,150	264,960	149,760	222,600
Mar	285,730	296,960	154,880	245,900
Apr	299,780	248,320	253,150	267,100
May	291,830	268,800	285,730	282,100
Jun	222,700	199,680	299,780	240,700
Jul	178,430	376,320	291,860	282,200
Aug	141,890	185,600	263,860	197,100
Sep	152,020	162,560	180,000	164,900

Part C Exploring Electricity Use Patterns

8) A graphing calculator or spreadsheet can be used to construct a connected line graph for the data in each table. Coded values (1 through 12) for the months should be recorded on the x-axis, with corresponding electricity use in kilowatt hours on the y-axis. Although the E&O building uses more electricity than Hangar S, the electricity use pattern for the two buildings is very similar. Both buildings use considerably less electricity from November through April than they do from May through September. For both buildings the electricity use for February is less than for any other month.

   Hangar AF uses more electricity the other two buildings and its electricity use pattern is quite different. The electricity use for Hangar AF for the six month period from August through January is considerably lower than for the six month period from February through July. The lowest electricity use occurs in November.

9) No, the summer months may have higher air conditioning costs. Seasonal differences affect energy use. Building usage is another cause for variability in energy use. For example, more electricity is used in Hangar S and in Hangar AF for the months October through March FY97 than for the same months in FY98. This difference would not be attributable to seasonal differences. It may be due to higher building usage in FY97.

10) October through March FY98: 132,690 kWh
    April through September FY98: 262,400 kWh
    Usage for April through September is indeed higher than for October through March FY98.

11) Total electricity use for each fiscal year by building is shown in the following table.

Building	FY96	FY97	FY98
E&O Building	854,880	880,040	848,810
Hangar S	986,030	1,134,420	975,640
Hangar AF	2,456,880	2,976,000	2,370,540