Chapter 20 LIGHT, HEAT AND ELECTRICITY

In chapter 18 and 19, we examined part of the kinematics of light. However neither reflection nor refraction of light spoke to the concepts of momentum and energy or of the individual involvement of atoms as they relate to light.

Here, our first area of investigation will deal with the emission of light from an incandescent source in which electrical energy is converted to heat energy. The text then presents a few statements relative to solar energy. (Your instructor strongly believes that the sun is the energy source of the future and that full speed ahead on solar research is the way to go.) So if you want to know more about solar energy you will need to look to another source.

Finally we will take a first look at the photoelectric effect where electrons in metallic atoms absorb light. This will help set the stage for the particle model of light which we will begin to investigate in chapter 21.

PERFORMANCE OBJECTIVES

After completing this chapter, you should be able to

1. Measure the electrical work on an electric bulb and the internal energy of a calorimeter in which the bulb is placed.

2. Explain how to measure the amount of energy received from the sun.

3. Cite evidence that light can be absorbed by electrons.

4. Examine the effect of intensity and color of light on the energy of ejected electrons.

1. Read: Section 20-1 The Incandescent Light Source page 421
   20-2 Infrared and Ultraviolet Light page 423

2. Problems: page 423: #1 #2
   page 424: #4 #5

3. Read: Section 20-3 Solar Energy page 424

4. Problems: page 426: #6 $7 (Let P = 1500 watts in #6.)

5. Read: Section 20-4 The Photoelectric Effect page 427
   20-5 The Kinetic Energy of Photons page 431

6. Obtain an electroscope, ultraviolet light source and a regular light bulb and socket. Perform the demonstration described on pages 427 and 428.

7. Have instructor explain photoelectric effect using Transparency T-36.

8. Problems: page 429: #8 #9 #10 #11 (try it and see)
   page 433: #17 #18 #19 #20

ANSWERS

2. (1) S.A.B.
   (2) S.A.B.
   (4) About 10% of energy supplied to the bulb appears as visible light
   (5) Converted into internal energy of the window glass.

4. (6) 90 m^2
   (7) (a) 24^o Celsius (b) S.A.B.

8. (8) Yes, a positive charge
   (9) The electroscope would be discharged in both (a) and (b).
   (10) (11) (12) (17) (18) S.A.B.
   (19) 470 watts
   (20) 1.47 times longer

CH - 20 LECTURE NOTES

1. WHAT HAPPENS TO ENERGY SUPPLIED TO LIGHT BULB?

ENERGY IN = VIt

ENERGY OUT = mc ΔT

C IN $\frac{KJ}{Kg°C}$ 4.19 → H_2O 2.60 → Glycol 0.90 → AL

$E_{OUT}/E_{IN} = \frac{mc\Delta T}{VIt}$

$77\,gm \times 4.19 \frac{KJ}{Kg°C} \times 1.55°C \times \frac{1\,Kg}{1000\,gm} \times \frac{sec}{0.67\,coul} \times \frac{}{180\,sec} \times \frac{coul}{5.1\,Joul} \times \frac{1000\,J}{1\,KJ}$

$\frac{77 \times 4.19 \times 1.55}{0.67 \times 180 \times 51} = .813$

BULB w/o AL COVER ≈ 82% Efficient Table 1

BULB w AL COVER ≈ 97% Efficient Table 2

2. WHAT HAPPENS IF USE BLACK WATER?

≈ 49% Efficient

↳ ADD $CuSO_4 \cdot 5H_2O$ to black INK ≈ 97% EFFICIENT

⇒ RADIATION NEAR RED END

3. HOW DO WE MEASURE SUN'S ENERGY STRIKING EARTH?

a. Upon WHAT DOES AMOUNT DEPEND?

(1) Sun's Angle of Elevation

Time of Day - Date - Latitude

(2) ATMOSPHERIC FACTORS

ALTITUDE - H_2O CONTENT - AIR POLLUTION

b. WHAT UNITS SHALL WE USE?

Watts/M^2 Joules/sec. M^2

c. SOME DATA

ABOVE ATMOSPHERE		1380	Watts/m^2
If Completely Transparent 40° LATITUDE	25%	345 ~~350~~	"
↳ 50% ABSORBED		175	"
Solar Pannel 20% Eff		35	" 2.5%

GREATER LIFE BULB LIFE VS EFFICIENCY

(IS IT A GOOD TRADE-OFF) → BULBS HARD TO CHANGE → TAIL LIGHT IN CAR

WHY BULBS FAIL? MOST EVAPORATION OF FILAMENT
↳ steep function of temperature

A. WAFER - THERMISTOR (IN SERIES)

THERMISTOR → RESISTANCE DECREASES AS TEMPERATURE INCREASES

→ HEATS INTERNALLY WHEN CARRIES A CURRENT

Lower Efficiency
Cost Wafer = 5 bulbs replacement

WHY NOT RESISTOR? NEED TO LOWER VOLTAGE & SAME # OF VOLTS FOR HIGH & LOW WATTAGE BULBS

HIGH WATTAGE ⇒ HIGH "I" ⇒ HIGH "TEMP" ⇒ "R" LOWER ∴ LESS "V" drop

				Voltage Drop Thermistor	Voltage Drop if R = 15Ω
2.6x life	79% Light	88% Effic't	15 watt	8.0	2
			25 watt	7.7	3
2.0x life	84% Light	91% "	60 watt	6.3	7
1.6x life	90% Light	94% Efficient	150 watt	4.5	16
			300 watt	4.0	29

RESULTS: LIFE EXTENSION < 4x → W/IN BALL PARK
2 TO 4x

B. DIODE - HALF-WAVE RECTIFIER reduces power & temperature

POWER DELIVERED = V^2/R (AVG)

HALF WAVE HEAT AS WOULD FULL WAVE X.71

NORMAL BULB		W/ DIODE
X	LIGHT OUTPUT	¼ X
V	VOLTAGE	.71 V
P	POWER CONSUMED	.60 P
100%	Efficiency	40%

To get same light as 100 watt → need ~~240~~ 400 watt bulb to get 240 watts

∴ to not have to replace 100 watt bulb at end 1000 hrs

bill for wasted power

1000 hrs x ~~240 watts~~ = ~~240~~ 400 Kwatts x .07 = ~~$16.80~~ $16.80

if 40% Efficient ∴ Total cost $42 / ∴ $25.80 lost

GREATER LIGHT BULB LIFE VS EFFICIENCY

- Main problem → evaporation of filament
  5% change voltage ⇒ 2× or ½× change in life

WAFER → THERMISTOR - in series in circuit
↳ DESIRE → LOWER VOLTAGE BY ABOUT SAME # VOLTS for ALL wattages
- thermister → resistance decreases as temperature increases
↳ heats internally when it carries a current

15 watt	8.0 Δ voltage	2
25 watt	7.7 "	3
60 "	6.3	7
150 "	4.5	16
300 "	4.0	29

Δ Voltage for reaction

$12\text{¢} \times \frac{5}{100\text{¢}}$ = 6 volts ⇒ 2× longer

12 volts ⇒ 4× longer

Results → life extension less than 4 as claimed

Simple diode → ½ Wave rectifier reduced Power ∴ ∴ temperature
FOR RESISTANCE LOAD
$P = V^2/R$ (time average of)

Thermister → lowers temp ∴ extends life by factor of 2 to 4
w/o much light reduction
→ lowers efficiency, costs × 5 replacement bulbs

Diode → case of overkill
TO get same light from 100 watt bulb - need 400 watt bulb
↳ 240 Watts

∴ TO AVOID changing bulb after 1000 hrs
run up electric bill to buy basket full of bulbs

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1. A motor is described as a device that changes electrical energy into mechanical energy. Explain in detail with or without diagram(s) how it works. (5)

2. How does a generator differ from a motor? (3)

3. What is the purpose of a transformer? (2) Which current (AC) or (DC) is essential for its operation? (1) Explain. (3)

4. Compare the energy used by toasting 2 pieces of bread in a 1050-watt pop-up toaster that takes 2.0 minutes with that used to toast them in a 3200-watt broiler that takes 3.5 minutes including warm-up time? (2) (2) Conclusion? (1)

5. Lightning rods are for the purpose of . . . Complete the sentence. (2) Then describe how they do what they do. (3)

6. If a lightning bolt flashes across a potential difference of 200 megavolts between cloud and ground, and carries down a charge of 20 coulombs, how much energy is dissipated? (b) How high would this much energy lift a 20000-kg bulldozer if converted to mechanical work?

   a. _____ (3)

   b. _____ (3)

7. Why is the sky blue and the sunset red? Explain fully. (4)

8. The technical crew for a stage performance can change the color of the performers' clothes in the middle of a performance. How do they do this? (2) What is the physics of this change? (3)

9. A short person driving a car moves the seat forward to better reach the steering wheel and pedals, while a tall person moves the seat farther back. Which person will see a wider field of view in a fixed rear-view mirror? (1) Why? (3)

10. Suppose you look at a dime under a magnifying glass of focal length 5 cm. If the dime is 3 cm from the magnifier, how far away will it appear to be? (b) How big will it appear?

    a. _____ (3)

    b. _____ (3)

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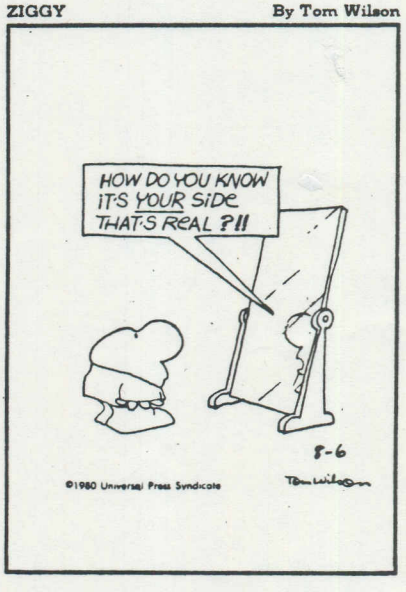
11. The advertisement at the right indicates that rooms seem twice as big and beautiful? Is this true? (1) Explain. (3) (b). It also says that it lights up decor! Also explain. (3)

a. (1) (3)

b. (3)

12. How will Ziggy answer the question that his image proposes? (5)



13. Explain in detail why Scamp thought the water was deeper than it was? (5)

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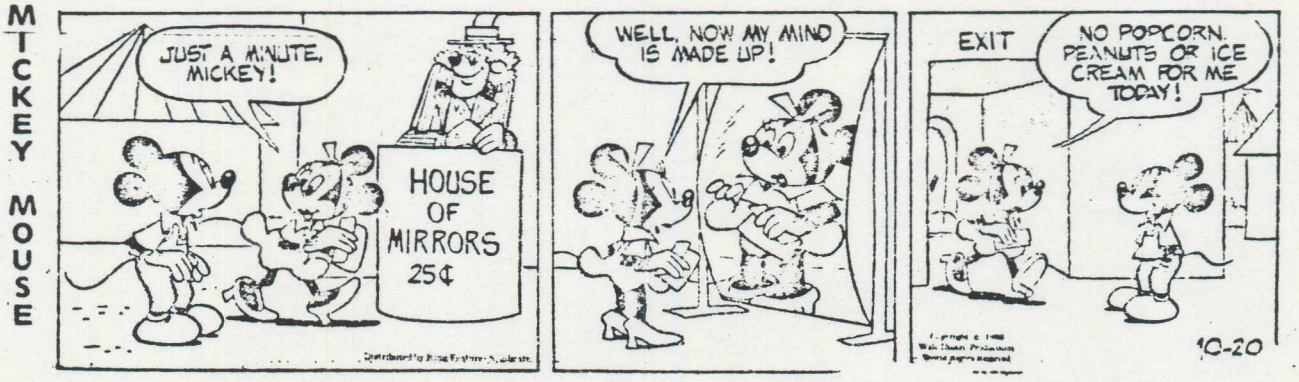
14. Minnie decides she will not eat anything today. Did she need to come to that conclusion? (1) Describe the image and why it is as it is. (4)



15. Describe in detail the physics behind mixing a red and yellow gumdrop to get orange? (4) Is this color addition or color subtraction? (1)