Introduction to Lighting Systems and Controls

Course No. ENRG 54

Outline

A. Introduction to fundamentals of lighting
- Lighting terminology
- Physics and principles of lighting
- Units of measurement
- Vision and colors
- Ambient, directional and task lighting
- Over- and under-illuminance

B. Lighting systems
- Components
- Types of lamps
- Ballasts
- Lamp comparison matrix
- Types of lighting luminaires and intensities
- Energy efficiency measures (EEMs)

C. Lighting controls
- Basic concepts of effectiveness of lighting control
- Types and appropriate applications of lighting controls
- Lighting control equations
- Energy efficiency measures (EEMs)

D. Additional EEMs
- De-lamping
- Scotopic lighting
- Task and ambient light levels
- Circadian rhythms

E. Lighting measurements
- Tools
- Data loggers and applications

F. Lighting calculations
- Equation and method of calculating lumens (zonal cavity formula)
- Equation and method of calculating energy savings
- Method of calculating skylight energy savings

G. Lighting standards, codes and regulations
- Underwriters' Laboratory (UL)
- Uniform Building Code (UBC)
- Americans with Disabilities Act (ADA)
- Title 24 applications

H. O&M measures to assure optimal performance

D. Additional EEMs

1. De-lamping
2. Scotopic lighting
3. Task and ambient light levels
4. Circadian rhythms

D. Additional EEMs

1. De-lamping
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De-lamping

- The removal of one or more lamps from a luminaire
- Save energy (kWh), reduce demand (kW), save maintenance parts and labor.
- May combine with re-lamping
- Strategies:
  - reduce # of fixtures
  - de-lamp 4- or 3-lamp fixtures
  - retrofit

De-lamp 4- or 3-lamp fixtures

- Quite often offices, schools, warehouses are overlighted
- Pay attention to the lighting level after de-lamping
- Pay attention to # of ballast and wiring
- May combined with reflector installation

Case study

A warehouse has 50 fixtures of 48”, four (4) T8 lamps with 2 electronic ballast in series. The lighting level is 60 fcd. Delamping in half will still provide acceptable light, according to IES illumination level standard, assuming the lighting pattern is distributed well through out the area.

The fixtures have 4 units of 32W T8 and 2 units of 10W electric ballasts. Working time is 4700 hours a year. It takes 15 minutes to delamp a fixture, and the labor cost is $35/hour. If the average Energy rate is $0.15/kWh, and Demand rate is $10/kW, calculate:

1. Total energy savings
2. Simple payback period
3. Other saving

Case study

1. Total energy savings

Energy savings = ((2X32W)+(1X10W))/1000 X 50 X 6000h X $0.15 /kWh =$ 3330/yr

Demand saving = ((2X32W)+(1X10W))/1000X50 X$10X 12 months = $444/yr

Total energy savings = $3330 + $444 = $3774/yr

2. Simple payback period

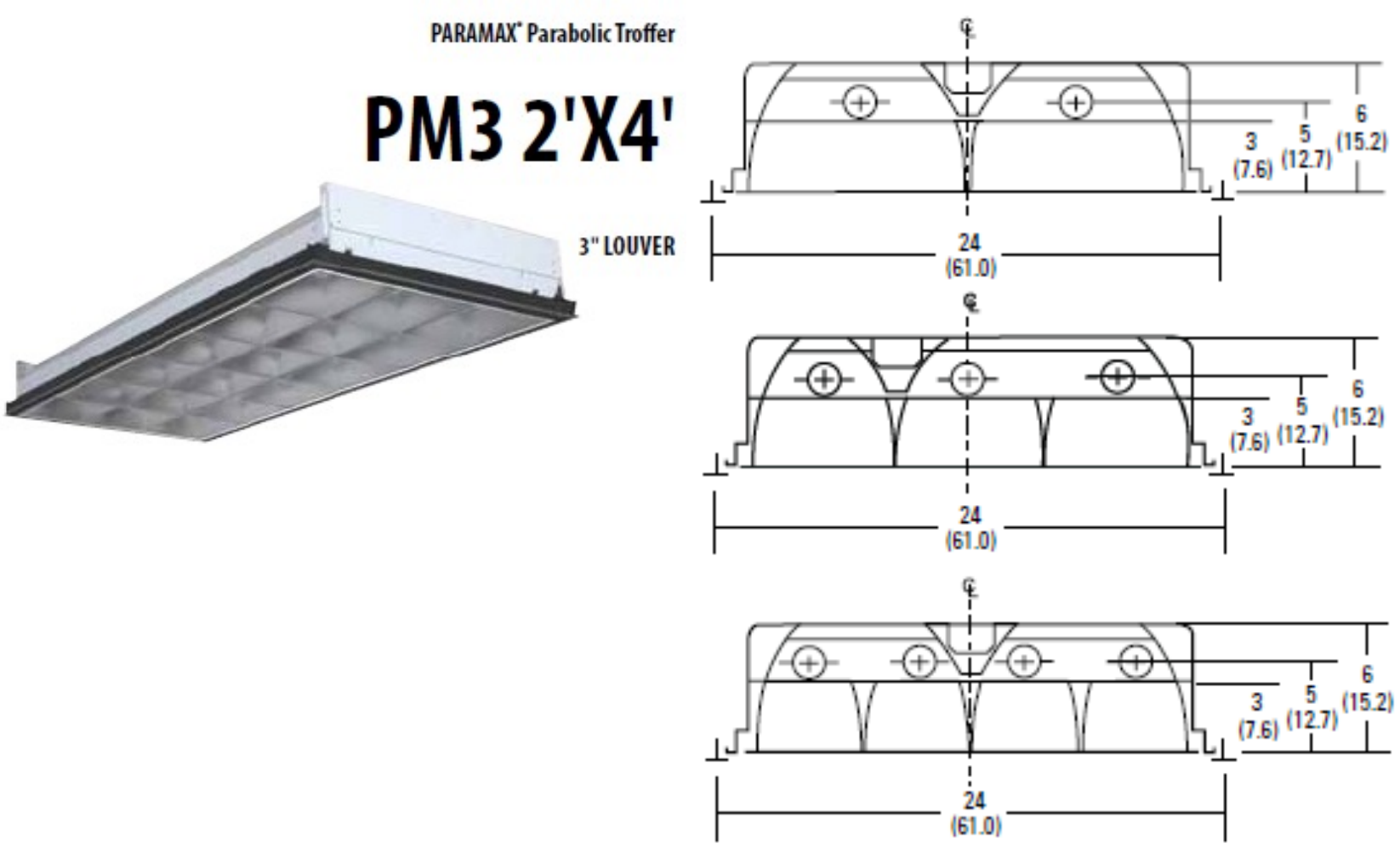
Implementation cost = $35/hr X 50 fixtures X (15 min/ 60 min per hr) = $ 437.5

Simple payback period = $437.5/$3774 = 0.12 yr = 1.4 months

3. Other savings

Lamp replacement parts and labor

Retrofit – fluorescent troffer



D. Additional EEMs

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Scotopic lighting

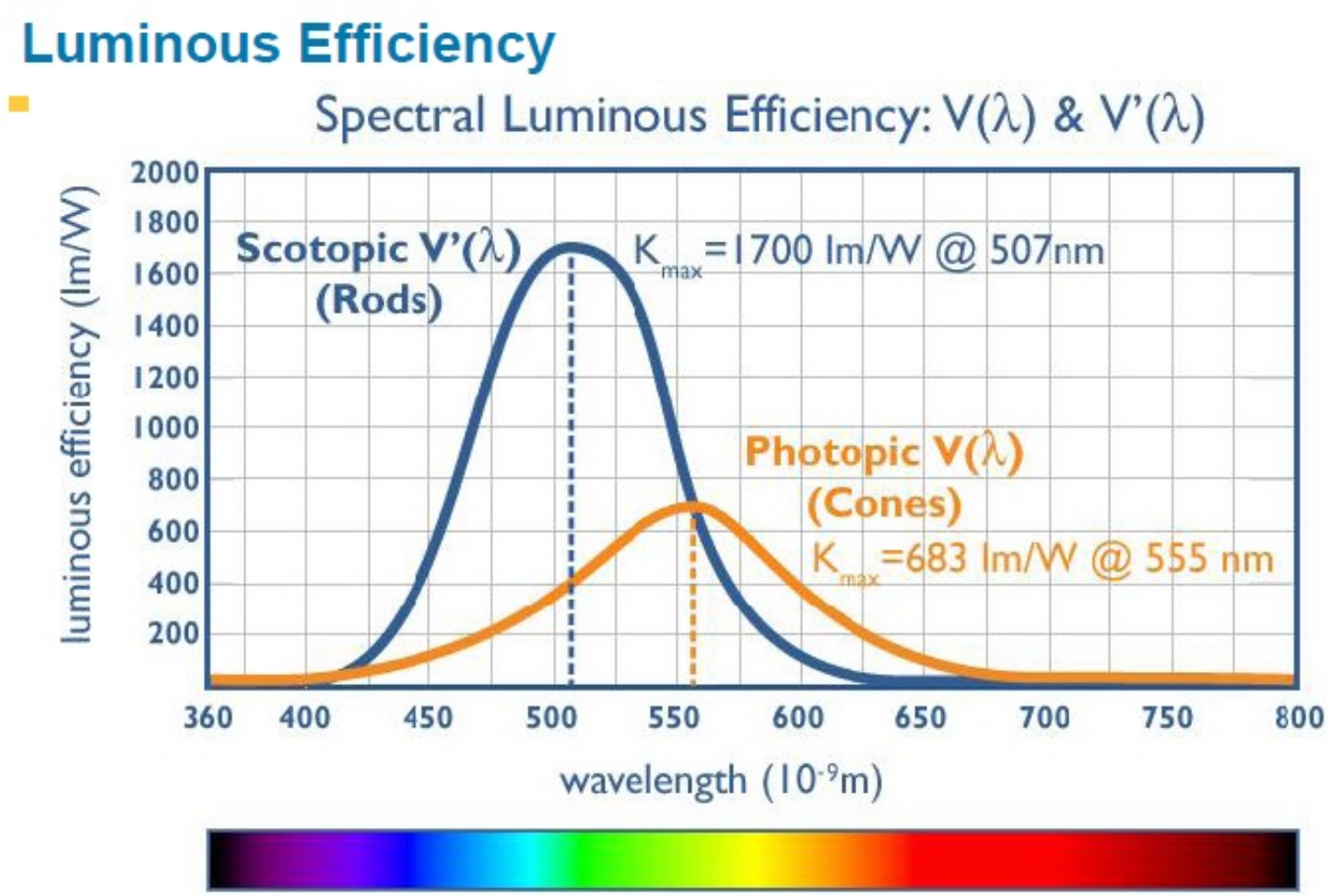
- Refers to the “whiter” or “cooler” color temperature
- Human eye’s ability to see more clearly and further across a whiter light
- Reduces visual fatigue when viewing a computer screen

250 W HPS vs. 100 W Inductions

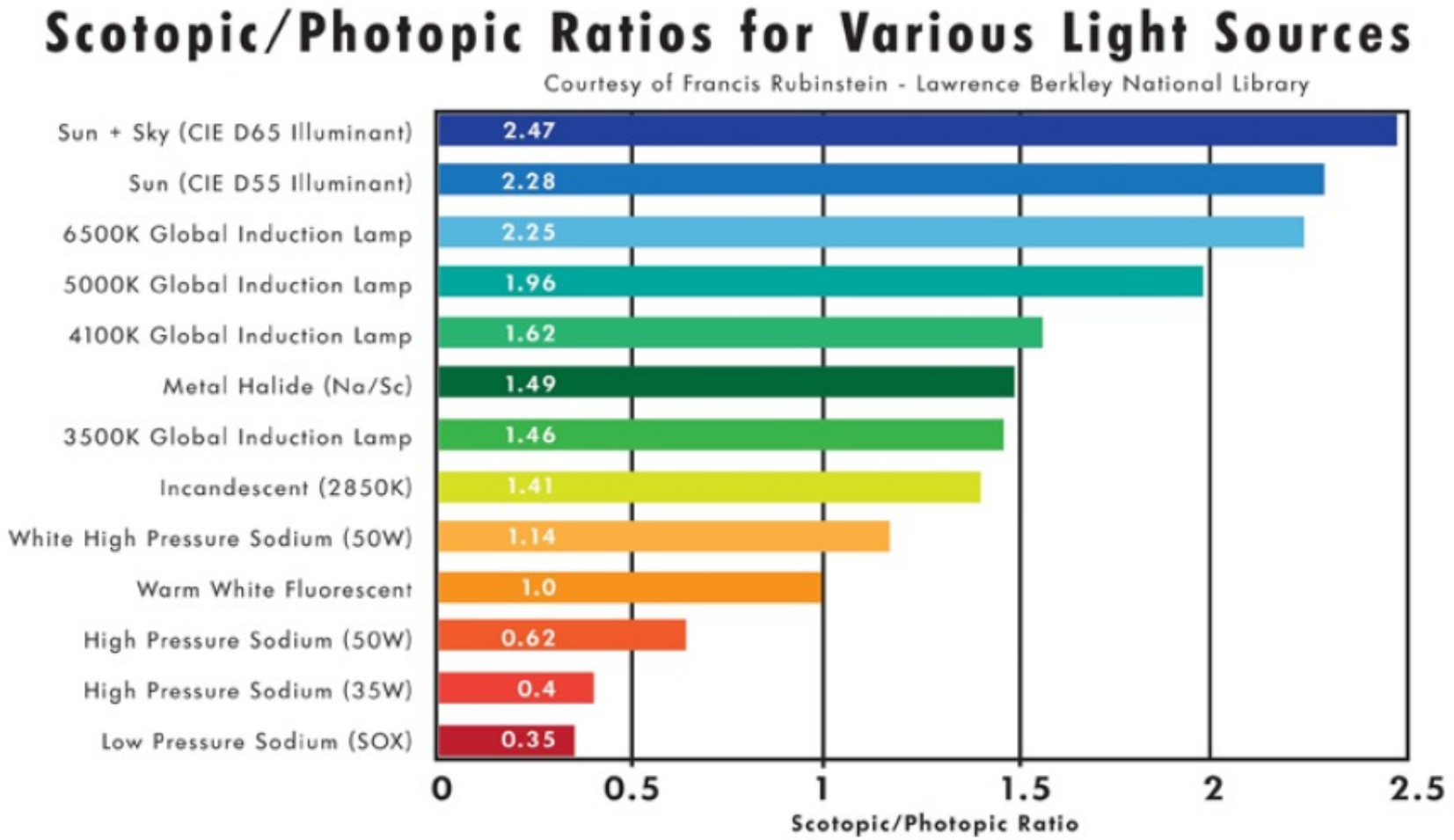
175 W HPS vs. 80 W Induction

http://www.neweralighting.com/What%20is%20scotopic%20lighting.html

Scotopic lighting



Ratio of scotopic to photopic (S/P ratio)



Scotopic lighting

- Reading materials:

http://www.lightenergysource.com/Scotopic.htm

http://www.solarlight.com/products/Energyconservations

cotopic.pdf.pdf

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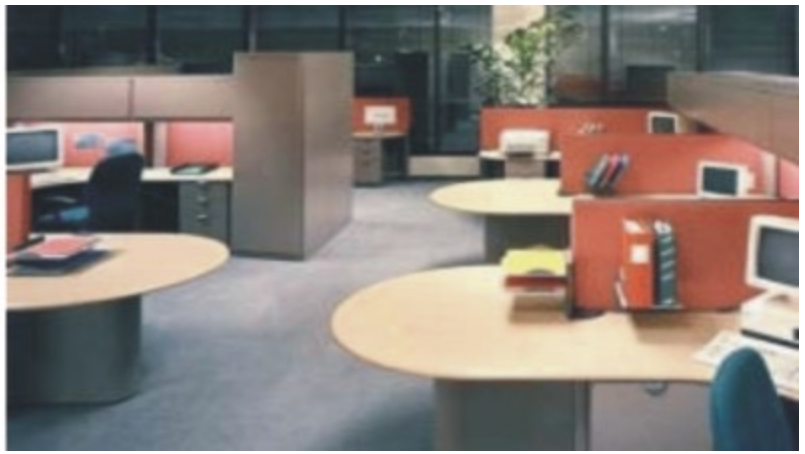
Task and ambient light level

- Decoupling ambient lighting and task lighting
- In office, provide uniform low-level ambient lighting with individually controlled task fixtures
- Task lighting gives the user maximum control
- Reading material:

http://www.dazor.com/benefits.html



Michaelsenergy.com

Task and ambient light level

Example: a work environment can maintain lower levels of overhead light by illuminating desktops with energy-efficient task lights. Considering an office with 16 workstations illuminated by 16 overhead fixtures each with four T8 32-watt fluorescents.

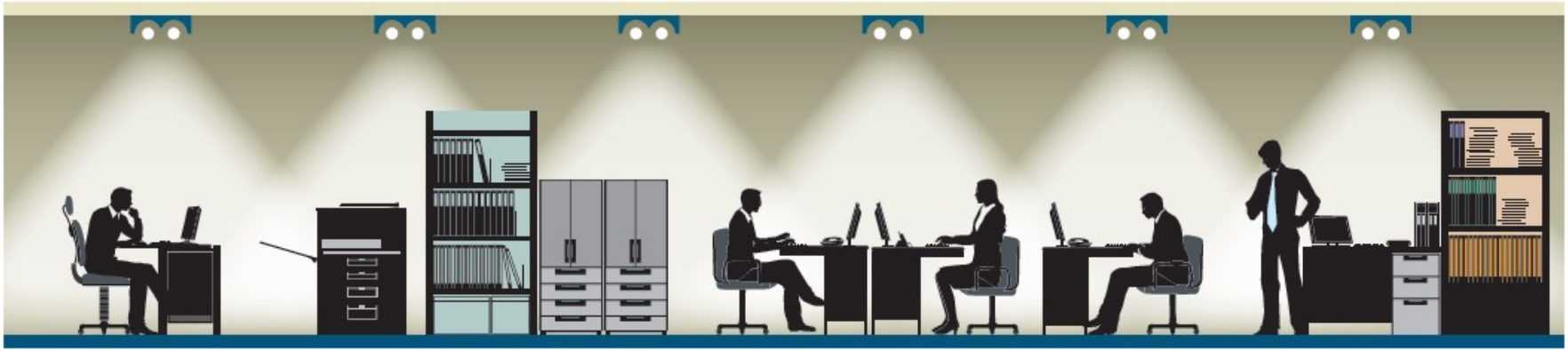
The total wattage = 16 X 4 X 32 W = 2,048W.

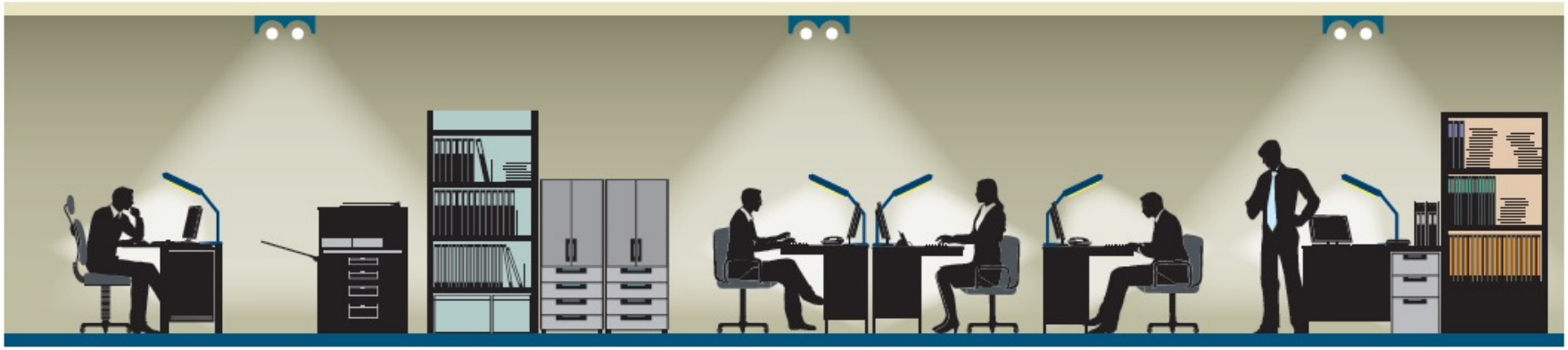
If each fixture used two T8 instead of four, and each workstation was equipped with an 18-watt task light,

The new wattage = 16 X 2 X 32 + 18 X 16 = 1312 W

Energy consumption would be reduced by 36 percent!

Task and ambient light level





http://www.emsd.gov.hk/emsd/e_download/pee/Task_Lighting_Design.pdf

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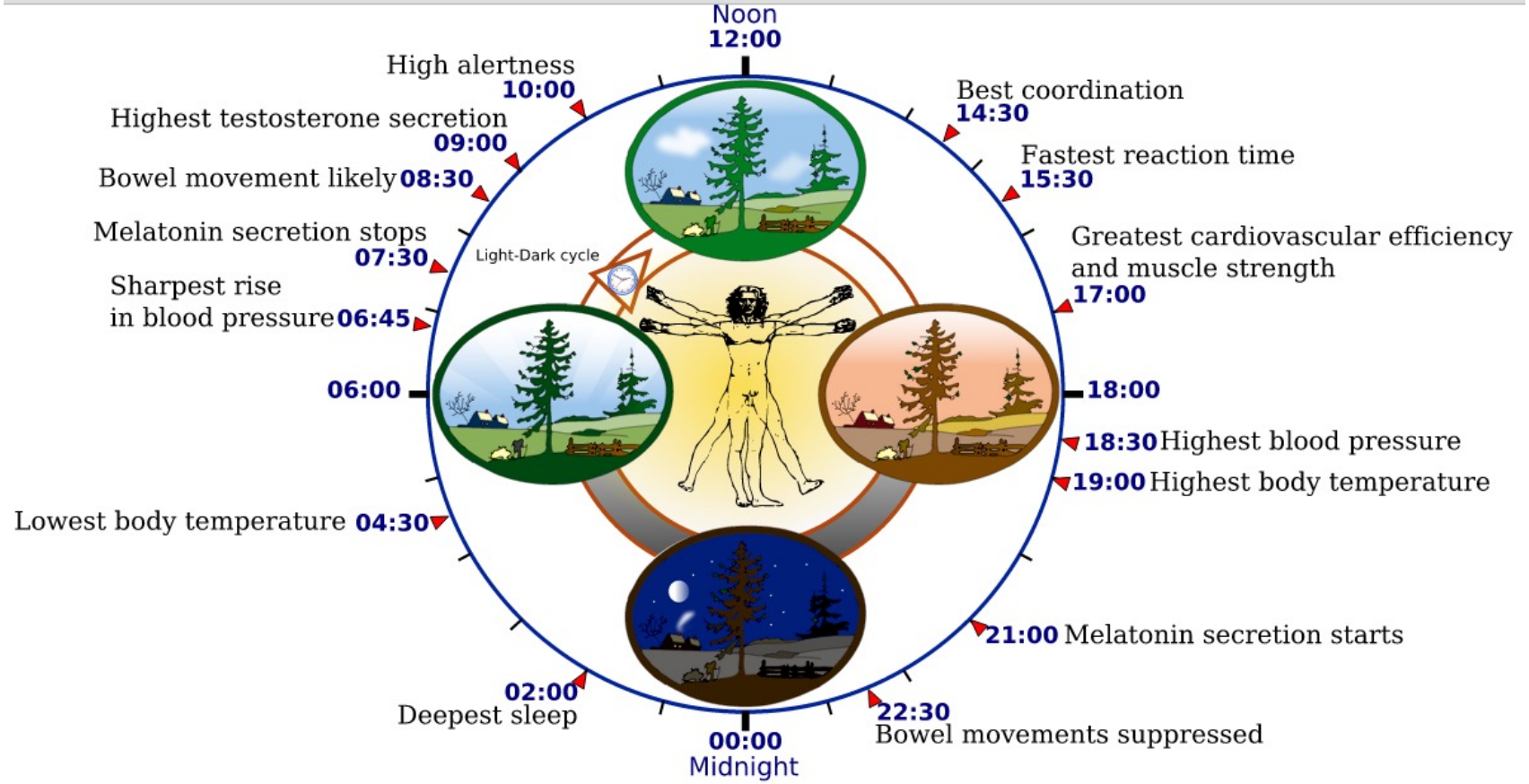
Circadian rhythms

Biological process that displays an endogenous, entrainable oscillation of ~24hrs.



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Circadian rhythms – general criteria:

- Around the day - the rhythms repeat in a 24-hr period
- Endogenous - the rhythms persist in the absence of external cues
- Entrainable - the rhythms can be adjusted to match the local time
- Temperature compensation – the rhythms maintain circadian periodicity over a range of physiological temperatures

Circadian rhythms

- Allow organisms to anticipate and prepare for precise and regular environmental changes
- Can be disrupted by the wrong timing, intensity and/or spectral composition of light
- Lighting needs to be designed in a way that is “circadian rhythm friendly”
- An example: dimming and Kelvin changing LED troffers

Homework 2 discussion

Chapter C homework project:

Design lighting control strategies for a campus space: e.g. conference room, hall way, restroom, classroom, office. Requirement:

- choose the right type(s) of controls, explain why.
- choose the proper physical place to install, explain why.

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation