# Final Exam

- Wed Dec. 9 from11:30am-2:29pm York 2722
- Will cover all the course material including the last week
- 25 questions –multiple choice.
- You are allowed to bring 1sheet of paper with equations on both sides, scratch paper for calculation, calculator
- You must bring a scantron form and a picture id.
- Problem Session Mon. Dec. 7 from 8-10 pm in Ludden Auditorium.

# 10.2 Review and Overview Energy Problem

**Ch. 13 Harmonic Oscillations**

Know the relations between displacement and time for simple harmonic motion..

Harmonic oscillators

Displacement $y=A\cos(\omega t)$

$$v = \frac{\lambda}{T} = \lambda f \qquad \omega = 2\pi f$$

Know how the frequency depends on properties of the system.

Mass on a spring $\omega = \sqrt{\frac{k}{m}}$

Pendulum $\omega = \sqrt{\frac{g}{L}}$

**Chapter 14 Waves**

Longitudinal Waves
Transverse Waves
Know the relation between wavelength, frequency, period, speed

$$f = \frac{1}{T} \qquad f = \frac{v}{\lambda}$$

Transverse wave on a string.
Know how to calculate the velocity. $v = \sqrt{\frac{F}{\mu}}$

Power - proportional to the square of the amplitude.
Intensity =power/area
Superposition principle.
Interference – know how to calculate the conditions for constructive and destructive interference.

Beat frequency- the difference between two frequencies.

**Chapter 14 Sound**

Speed of sound in a gas
(speed of sound in air at 20 C= 340 m/s) $v = \sqrt{\frac{\gamma P}{\rho}}$

Intensity of sound
Decibels (dB) $\beta = 10\log\left(\frac{I}{I_o}\right)$ $I_o = 10^{-12}\ W/m^2$

Speed of sound in a solid $\sqrt{\frac{B}{\rho}}$

Phase shift on reflection.
Standing Waves.
Know how to find f, $\lambda$ for different boundary conditions. e.g.

m=1 m=3

$\lambda = 4L$

$f_1 = v/4L$

Doppler effect. know the difference between moving source and moving observer.

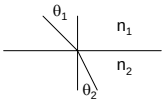
$$f_o = f_s\left(\frac{v \pm v_o}{v \pm v_s}\right)$$

**Chapter 22. Reflection and Refraction**

Reflection $\theta_{incidence} = \theta_{reflection}$

Refraction
refractive index $n = \frac{c}{v}$

Snell's Law $n_1 \sin\theta_1 = n_2 \sin\theta_2$



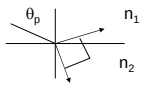

Be able to solve Snell's law problems.

Total Internal Refraction $n_1 \sin\theta_c = n_2$

Polarization by Reflection

Polarization angle (Brewster's angle)

$$\tan\theta_p = \frac{n_2}{n_1}$$




Know how light is dispersed by a prism.

**Chapter 23 Image Formation and Optical Instruments**

Mirrors. plane, spherical (f=R/2), concave, convex.

Lenses, converging, diverging, concave, convex.

Be able to solve problems on image formation using mirrors and lenses.

Use Ray tracing and lens (mirror) equation $\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$

Know how to calculate the magnification and how to determine if the image is real or virtual, inverted or upright.

Lens Power $P=\frac{1}{f}$ diopters ($m^{-1}$)

Know how to analyze optical systems
eye, camera, projector

Magnification of optical instruments

simple magnifier $m=\frac{25cm}{f}$ microscope $m=\frac{L}{f_o}\left(\frac{25cm}{f_e}\right)$ telescope $m=\frac{f_o}{f_e}$

**Chapter 24 Interference and Diffraction**

Two-slit interference. $d\sin\theta=m\lambda$ (for constructive interference)

Know the properties of multiple slit interference and diffraction gratings.

x-ray diffraction. Bragg condition $2d\sin\theta = m\lambda$

Single-slit diffraction $a\sin\theta=m\lambda$ (for destructive interference)

Resolution and the diffraction limit (Rayleigh criterion)

single slit diffraction limit $\theta_{min}=\frac{\lambda}{a}$

circular aperture $\theta_{min}=\frac{1.22\lambda}{D}$

Thin-film Interference
Know how to calculate wavelengths for constructive and destructive interference due to reflection from thin films. Remember phase shift rules.

**Chapter 27 Quantum Physics**

**Particle properties of light**

Know the properties of Blackbody (thermal) radiation and the Photoelectric Effect.

Know the basic relations between wavelength and photon energy.

$E=hf$ f = Planck's Constant

Know the properties (energies, wavelength, frequencies) of electromagnetic waves with different wavelengths and frequencies. Radio waves, microwaves, infrared, visible , ultraviolet, x-rays, gamma rays.

**Wave properties of matter.**

Know how to calculate the de Brogie wavelength $\lambda=\frac{h}{mv}$

Know the consequences of the Uncertainty Principle $\Delta x\Delta p_x \geq \frac{h}{4\pi}$

Know that these quantum effects are important for microscopic objects.

**Chapter 28 Atomic Physics**

Know the ideas behind the Bohr model of the atom and how this leads to discrete energy states and spectra.

$$E_n=-\frac{m_e k_e^2 e^4}{2\hbar^2}=-13.6\left[\frac{1}{n^2}\right]eV$$

Know about Quantum numbers and the Exclusion Principle and how this explains the Periodic Table.

Know how characteristic x-rays are formed from transitions of electron to fill electrons lost from the inner shell.

**Applications of Quantum Physics**

Lasers -- Stimulated Emission, Population inversion

Semiconductors -- Band Gap, Conduction Band, Valence Band.

Light emitting diode -Current drop across band gap -> light

Solar Cells -- Light absorbed -> current flow

Transistors – Electrical valve regulates current flow

**Ch. 29 Nuclear Physics**

Know the properties of nuclei, size, composition.

Binding energies. Know how to calculate this from the mass of atoms.

**$E=mc^2$**

Know the curve of the binding energy. How it arise from the competition between nuclear and electrostatic forces. Why it goes through a maximum.

Radioactive decay.

$$N=N_o e^{-\lambda t}=N_o\left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}} \qquad T_{1/2}=\frac{0.693}{\lambda}$$

Radioactivity

Know the properties of alpha particles, beta particles and gamma rays.

**Applications of Nuclear Physics**

Radiation Damage

Imaging

**Ch. 30 Nuclear Energy**

Know how the fusion and fission processes arise from the curve of the binding energy.

**Fission**-Know the conditions needed for fission.

Requires neutrons, produced in a chain reaction.

Nuclear reactor- Enriched uranium, Moderator, control rods.

**Fusion-** Know the conditions needed for fusion

High temperature,

Lawson criterion. Product of density and time must exceed critical value.

Magnetic Confinement

Inertial Confinement (Laser Fusion)

## Energy and Society

- The US and the world is running out of petroleum.
- Alternative sources need to be found.

## Energy consumptions vs gross national product

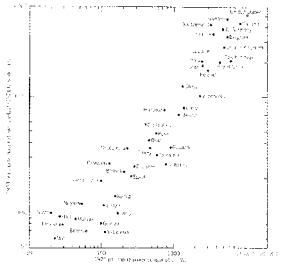
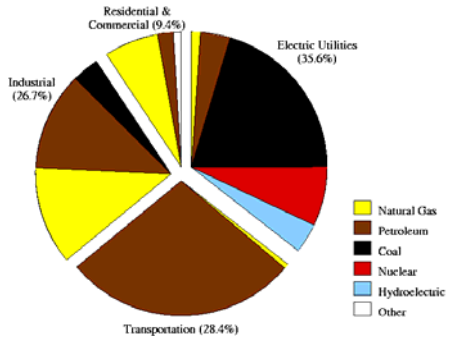


Figure 1–14.
Per capita gross national product and average per capita power consumption by various countries of the world in 1971. This does not include the energy in the food that is consumed.

## Energy Use




## Oil Production in the US has peaked

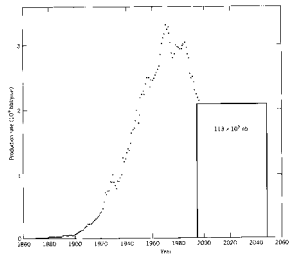
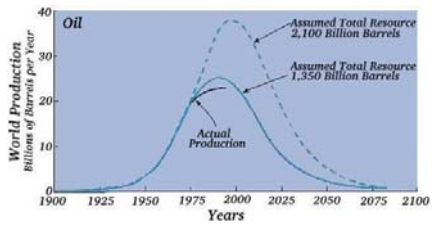
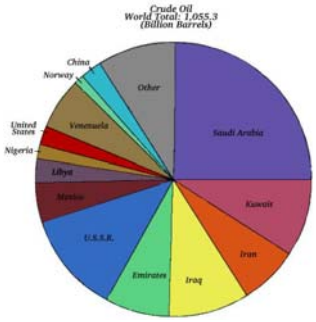


Figure 2.2 Annual petroleum production in the United States, including Alaska, since 1860. The rectangle at the right has an area representing the 113 billion barrels estimated to be remaining for future production.

## World production is close to peaking




## World Oil Resources



Alternatives to oil

Coal

Nuclear Energy

- Fission
- Fusion

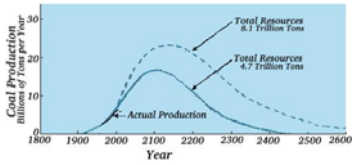
Hydroelectric

Wind

Solar

Biomass

## Coal




Lots of coal
Problem -coal produces even more $CO_2$ per BTU than oil
Serious effects on global warming, also pollution.
Coal is not a liquid fuel – need storage- Hydrogen?

## Nuclear Energy-Fission

Uranium -> fission produces + energy

- Problem with radioactive waste disposal.
- Release of radioactivity by accidents or terrorist attack
- With the current fuel cycle uranium would be depleted in ~150 years.
- Breeder reactor technology may increase this time.

## Nuclear energy-Fusion

$^{2}H + ^{3}H \rightarrow ^{4}He + n + \text{energy}$

- Power plants using nuclear fusion have not been built.
- Severe problems in attaining the conditions for fusion. High temperatures, high density of fuel, isotopes of hydrogen.
- Although the fuel source is almost unlimited, the technology is uncertain.

## Hydroelectric

- This is a efficient clean source of energy
- However most of the easily available dam sites have already been used.
- Not much more room for expansion

## Wind Energy

- Windmills are now producing electricity at competitive prices in selected locations
- The energy densities are roughly comparable to solar energy.
- Wind energy will be a more important source in the future.

## Solar Energy

- The amount of energy from the sun is large $2 \times 10^{17}$ W, incident
- The average power density is low about 100-300 W/m$^2$
- Large areas must be covered.
- Collection costs must be cheap.

## Photovoltaic

light -> electrical energy

- Current silicon solar cells are commercially available.
- The costs for the are often subsidized by government to make solar energy competitive.
- Newer technologies (nano-particle, non-silicon) may reduce the costs further.

Value of solar energy produced by a solar cell (1m$^2$)

Estimate

light intensity – 1000 W/m$^2$ ( 3hr/day)
efficiency of solar collector 20%
cost per kwhr \$0.15
lifetime of the solar collector 20 yr.

$$\text{Value of Energy} = 1.0\text{kW}(0.2)\left(\frac{3\text{hr}}{\text{day}}\right)\left(\frac{365\text{day}}{\text{yr}}\right)(20\text{yr})\left(\frac{\$0.15}{\text{kwhr}}\right)$$

$$= \$700/\text{m}^2$$

Cost of solar panels is in the range \$500-\$1000/m$^2$ (uninstalled.)

## Biomass

sunlight -> fixed carbon -> energy

- Photosynthesis stores solar energy in carbon compounds such as ethanol
- Fixed carbon used as fuel.
- Ethanol from corn uses a lot of energy in production, farming and processing.
- Other plants and fuel processes may be more efficient.
- Problem - converting biomass into fuel involves complex processing.

## Summary

- Finding sources of energy will be a major concern in the near future.
- Alternative technologies and resources will need to be developed.
- Future generations of scientists and engineers will be at the forefront of this development.
- Hopefully the lessons that you learned in Physics will help you understand and contribute to solving these problems.