Overview

Review

Science and Society

Final Exam

- Wed. June 10, 3:00-6:00 pm – 2001 WLH
- 20 questions multiple choice
- Similar to the quizzes
- You can bring 2 sheets of equations, 8x10 two sides
- Calculator
- Bring a picture ID.
- Scantron

Review

Chapter 16 Waves

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

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

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 17 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

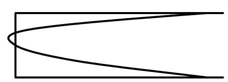
Decibels (dB) $\beta = 10\log\left(\frac{I}{I_o}\right)$ $I_o = 10^{-12}\ W/m^2$

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

Phase shift on reflection.

Standing Waves.

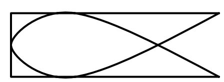
Know how to find f, λ for different boundary conditions. e,g.



m=1

$\lambda = 4L$

f=v/4L



m=3

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

$f' = \frac{f}{(1 \pm u/v)}$ moving source

$f' = f(1 \pm u/v)$ moving observer

Chapter 34 Light Waves – Maxwell's Equations.

Properties of EM Waves. $c = \sqrt{\frac{1}{\mu_o \varepsilon_o}} = 3.00x10^8 m/s$ E=cB (perpendicular)

know the approximate values for λ and f for different regions in the EM spectrum i.e. radio waves, microwaves, infrared, visible, ultraviolet, x-rays.

Polarization of light

Law of Malus $S=S_o \cos^2 \theta$

Know about the production and detection of EM waves.

Energy of EM Waves

$$\vec{S} = \frac{\vec{E}x\vec{B}}{\mu_o} \qquad S = \frac{E^2_{max}}{2\mu_o c} = \frac{cB^2_{max}}{2\mu_o}$$

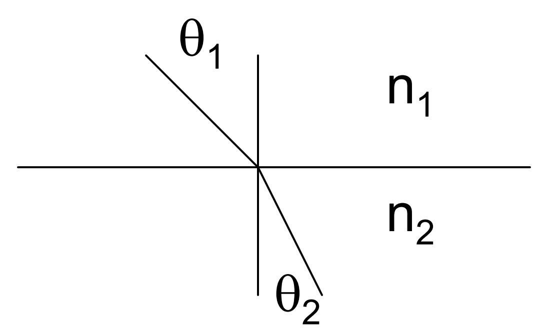
Chapter 35. Reflection and Refraction

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

Refraction

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

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



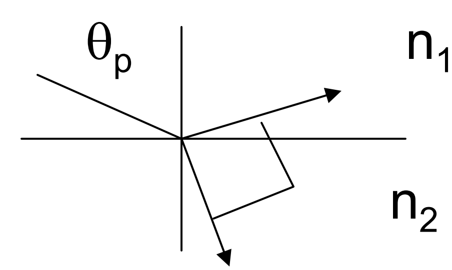
Be able to solve Snell's law problems.

Total Internal Refraction $n_1 \sin\theta_1 = n_2$

Polarization by Reflection

Polarization angle (Brewster's angle)

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



Chapter 36 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 $$\frac{1}{\ell}+\frac{1}{\ell'}=\frac{1}{f}$$

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
- 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 36 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 18 Fluids.

Pressure P=F/A (P_a =1.0x10^5 Pa)

Know how to solve problems of pressure increase with depth $P = P_o + \rho g h$

Know how to apply Pascal's Law $\Delta P = F/A = \text{constant}$

Archimedes Principle

Buoyant force =weight of fluid displaced $F_B = g\rho_{fluid} V_{displaced}$

Fluid Dynamics

Continuity equation $\rho v A$= constant

Bernoulli's Equation

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

Know how to apply Bernoulli's Equation in different conditions.

Chapter 19 Temperature an heat

Temperature scales, Celsius, Kelvin, Fahrenheit

Mechanical equivalent of heat. 1cal=4.18J

Heat capacity $Q=C\Delta T$

specific heat $Q=mc\Delta T$

Heat Transfer

Conduction $$H=-kA\frac{\Delta T}{\Delta x}$$

Radiation $P=e\sigma AT^4$ $\sigma=5.67\times10^{-8}$ W/m^2K^4 Stefan-Boltzmann const.

Know how to treat problems of thermal energy balance
Know how to calculate rates of heat flow..

Chapter 20 Thermal Behavior of Matter

Ideal gas law   PV=NkT=nRT   k= 1.38×10^{-23} J/K , R=8.31J/K·mol

Kinetic Theory of gases $$\frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$$ $$v_{thermal} = \sqrt{\frac{3kT}{m}}$$

Phase changes

fusion $Q = L_f m$

vaporization $Q = L_V m$

Chapter 21. First Law of Thermodynamics

$$\Delta U = Q - W$$

U is a state function, Q and W are not state functions

For an ideal gas U is only a function of T.

Work $W = \int P dV$ $\gamma = \frac{c_p}{c_v}$

process	property	First Law	work	Other relations
isothermal	T constant	$\Delta U=0$ $W=Q$	$nRT\ln(V_2/V_1)$	$PV=$constant
Constant V	V constant	$W=0$ $\Delta U=Q$	0	$Q=nc_V\Delta T$
Isobaric	P constant	$Q=\Delta U+W$	$P\Delta V$	$c_p=c_V+R$
Adiabatic	Q=0	$\Delta U=-W$	$\frac{P_1V_1-P_2V_2}{\gamma-1}$	$PV^{\gamma}=$ constant $TV^{\gamma-1}=$ constant

Chapter 21
Specific Heat of ideal gas
Know the degrees of freedom for monatomic, diatomic and polyatomic gases.

Equipartion theorem
KE is equal to ½ kT times the number of degrees of freedom.

Be able to calculate c_V and c_P for different gas molecules.

Chapter 22 Second Law of Thermodynamics

Know the three formulations of the second law, Kelvin Planck, Claussius, Entropy Principle

Know the features of the Carnot Cycle.

Carnot Efficiency of a heat engine $e = 1 - \frac{T_c}{T_h}$

Refrigerators Coefficient of performance $COP = \frac{T_c}{T_h - T_c}$

Entropy $\Delta S = \int_1^2 \frac{dQ}{T}$

Know how the entropy changes for an irreversible process

Be able to calculate the entropy changes between different states.

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

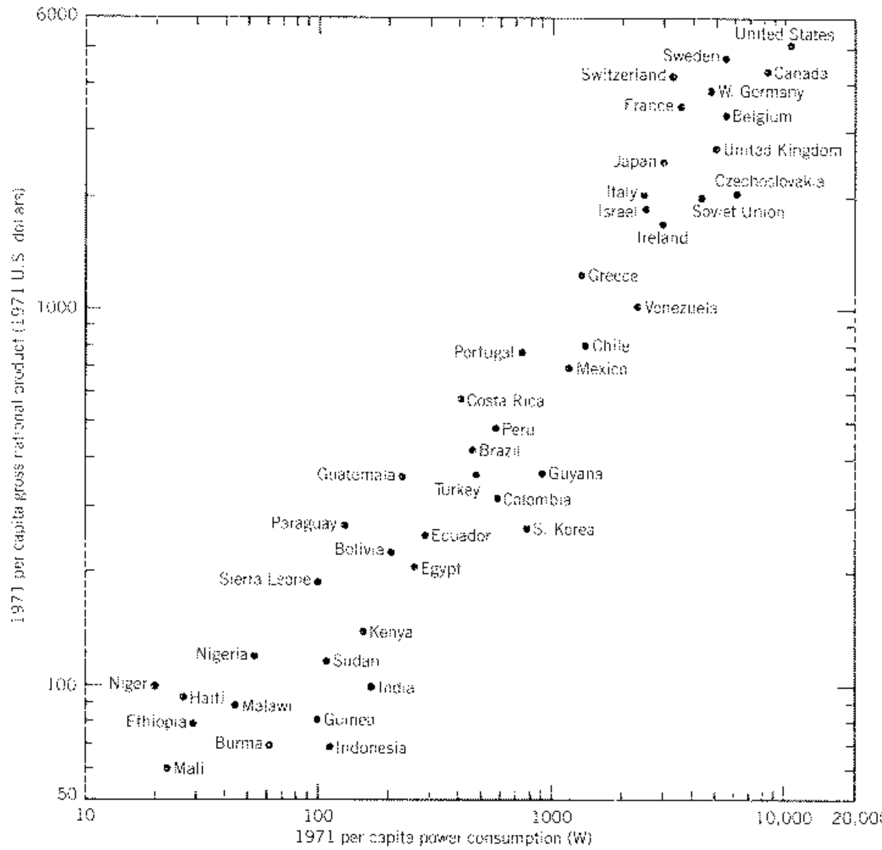
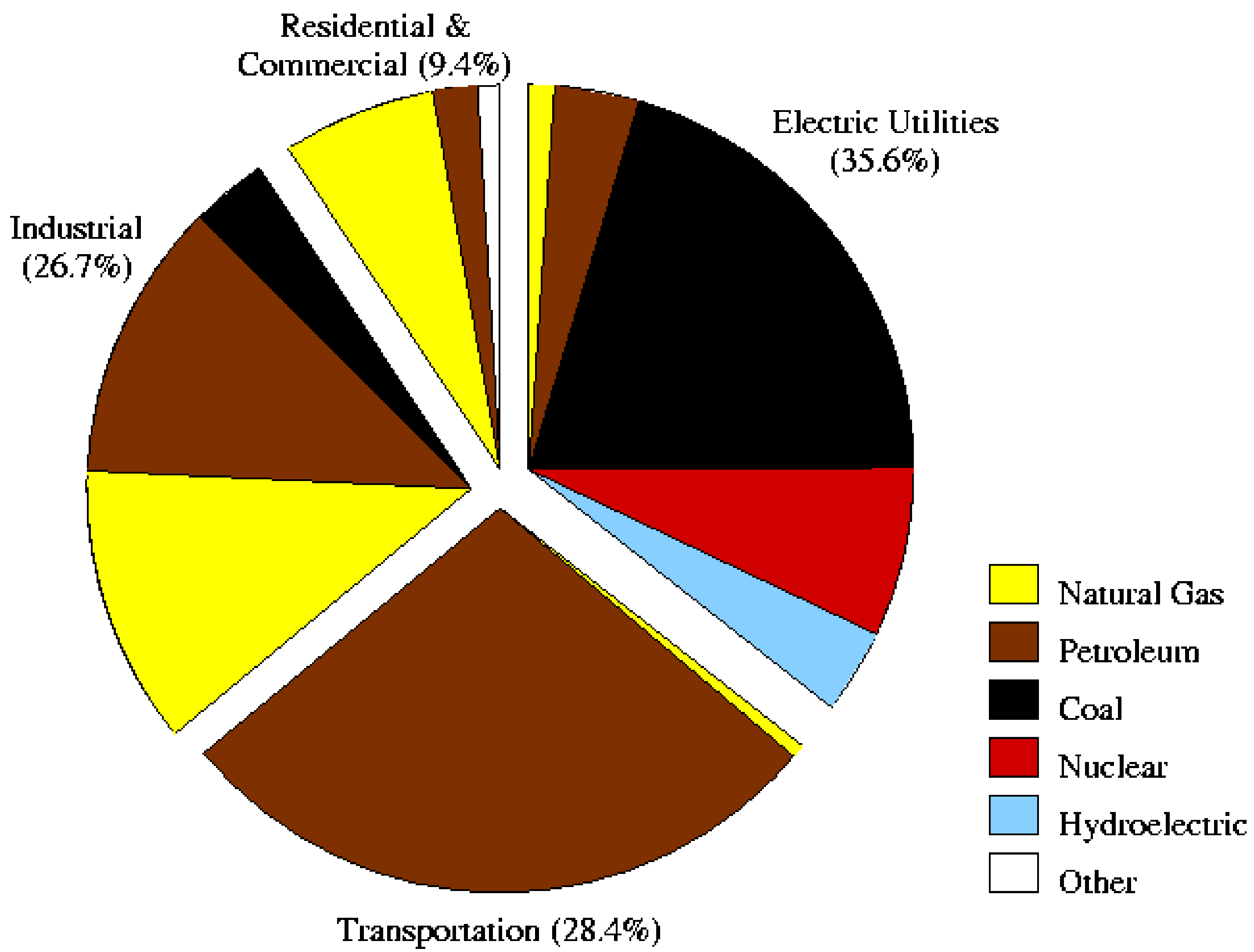


Figure 1–14.
Per capita gross national product and average per capita power consumption for various countries of the world in 1971. This does not include the energy in the food that is consumed.

Energy Use


Residential &
Commercial (9.4%)
Electric Utilities
(35.6%)
Industrial
(26.7%)
Transportation (28.4%)
Natural Gas
Petroleum
Coal
Nuclear
Hydroelectric
Other

Oil Production in the US has peaked

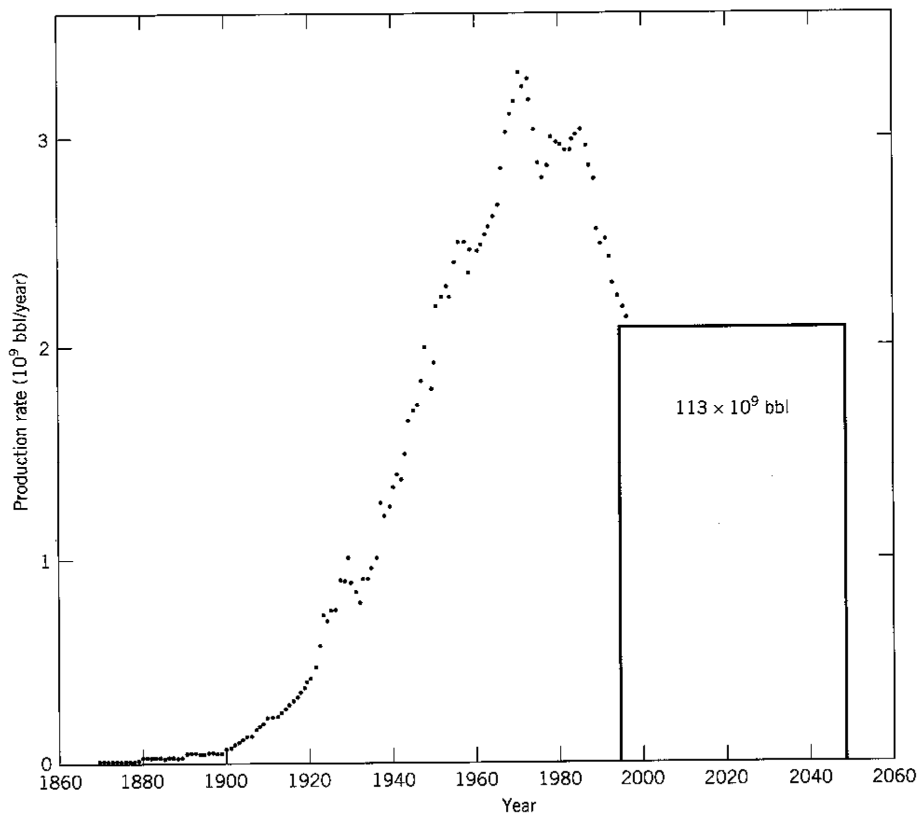
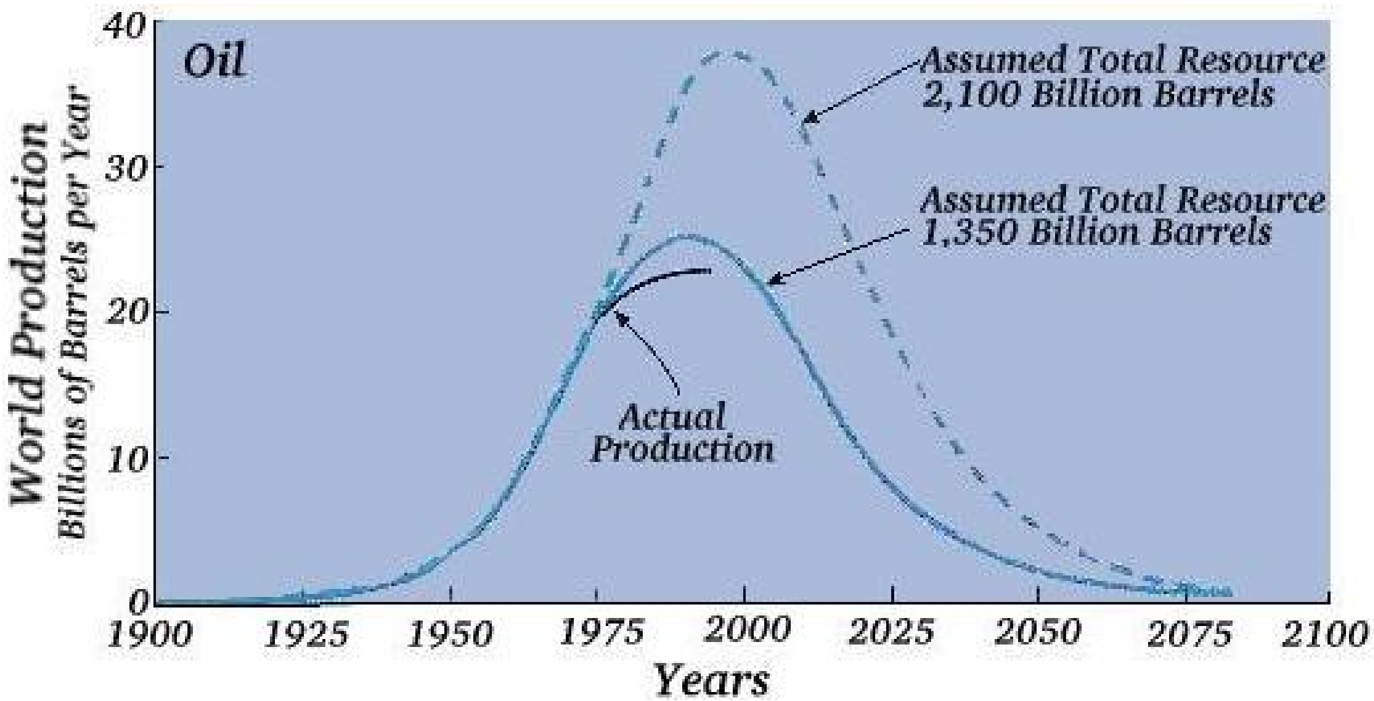
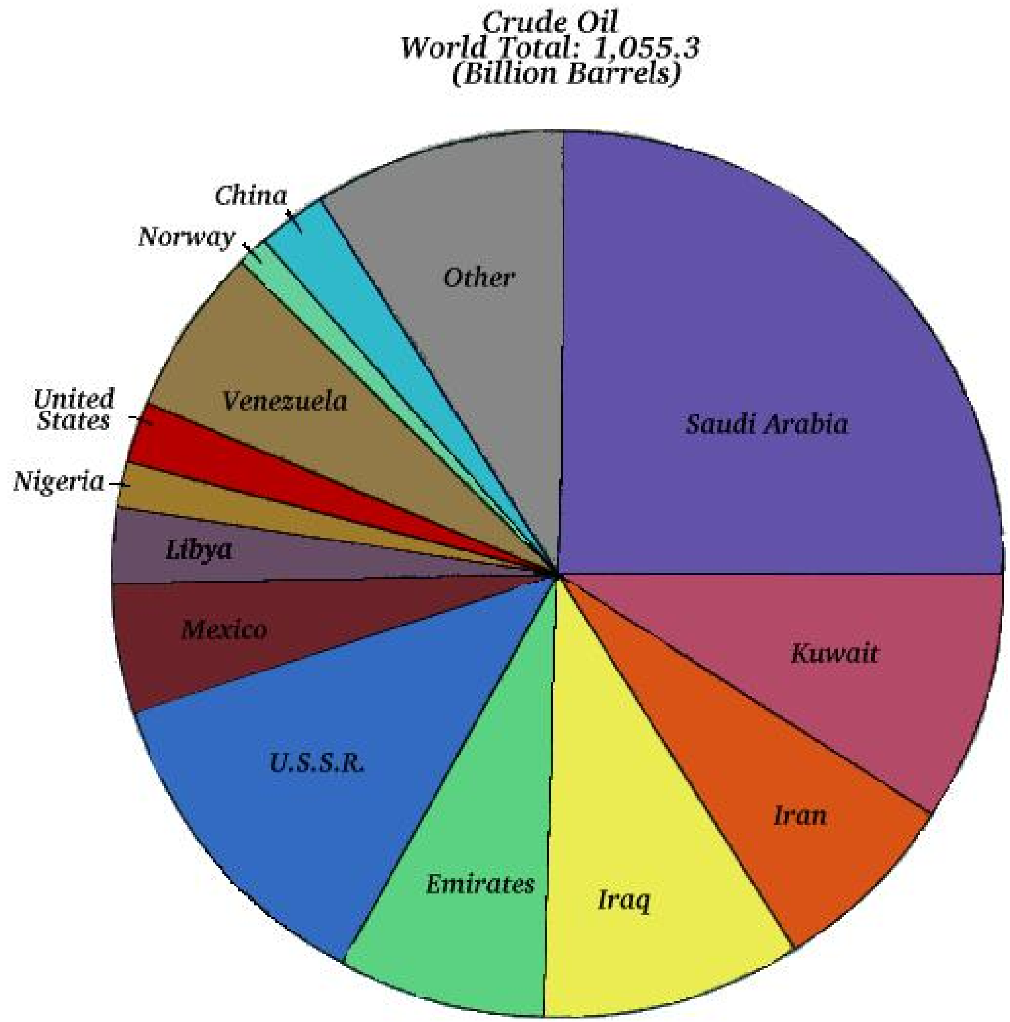


Figure 2.2 Annual petroleum production in the United States, including Alaska, since 1860. The rectangle at the right has an area representing the 113 billion barrels estimated to be remaining for future production.

World production is close to peaking



World Oil Resources



Alternatives to oil

Coal

Nuclear Energy

- Fission
- Fusion

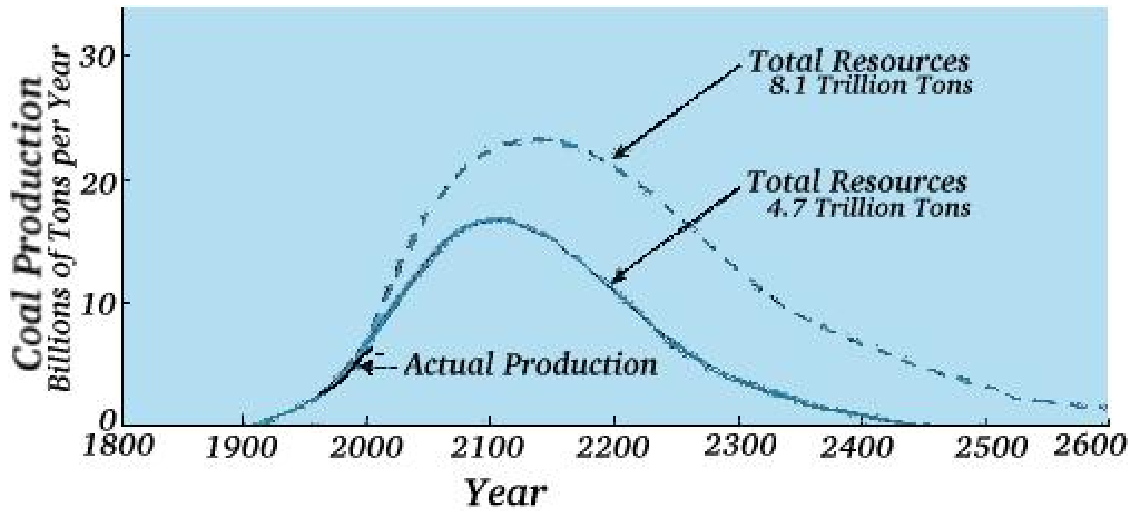
Hydroelectric

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 $2x10^{17}$ 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.

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

Estimate

average light intensity – 200 W/m^2
efficiency of solar collector 20%
cost per kwhr \$0.10
lifetime of the solar collector 20 yr.

$$0.2kW(0.2)(\frac{24hr}{day})(\frac{365day}{yr})(20yr)(\frac{\$0.1}{kwhr})$$

$$= \$700$$

may be reasonable for some locations.

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.