Physics 140– Exam I
February 21, 2007
Prof. Karin M. Rabe

Your name sticker

with exam code

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1. The exam will last until 4:00 p.m. All cell phones must be turned off. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Identification Number.
4. Enter 140 under COURSE, and leave SEC blank.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator (not a cell phone) and your one-sided 8.5 inch x 11.0 inch information sheet. Detach the last page with the FIGURE and table of conversions for convenient reference during the exam.
7. There are 2 written (W1 and W2) and 18 multiple-choice questions (1-18) on the exam. For each multiple-choice question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, hand in the multiple-choice answer sheet and the cover page of the exam with the answers to the two written questions. Retain the rest of the exam for future reference and study.
8. Before starting the exam, make sure that your copy contains all 20 questions (W1,W2, and 1-18). Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.

Useful Information

Be sure to quickly scan through all the questions in the exam before beginning in earnest. You may want to do the easy ones first. Some of the questions may be related to each other, so you may want to do them together. Don't assume that a longwinded question is necessarily a difficult one.

To convert a fraction into %, multiply by 100. For example, 1/5 = (1/5)100% = 20%

If a quantity x changes to y, then the percentage change is $100(y-x)/x$ %. For example, if the price of a gizmo was 20 and became 25, the change is (100(25-20)/20)% = 25%

1. Which of the following is NOT a unit of energy?

   a) Btu b) Joule c) kW d) kWh
   e) calorie

2. REFER TO THE FIGURE! From 1990 to 1991, CO_2 emissions decreased in

   a) China
   b) India
   c) the United States and Europe
   d) None of the 4 regions
   e) Europe only

3. Which of the following statements is FALSE?

   a) Combustion of hydrocarbons produces carbon dioxide, water, light and heat
   b) Natural gas is mostly methane (CH_4) and other light hydrocarbons.
   c) Coal was formed from the remains of animals and plants that lived millions of years ago.
   d) Current estimates show that the oil reserves in the ANWR fields could fully supply U.S. consumption at its present rate for about 5 years
   e) Petroleum is an important raw material for making plastics

4. If there were a carbon tax of $40 per ton of carbon dioxide, how much would the tax add to the price of a gallon of gasoline? (Recall that burning one gallon of gasoline produces 20 lbs of carbon dioxide).

   a) $0.65 b) $0.40 c) $800 d) $0.04
   e) $2.50

5. Which of the following best describes the energy conversions in a conventional fossil-fuel fired power plant?

   a) chemical → mechanical → thermal → electrical
   b) chemical → thermal → electrical → light
   c) nuclear → thermal → mechanical → electrical
   d) chemical → thermal → mechanical → electrical
   e) chemical → thermal → chemical

6. REFER TO THE FIGURE! The CO_2 emission of China in 1990 was approximately

   a) 2200 billion tons
   b) 2200 tons
   c) 2200 million tons
   d) 600 million tons
   e) 5000 million tons

7. REFER TO THE FIGURE! From 1980 to 2000, the CO_2 emission of India increased by

   a) 700 million kWh
   b) 700 million tons
   c) 700 tons
   d) 400 million tons
   e) 400 billion tons

8. Your neighbor drives 12,000 miles a year. Right now, he has a large SUV that gets 12 miles per gallon. If he switched to a smaller SUV that gets 16 miles per gallon, the annual carbon dioxide emission from the vehicle

   a) would go up by 33%
   b) would go up by 25%
   c) would go down by 25%
   d) would go down by 33%
   e) would remain unchanged

9. REFER TO THE FIGURE! From 1990 to 2003, the CO_2 emission of the US increased by approximately

a) 60% b) 16% c) 0% d) 100% e) 50%

10. The energy source that accounts for the highest percentage of electricity generation in New Jersey is

a) coal b) gas c) nuclear d) oil
e) renewables

11. Which of the following statements is FALSE?

a) Recent projections suggest that China will emit more CO_2 than the US starting around 2009
b) In addition to CO_2, burning coal also produces emissions, such as sulfur, nitrogen oxides and mercury, that can pollute the air and water.
c) Adverse effects of acid rain include changes in soil nutrient content, algal blooms and deterioration of marble buildings and statues
d) Compact fluorescent bulbs generate more heat than incandescent bulbs of the same brightness
e) During braking of most gasoline-powered cars, the kinetic energy of the moving car is converted to heat.

12. What is the power output required for a heater to melt 4.2 pounds of ice at 32 F into water at 32 F in 3.0 minutes? Recall that the heat of fusion of water is 140 Btu/lb.

a) 11,760 Btu b) 11,760 Btu/min c) 35,310 Btu/hr
d) 11,760 Btu/hr e) 35,310 Btu

13. REFER TO THE FIGURE! For the US to meet its Kyoto Protocol target of reducing emission of CO_2 to 7% below its 1990 level, its annual emission could be at most

a) 4,650 million tons
b) 7 million tons
c) 5,000 million tons
d) 4,650,000 tons
e) the 1990 CO_2 emission of China

14. Which of the following statements is FALSE?

a) Changing to compact fluorescent light bulbs would not significantly reduce US dependence on imported oil.
b) A typical fossil-fuel-fired power plant has an efficiency of about 70%
c) In a cogeneration plant, the waste heat produced in the generation of electricity is used for other purposes
d) The US is the country with the highest energy consumption
e) The efficiency of any energy conversion device can be at most 100%

15. What is the kinetic energy of a 1000 kg car moving at 100 km per hour?

a) 5,000,000 J b) 10,000,000 J c) 13,900 J
d) 386,000 kW e) 386,000 J

16. If 22% of energy consumption in the US is for residential use, and 47% of that is used for space heating, how many quads per year are used in the US for space heating? Assume that total energy consumption in the US is 100 quads per year.

a) 1034 b) 47 c) 10.3 d) 22 e) 25

17. Your television draws 8.2 W while in standby. How much would your TV add to your annual electric bill if it were in standby for the whole year? Assume that electrical energy costs \$0.12 per kWh.

a) \$8.20 b) \$1,051 c) \$8.62 d) \$0.08
e) \$0.36

18. REFER TO THE FIGURE! From the figure, one can conclude that in the period 1980-2004

a) the amount of CO_2 emitted by Europe was always more than that emitted by China
b) CO_2 emissions increase every year in every region
c) CO_2 emissions by China more than doubled in the period
d) there was no year when CO_2 emissions by Europe and the US were about the same
e) CO_2 emissions by Europe were at their lowest in 1980

W1: You want to convince your apartment manager to replace a 100 W incandescent light bulb in the lobby with a 27 W compact fluorescent bulb. The bulb is always on. If the compact fluorescent bulb costs $5.00 and electricity costs $0.12 per kWh, what is the payback time?

Answer:
With the 100 W bulb, it costs 100 W x 1 kW/1000 W x 24 hr/day x $0.12/kWh = $0.288/day

With the 27 W CF bulb, it costs 27 W x 1 kW/1000 W x 24 hr/day x $0.12/kWh = $0.078/day

Making the replacement saves ($0.288 - $0.078) = $0.21 / day

To recoup the $5.00 initial investment, it takes $5.00 x 1 day / $0.21 = 24 days

W2: The alternatives to fossil fuel we discussed in class each have positive and negative aspects. Taking two of these, nuclear energy and hydroelectric energy, briefly describe, for each, one substantive consideration in its favor and one against, using information discussed in class.

Nuclear +
Full credit answers include
It does not produce carbon dioxide emissions
It produces less air pollution than burning coal.
Much more energy is obtained per pound of fuel than for fossil fuels
Uranium ore reserves are adequate

Nuclear -
Full credit answers include
Safety issues, including release of radioactivity into the environment; accidents
Security issues, including possible proliferation of weapons technology
The high cost of building a plant
The forty-year lifetime of a plant

Hydroelectric +
Full credit answers include
It does not produce carbon dioxide emissions
It does not produce air pollution
It is renewable

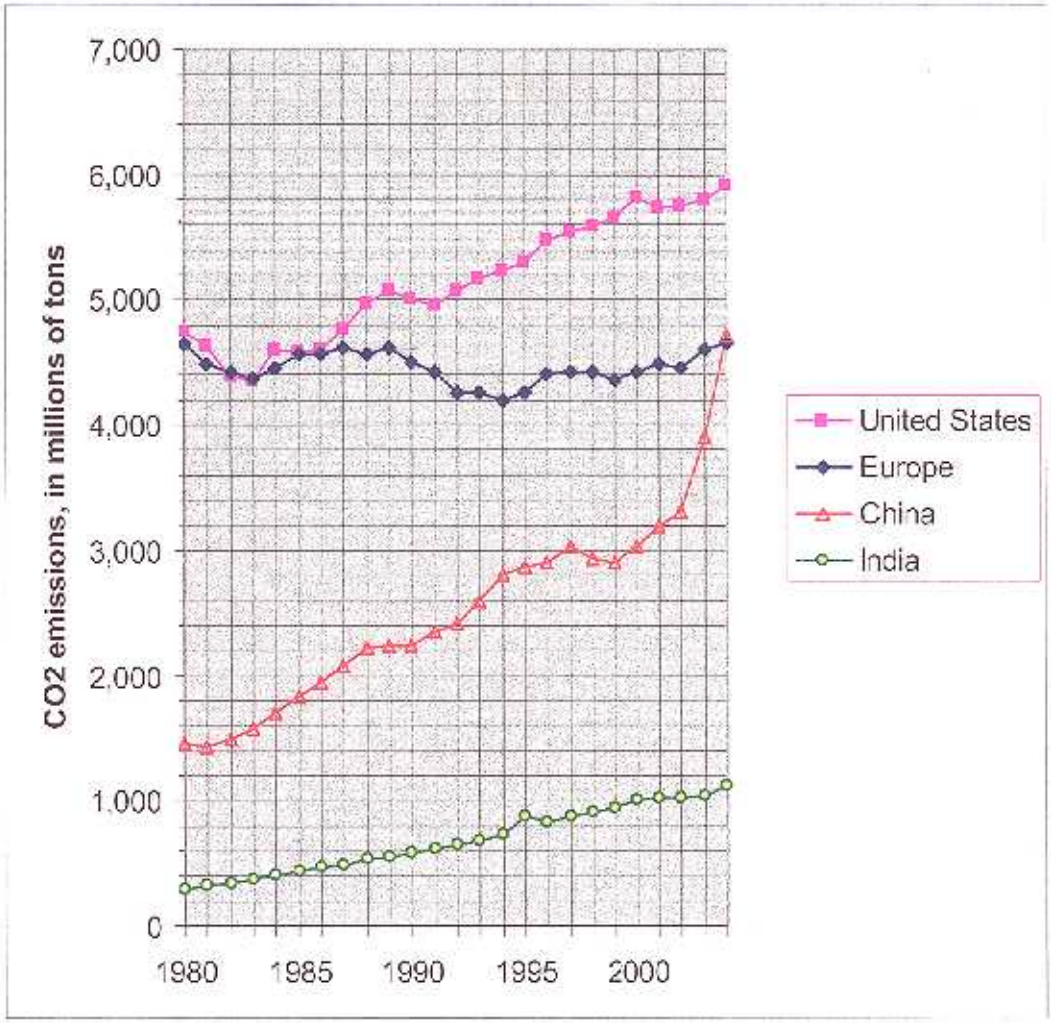
Hydroelectric –
Building of large dams has a major impact on ecosysems and displaced human populations
Sites appropriate for building large dams are limited

Conversions
1 ton = 2000 lbs
1 Btu = 1055 J = 252 cal
1 kWh = 3413 Btu
1 W = 1 J/s = 3.41 Btu/h
1 kW = 1000 W
1 quad = 293 billion kWh

Metric prefixes
Kilo (k) = 10^3 (one thousand)
Mega (M) = 10^6 (one million)
Giga (G) = 10^9 (one billion)

Energy content of various fuels
1 barrel (42 gallons) of crude oil = 5,800,000 Btu
1 gallon of gasoline = 124,000 Btu
1 gallon of heating oil = 139,000 Btu
1 cubic foot of natural gas = 1,026 Btu
1 pound of coal = 10,000 Btu

More useful information
1 Btu will raise the temperature of 1 lb of water by 1°F
US oil consumption is a little over 7 billion barrels per year
Kinetic energy = $(1/2)mv^2$
Potential energy = mgh
1 J = 1 kg m^2/s^2
20 lbs of CO_2 is produced on burning 1 gal of gasoline



Annual carbon dioxide emissions of the US, Europe, China and India from 1980-2004, in millions of tons