

**Physics/Global Studies 280**  
**Nuclear Weapons, Nuclear War, and Arms Control**

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**Midterm Examination**  
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Full Name \_\_\_\_\_

UIUC ID No. \_\_\_\_\_

This is a closed book examination—you are not to consult any materials other than the exam itself, or any person. Giving or receiving unauthorized help is a violation of the University's rules on academic integrity.

- You have the full exam period (90 minutes) to complete it.
- Answer all the questions on all 10 topics. The total point value of each topic is indicated by a boldface number in square brackets, e.g., **[15]**.
- The point value of each question within a topic is indicated by a boldface number in square brackets, e.g., **[2]**.
- Write your answers in the spaces provided below each question. *Do not submit any additional pages.* If you need more room, write on the back of the preceding page.
- To receive full credit for definitions, give numbers where relevant.

Scores

1. _____ <b>[15]</b>	6. _____ <b>[15]</b>
2. _____ <b>[15]</b>	7. _____ <b>[15]</b>
3. _____ <b>[15]</b>	8. _____ <b>[15]</b>
4. _____ <b>[15]</b>	9. _____ <b>[15]</b>
5. _____ <b>[15]</b>	10. _____ <b>[15]</b>

Total \_\_\_\_\_**[150]**

**1. The Unique Power of Nuclear Weapons [15]**

- (a) About how many times more powerful is a nuclear bomb than a high-explosive bomb of the same mass? [3]

To answer the following questions, circle the right answer.

- (b) If a 10 kiloton nuclear bomb were exploded in midtown Manhattan [4]

i. Roughly how many people could be killed immediately?

10                                      30,000                                      3,000,000

ii. Roughly how large an area would be reduced to rubble?

0.001 square km                      10 square km                      300 square km

- (c) If a 1 Megaton nuclear bomb were exploded in midtown Manhattan [4]

i. Roughly how many people could be killed immediately?

10                                      30,000                                      3,000,000

ii. Roughly how large an area would be reduced to rubble?

0.001 square km                      10 square km                      300 square km

- (d) If a radiological truck bomb were exploded in midtown Manhattan [4]

i. Roughly how many people could be killed immediately?

10                                      30,000                                      3,000,000

ii. Roughly how large an area would be reduced to rubble?

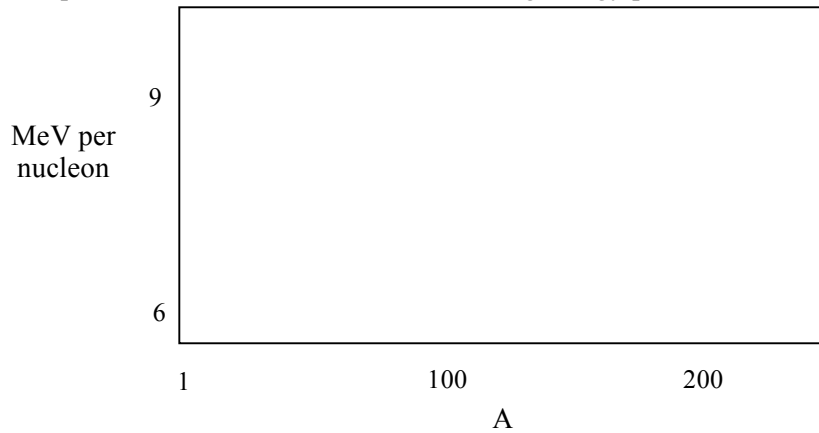
0.001 square km                      10 square km                      300 square km

**2. Early History of Nuclear Weapons [15]**

- (a) What country dropped the first nuclear weapon used in World War II? [1]
- (b) What city was destroyed by the first nuclear weapon used in World War II? [1]
- (c) What special nuclear material (nuclide) was used in this weapon? [1]
- (d) What technology was used to obtain this nuclear material? [1]
- (e) What was the initial geometry of this nuclear material inside the weapon? [1]
- (f) How was it assembled quickly enough to produce a nuclear explosion? [1]
- (g) Was this design tested before it was used? [1]
- (h) What country dropped the second nuclear weapon used in World War II? [1]
- (i) What city was destroyed by the second nuclear weapon used in World War II? [1]
- (j) What special nuclear material (nuclide) was used in this weapon? [1]
- (k) What technology was used to obtain this nuclear material? [1]
- (l) What was the initial geometry of this nuclear material inside the weapon? [1]
- (m) How was it assembled quickly enough to produce a nuclear explosion? [1]
- (n) Was this design tested before it was used? [1]
- (o) What country first successfully tested a true thermonuclear weapon? [1]

**3. Physics of Nuclear Weapons [15]**

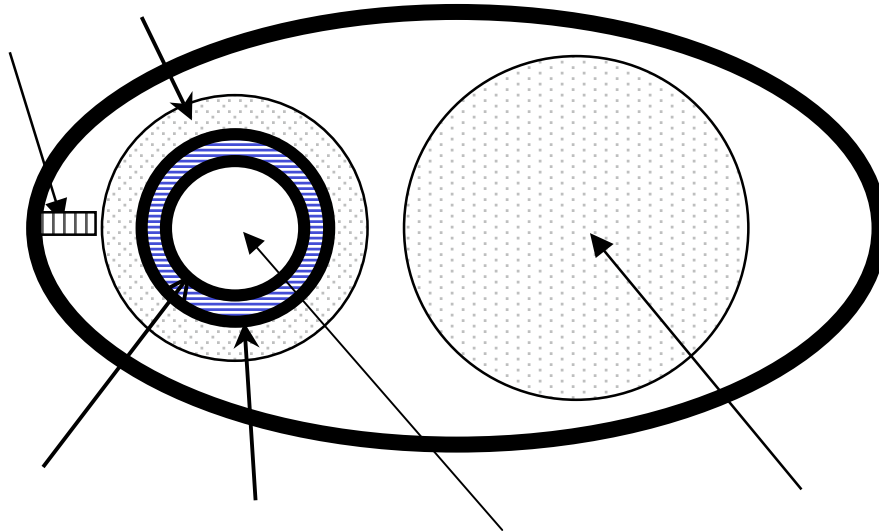
- (a) In the panel below, sketch the curve of binding energy per nucleon from  $A=1$  to  $A=240$ . [2]



- (b) What are the two fundamental forces responsible for the shape of this curve? [2]
- (c) Is there any fundamental limit to the yield of a fusion weapon? [1]
- (d) What is the definition of a fissile nuclide? [1]
- (e) What is the definition of a fissionable but not fissile nuclide? [1]
- (f) Which of these two types of nuclide is required to make a nuclear bomb? [1]
- (g) What is the difference between spontaneous and induced fission? [1]
- (h) List two properties of reactor-grade plutonium that would interfere with its use as a nuclear explosive. [4]
- i.
  - ii.
- (i) Is it possible to make a functioning a nuclear weapon using reactor-grade plutonium? [2]

#### 4. Nuclear Weapon Designs [15]

Shown below is a schematic diagram of a modern nuclear weapon.



(a) Number the arrows in the diagram above from 1 to 6 to indicate the locations of the following major components: (1) the pit, (2) the tamper/reflector, (3) the boost gas (at the time the weapon is detonated), (4) the high-explosive lens assembly, (5) the neutron-emitting initiator, (6) the secondary. [6]

(b) Explain in one sentence why this design is known as a “fission, fusion, fission” design. [3]

(c) Answer each of the following questions in a single sentence. [4]

i. What is the purpose of the initiator?

ii. How does it achieve this purpose?

iii. How is the yield of the primary “boosted”?

(d) Several significant nuclear weapon design challenges must be overcome before a nuclear device can be reliably delivered as a warhead on a long-range ballistic missile. List two. [2]

i.

ii.

**5. Terrorism [15]**

(a) Give a one-sentence definition of each of the following terms: **[4]**

i. Terrorism

ii. State terrorism

iii. State-sponsored terrorism

iv. War terrorism

(b) Answer the following questions in one sentence: **[3]**

i. What is the standard definition of “war”?

ii. Why is the phrase “war on terror” nonsensical?

iii. Why is the phrase “war on terrorism” nonsensical?

(c) Richardson argues that a “lethal cocktail” of three factors produces terrorism. List them. **[6]**

i.

ii.

iii.

(d) Answer the following questions, using as your basis the historical record. **[2]**

i. Are the long-term objectives of terrorists generally similar across groups, or different?

ii. Are the immediate objectives of terrorists generally similar across groups, or different?

**6. Countering Terrorism and Insurgency [15]**

(a) According to Richardson, terrorists are motivated by three immediate objectives, which she calls “the three R’s”. List them and give a one-sentence definition of each. [6]

i.

ii.

iii.

(b) What are the three standard phases in an inexperienced nation’s reaction to terrorism? [3]

i.

ii.

iii.

(c) List any three of the “Six Rules for Counteracting Terrorism” discussed by Richardson. [3]

i.

ii.

iii.

(d) How many troops are necessary to defeat an insurgency? [3]

i. About how many troops are needed per 100,000 inhabitants to defeat an insurgency, according to the current U.S. Army Field Manual?

ii. According to this rule of thumb, how many troops would be needed to defeat the current insurgency in Iraq?

iii. Approximately how many U.S. and coalition troops are currently in Iraq?

**7. Effects of Nuclear Explosions [15]**

- (a) By what fraction is the energy of a pure fission bomb reduced (compared to its intended yield) if the fission process ends one generation (0.01 microseconds) earlier than intended? [1]
- (b) After the first 100 microseconds, a nuclear explosion depends on (circle all that apply): [2]
- |                  |                    |                     |                           |
|------------------|--------------------|---------------------|---------------------------|
| The energy yield | The type of weapon | The delivery method | The fissile material used |
| The time of day  | The weapon casing  | The ambient medium  | The high explosive used   |
- (c) What is the definition of an air burst? [1]
- (d) What is the definition of a surface burst? [1]
- (e) Which produces more radioactive fallout? [1]
- (f) Why does it produce more radioactive fallout? [1]
- (g) Would a significant quantity of radioactivity escape if a 100-kiloton earth-penetrating nuclear warhead were detonated at the maximum depth it could reach? [1]
- (h) List one example of ionizing radiation and one example of non-ionizing radiation. [2]
- Ionizing radiation
  - Non-ionizing radiation
- (i) State in one sentence the general effect of non-ionizing radiation on matter. [1]
- (j) State in one sentence the most damaging effect of ionizing radiation on matter. [1]
- (k) In the list below, circle the types of radiation-induced DNA mutations that *could* cause a cell to malfunction. [3]
- |        |          |          |             |          |
|--------|----------|----------|-------------|----------|
| Silent | Missense | Nonsense | Frame-shift | Deletion |
|--------|----------|----------|-------------|----------|



**8. Delivering Nuclear Weapons – I [15]**

- (a) Jet and rocket engines burn (oxidize) fuel. State in a word or two where each of these two types of engines get their fuel and oxidizer when they are powering a vehicle in flight. [4]

Source of fuel

Source of oxidizer

- i. Jet
- ii. Rocket
- (b) The flight of a long-range ballistic missile lasts about 30 minutes whereas the flight of a long-range cruise missile lasts several hours. What is the main effect that keeps each type of missile “up” during most of its flight? [2]

i. Ballistic missile:

ii. Cruise missile:

- (c) Decode the following acronyms for delivery systems and give their ranges. [4]

i. ICBM

ii. SRBM

iii. MRBM

iv. IRBM

- (d) Can a ballistic missile be recalled after it has been launched? (Yes or No) [1]

- (e) Can a cruise missile be recalled after it has been launched? (Yes or No) [1]

- (f) Answer the following questions about the ranges of modern cruise missiles.

i. About how many kilometers can the longest-range nuclear-tipped cruise missiles fly? [1]

ii. Which has a longer range: a cruise missile fitted with a nuclear warhead or a similar cruise missile fitted with a conventional warhead? [1]

- (g) Which of the following containers has a length and diameter closest to those of a modern long-range cruise missile? (Circle one.) [1]

a grain silo

the tank of a gasoline truck

the tank of a home water heater

**9. Delivering Nuclear Weapons – II [15]**

- (a) Five technological advances that made cruise missiles powerful and militarily effective weapons were discussed in class. List any three of them. [3]

i.

ii.

iii.

- (b) List the four phases of the flight of a MIRVed ICBM and the approximate duration of each phase in minutes. [8]

PHASE	DURATION (MINUTES)
i.	
ii.	
iii.	
iv.	

Answer the following two questions in a phrase or sentence, as appropriate.

- (c) List two methods for delivering nuclear weapons that are among those the U.S. intelligence community assesses are most likely to be used to attack the territory of the U.S. [2]

i.

ii.

- (d) List two reasons an attacker is likely to prefer one of these methods over other methods. [2]

i.

ii.

**10. Current Events [15]**

- (a) In January 2008, British Prime Minister Gordon Brown urged the international community to take several steps to reduce the threat of nuclear weapons. Indicate the steps he advocated by writing Yes or No next to each of the actions listed below. [3]
- i. Reduce the nuclear arsenals of the official nuclear weapon states with the goal of worldwide nuclear disarmament.
  - ii. Bring the Comprehensive Nuclear Test Ban Treaty into force.
  - iii. Negotiate a treaty that would prohibit the production of nuclear material for weapons and ban enrichment and reprocessing activities outside of international safeguards.
- (b) The United States is currently seeking to deploy a midcourse missile defense system in Europe. Answer the following questions in a phrase or sentence, as appropriate: [6]
- i. What is the threat the United States says it is seeking to counter using this system?
  - ii. What technology is the United States planning to use in this system?
  - iii. What part of this system is the United States seeking to deploy in Poland?
  - iv. What part of this system is the United States seeking to deploy in the Czech Republic?
  - v. Has this system been shown to be effective by tests conducted under realistic conditions?
  - vi. List one reason Russia has objected to the U.S. plan to deploy this system.
- (c) In February 2008, the United States attacked and destroyed the satellite USA-193 in low Earth orbit (LEO), demonstrating that it has anti-satellite (ASAT) capability. Answer the following questions in a phrase or sentence, as appropriate: [6]
- i. Which country is most dependent on the safe operation of its satellites?
  - ii. Is it easier or harder to destroy a satellite in LEO than an attacking warhead?
  - iii. What system did the United States use to destroy this satellite?
  - iv. What hazard did the United States say justified the destruction of this satellite?
  - v. What hazard was created by the destruction of this satellite?
  - vi. Other countries objected to this attack on several grounds. List one.