

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

Final Examination – v1

2008 May 8

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 (180 minutes) to complete it.
- Answer all the questions on all 15 topics. Each topic counts 20 points.
- 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. _____ [20]	6. _____ [20]	11. _____ [20]
2. _____ [20]	7. _____ [20]	12. _____ [20]
3. _____ [20]	8. _____ [20]	13. _____ [20]
4. _____ [20]	9. _____ [20]	14. _____ [20]
5. _____ [20]	10. _____ [20]	15. _____ [20]

Total _____**[300]**

1. Physics of nuclear weapons – I [20]

- (a) What is the definition of a fissile nuclide? [2]
- (b) What is the definition of a fissionable but not fissile nuclide? [2]
- (c) Which of these two types of nuclide is required to make a nuclear bomb? [2]
- (d) What isotope of uranium is most common in nature? Is it fissile or nonfissile? [4]
- (e) Define the following special nuclear materials: [10]
- i. low-enriched-uranium –
 - ii. highly-enriched uranium –
 - iii. weapon-grade uranium –
 - iv. reactor-grade plutonium –
 - v. weapon-grade plutonium –

2. Physics of nuclear weapons – II [20]

- (a) What is the standard current technology for producing weapon-grade [4]
- i. uranium?

 - ii. plutonium?
- (b) About how many times more powerful is a nuclear bomb than a high-explosive bomb of the same mass? [2]
- (b) By what fraction is the energy of a pure fission bomb reduced (compared to its intended yield) if fissioning ends one generation (0.01 microseconds) earlier than intended? [2]
- (c) Is there any fundamental limit to the yield of a fusion weapon? [2]
- (d) List two properties of reactor-grade plutonium that interfere with its use as a nuclear explosive. [4]
- i.

 - ii.
- (e) Is it possible to make a functioning a nuclear weapon using reactor-grade plutonium? [2]
- (f) Several significant design challenges must be overcome before a nuclear device mounted on a long-range ballistic missile can be considered a reliable military weapon. Name two. [4]
- i.

 - ii.

3. Nuclear weapon effects [20]

- (a) List the four principal damaging effects that would be experienced by a person located 3 miles from a 1 Mt airburst, in the order they would be experienced. Describe the physical cause of each effect and its main consequence for a person exposed to it. **[8]**

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- (b) What is a conflagration? **[2]**

- (c) What is a firestorm? **[2]**

To answer the following questions, circle the right answer.

- (d) 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

- (e) 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

4. Delivering nuclear weapons – I [20]

- (a) Jet and rocket engines burn (oxidize) fuel. State in a word or two where the following types of engines get their fuel and oxidizer when they are powering a vehicle in flight. [6]

Location of fuel

Location of oxidizer

i. Jet aircraft

ii. Liquid-propellant rocket

iii. Solid-propellant rocket

- (b) Where and how big is the combustion chamber in the following types of rockets. [4]

ii. Liquid-propellant rocket

iii. Solid-propellant rocket

- (c) Decode the following acronyms for delivery systems and give their ranges. [8]

i. ICBM

ii. SRBM

iii. MRBM

iv. IRBM

- (d) Can a solid-propellant rocket engine be shut down after it has been started? (Yes or No) [2]

5. Delivering nuclear weapons – II [20]

- (a) Can a nuclear-armed bomber be recalled after it has been launched? (Yes or No) [2]
- (b) Can a nuclear-armed cruise missile be recalled after it has been launched? (Yes or No) [2]
- (c) Can a nuclear-armed ballistic missile be recalled after it has been launched? (Yes or No) [2]
- (d) 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? [2]
 - ii. Which has a longer range: a cruise missile fitted with a nuclear warhead or a similar cruise missile fitted with a conventional warhead? [2]
- (e) Which of the following containers has a length and diameter closest to those of a modern long-range cruise missile? (Circle one.) [2]
- a grain silo the tank of a gasoline truck the tank of a home water heater

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

- (f) 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. [4]
- i.
 - ii.
- (g) List two reasons an attacker is likely to prefer one of these methods over other methods. [4]
- i.
 - ii.

6. War and terrorism [20]

(a) Give precise, one-sentence definitions of each of the following terms: **[8]**

i. Terrorism

ii. State terrorism

iii. State-sponsored terrorism

iv. War terrorism

(b) Answer the following questions in one sentence: **[6]**

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.

8. North Korea's nuclear program [20]

- (a) By 1994 North Korea had reprocessed enough plutonium from its nuclear reactor at Yongbyon to make about how many nuclear weapons? [2]
- (b) In 2002, the plutonium North Korea had reprocessed was still under IAEA safeguards, in accordance with the 1994 Agreed Framework, and was unavailable for use in nuclear weapons. That year President George W. Bush labeled North Korea a member of an “axis of evil”, canceled nuclear negotiations with it, and ended the 1994 Agreed Framework. List two of the several important unilateral actions North Korea took in response in 2002–2003. [2]
- i.
- ii.
- (c) By 2005, North Korea was thought to have reprocessed enough plutonium to make about how many nuclear weapons? [1]
- (d) In 2005, North Korea announced that it has nuclear weapons. Does the outside world have any independent evidence that North Korea now has a nuclear capability? [1]
- (e) In response to North Korea's actions, the U.S. and four other nations engaged North Korea in talks about ending its nuclear weapon program. List the other four nations involved: [4]
- (f) Mark by a “P” the actions North Korea promised and by a “C” those it has completed: [8]
- Dismantlement of its nuclear facilities and elimination of its nuclear weapons and materials
A complete list of all its nuclear programs
Shutdown of its nuclear facilities at Yongbyon and elsewhere
Dismantlement of its nuclear facilities at Yongbyon
- (g) List two recent developments that have complicated completion of the agreed actions. [2]
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9. Iran's nuclear program [20]

- (a) When reading a National Intelligence Estimate, how should one interpret the phrase “high confidence”? (Circle one option below.) [1]

The available information is plausible but uncertain.	Information is high-quality, a solid judgment was made.	Information is fragmented, significant concerns exist.
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- (b) When reading a National Intelligence Estimate, how should one interpret the phrase “moderate confidence”? (Circle one option below.) [1]

The available information is plausible but uncertain.	Information is high-quality, a solid judgment was made.	Information is fragmented, significant concerns exist.
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- (c) Did Iran sign the Nuclear Nonproliferation Treaty (NPT)? (Yes or No?) [1]
- (d) Is Iran currently a party to the NPT? [1]
- (e) Does the NPT allow Iran to acquire nuclear materials and civilian nuclear technology? [1]
- (f) Did Iran violate the NPT? [1]
- (g) What fissile material is Iran currently seeking to produce? [1]
- (h) What year did Iran begin its fissile material production program? [1]
- (i) Did it announce this program openly or conduct it in secret? [1]
- (j) What technology is Iran currently using to produce this fissile material? [1]
- (k) From what source did Iran originally obtain this technology? [1]
- (l) What advance in this technology did Iran recently announce? [1]
- (m) Iran's Defense Minister was prominent in this announcement. Why is this surprising? [1]
- (n) Does Iran currently have an operating nuclear reactor? [1]
- (o) Are all of Iran's nuclear facilities currently under full IAEA Safeguards? [1]
- (p) What is the earliest date the U.S. intelligence community estimates that Iran could make a nuclear weapon? The more likely date? [2]
- Earliest: _____ • More likely: _____
- (q) Why does a civilian nuclear program complicate detection of a military nuclear program? [1]
- (r) Could the longest-range nuclear-capable ballistic missile Iran has tested reach the U.S.? [1]
- (s) Could it reach Israel? [1]

10. History of ballistic missile threats and defense programs [20]

- (a) Explain in one sentence “the fallacy of the last move”.
- (b) When did the USSR first demonstrate that it had a long-range ballistic missile?
- (c) When did the United States first begin work on a defense against ballistic missiles?
- (d) About how much, in 2008 dollars, has the United States spent to date on missile defenses?
- (e) When did the United States first declare a missile defense system “operational”? [1]
- (f) How long did that system remain operational? [2]
- (g) About how much did that system cost, in current U.S. dollars? [2]
- (h) What was the primary argument the Soviet Union made against the “Star Wars” program?
- (i) Some experts argued that the “Star Wars” program violated what treaty?
- (j) At the 1986 Reykjavik Summit, President Reagan rejected what arms control offer by Secretary Gorbachev to preserve his freedom to deploy “Star Wars” weapons before 1995?
- (k) List two important lessons learned from the failure of the Star War’s program:
 - i.
 - ii.
- (l) As explained in the documentary “Missile Wars”, the 1995 NIE on the missile threat to the U.S. assessed that “no country, other than the major declared nuclear powers, will develop or otherwise acquire a ballistic missile in the next 15 years that could threaten the contiguous 48 states or Canada.” Republicans charged that the report was distorted for what purpose?
- (m) An independent, blue-ribbon panel investigated this charge and concluded what?

Congressional Republicans then created a new panel on the missile threat to the United States. This panel used a criterion fundamentally different from all previous intelligence assessments.
- (n) What was this panel’s criterion?
- (o) What was this panel’s assessment?
- (p) What is the range of the longest-range missile North Korea successfully tested by 2008?
- (q) What is the range of the longest-range missile that Iran has successfully tested by 2008?
- (r) Does Iran currently have a solid-propellant missile program?
- (s) What is the current annual cost of the U.S. program to defend against ballistic missiles?

11. Current and proposed missile defense programs – I [20]

- (a) The current U.S. missile defense program is “capability based”. What does this mean? [3]
- (b) Underline the goals below that the current missile defense program seeks to achieve. [4]
- Defend the United States against ballistic missile attack
 - Defend the United States against cruise missile attack
 - Defend U.S. friends and allies against ballistic missile attack
 - Defend U.S. troops deployed abroad against ballistic missile attack
- (c) Are devices and technologies developed under the Star Wars program playing a major role in the current missile defense program? [1]
- (d) The United States is currently deploying a midcourse intercept defense system based in Alaska and California. [7]
- i. What threat is this system supposed to counter?
 - ii. What technology would this system use to attempt to intercept attacking warheads?
 - iii. How many hits did this system achieve in 12 tries?
 - iv. Were any of these tests conducted under realistic conditions?
 - v. List two countermeasures an adversary could use to defeat this system
 -
 -
 - vi. Is this system now fully operational?
- (e) The United States is currently seeking to deploy a similar midcourse intercept defense system in Europe. Answer the following questions in a phrase or sentence, as appropriate: [5]
- i. What threat is this system supposed to counter??
 - ii. What part of this system is the United States seeking to deploy in Poland??
 - iii. What part of this system is the United States seeking to deploy in the Czech Republic?
 - iv. Has this system been tested at all?
 - v. List one reason Russia has objected to the U.S. plan to deploy this system

13. Nuclear arms control – I [20]

- (a) According to the Law of Treaties, does a state that has signed a treaty have to comply with it before it goes into force. (Yes or No.) [1]
- (b) What is the difference between an Executive Agreement and a Treaty? [1]
- (c) What is horizontal proliferation"? [1]
- (d) What is vertical proliferation"? [1]
- (e) What does the Supreme National Interest clause allow a party to a treaty to do? [1]
- (f) Name of the first successful nuclear arms control treaty and list the date it was signed. [2]
- (g) What was its purpose? [1]
- (h) The 1968 Nuclear Nonproliferation Treaty (NPT) is essentially a grand bargain between the nuclear-weapon states and the non-nuclear-weapon states. State the main provision to which the nuclear-weapon state parties agreed. [2]
- (i) State the main provision to which the non-nuclear-weapon state parties agreed. [2]
- (l) Which of the following countries currently are *not* parties to the NPT? [circle them] [8]
Brazil China Pakistan India Iran Israel North Korea South Korea

14. Nuclear arms control – II [20]

- (a) What was the motivation for the Anti-Ballistic Missile Treaty (ABMT)? [1]
- (b) What was the basic thrust of the ABMT's provisions? [1]
- (c) When was the ABMT signed and which states signed it? [2]
- Date:
 - State parties:
- (d) What is the current status of the ABMT? [1]
- (e) Which treaty eliminated a whole category of nuclear weapon systems throughout the world, when was it signed, and which states are parties? [3]
- Name:
 - Date:
 - State parties:
- (f) What was the motivation for the Strategic Arms Reduction Treaty (START)? [1]
- (g) When was the START signed and which states signed it? [2]
- Date:
 - State parties:
- (h) What two main categories of weapons were restricted by START? [2]
- :
 - :
- (i) What is the current status of the START? [1]
- (j) What was the motivation for the Strategic Offensive Reductions Treaty (SORT)? [1]
- (k) When was the SORT signed and which states signed it? [2]
- Date:
 - State parties:
- (l) On what date does SORT enter into force? [1]
- (m) On what date does SORT expire? [1]
- (n) Does the SORT have an verification provisions? (Yes or No?) [1]

15. Possible future measures to reduce the threat of nuclear weapons [20]

(a) In our last class we discussed ten unilateral steps the next president could take to bring U.S. nuclear weapons policy into line with current political realities and demonstrate to the rest of the world that the United States is serious about addressing the grave threat posed by nuclear weapons. List six of these steps: **[12]**

i.

ii.

iii.

iv.

v.

vi.

(b) In our last class we discussed six possible future nuclear arms control treaties that would reduce the threat posed by nuclear weapons. List any four of these and explain the purpose of each in a sentence or phrase: **[8]**

i.

ii.

iii.

iv.