

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

Final Examination

2009 May 15

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 fissionable nuclide? [2]
- (b) What is the definition of a fissile nuclide? [2]
- (c) What is the definition of a nuclear-explosive nuclide? [2]
- (d) Are all fissile nuclides nuclear-explosive? (Yes or No) [1]
- (e) Are all nuclear-explosive nuclides fissile? (Yes or No) [1]
- (f) What is the definition of a nuclear-explosive material? [2]
- (g) What isotope of uranium is most common in nature? Can it be used to make a bomb? [4]
- (h) Can plutonium be mined? (Yes or No?) [2]
- (i) What is the main reason weapons-grade HEU would be the nuclear explosive material of choice for countries or non-state groups with very low technological capability? [2]
- (j) What is one reason weapons-grade plutonium would be the nuclear explosive material of choice for countries with high technological capability? [2]

2. Physics of nuclear weapons – II [20]

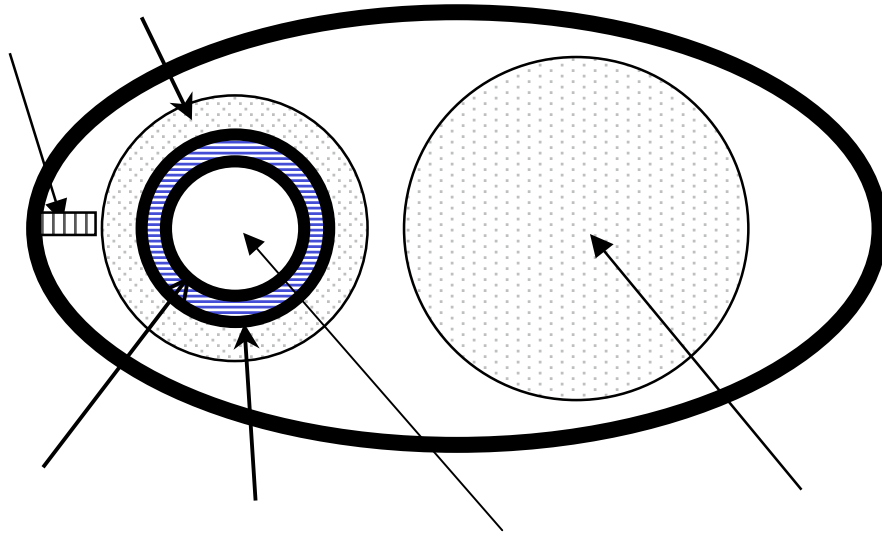
- (a) Define the following uranium materials in terms of the percentage of U-235: [6]
- i. low-enriched-uranium –
 - ii. weapons-usable HEU –
 - iii. weapons-grade HEU –
- (b) Define the following plutonium materials in terms of the percentage of Pu-239: [6]
- i. reactor-grade plutonium –
 - ii. fuel-grade plutonium –
 - iii. weapons-grade plutonium –
- (c) List the two main steps involved in producing weapons-grade plutonium: [4]
- i.
 - ii.
- (d) 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 explosions [20]

- (a) What is the definition of the neutron multiplication factor R in a configuration of nuclear material? [2]
- (b) What is the numerical value of the neutron multiplication factor R for [6]
- i. a sub-critical configuration of nuclear material –
 - ii. a critical configuration of nuclear material –
 - iii. a super-critical configuration of nuclear material –
- (c) List two things that can happen to a neutron released in a fission event in nuclear-explosive material that will prevent it from causing a subsequent fission event. [4]
- i.
 - ii.
- (d) List two properties of reactor-grade plutonium that complicate its use as a nuclear-explosive material. [4]
- i.
 - ii.
- (e) Is it possible to make a functioning a nuclear bomb using reactor-grade plutonium? [2]
- (f) Is there any fundamental limit to the yield of a fusion bomb? [1]
- (g) About how many times more powerful is a nuclear bomb than a high-explosive bomb of the same mass? [1]

4. Modern thermonuclear weapons [20]

- (a) Shown below is a simplified schematic diagram of a true thermonuclear weapon. Number the arrows in the diagram from 1 to 6 to indicate the locations of the following major weapon components: [1] the neutron-emitting initiator, [2] the high-explosive lens assembly, [3] the tamper/reflector, [4] the hollow shell (“pit”) made of nuclear-explosive material, [5] the boost gas (present when the weapon is detonated), and [6] the fusion packet. [6]



Answer the following questions in a single sentence.

- (b) What is the “primary” and why is it called this? [2]
- (c) What is the “secondary” and why is it called this? [2]
- (d) What is the function of the high-explosive lens assembly? [2]
- (e) What is the function of the tamper/reflector? [2]
- (f) What is the function of the initiator? [2]
- (g) What does the boost-gas do? [2]
- (h) What role does the bomb casing play if it is made of depleted uranium? [2]

5. Effects of a nuclear explosion [20]

- (a) About how many times more powerful is a nuclear bomb than a high-explosive bomb of the same mass? [1]
- (b) List the four principal harmful physical phenomena produced by a 1-Mt airburst in the order they would be experienced by a person located 3 miles from the center of the explosion. State the main harmful effect of each on a person exposed to them. [12]
- -
 -
 -
- (c) What harmful effect is much worse for a surface burst than for an air burst? [1]

To answer the following questions, circle the right answer.

- (d) If a 10-kiloton nuclear bomb were exploded in midtown Manhattan [2]
- 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 [2]
- 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
- (f) What is a conflagration? [1]
- (g) What is a firestorm? [1]

7. North Korea's nuclear and missile programs [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. [4]
- i.
 - ii.
- (c) By 2005, North Korea was thought to have reprocessed enough plutonium to make about how many nuclear weapons? [2]
- (d) North Korea has announced that it has nuclear weapons. Does the outside world have any independent evidence that North Korea does now have a nuclear weapon capability? [2]
- (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) Is North Korea currently participating in these “six-party” talks? [2]
- (g) North Korea has attempted to launch longer-range missiles three times. [4]
- What year was the most recent attempt?
 - How many of the attempts were successful?

8. Iran's nuclear and missile programs [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) What fissile material is Iran currently seeking to produce? [1]
- (d) What year did Iran begin its fissile material production program? [1]
- (e) Did it announce this program openly or conduct it in secret? [1]
- (f) What technology is Iran currently using to produce this fissile material? [1]
- (g) From what source did Iran originally obtain this technology? [1]
- (h) What advance in this technology did Iran announce last year? [1]
- (i) Iran's Defense Minister was prominent in this announcement. Why was this surprising? [1]
- (j) Is Iran currently a party to the NPT? [1]
- (k) Does the NPT allow Iran to acquire fissile materials and civilian nuclear technology? [1]
- (l) Did Iran violate the NPT? [1]
- (m) Does Iran currently have any operational nuclear reactors? [1]
- (n) Are all of Iran's nuclear facilities currently under full IAEA Safeguards? [1]
- (o) Why does a civilian nuclear program complicate detection of a military nuclear program? [1]
- (p) What is the earliest year the U.S. intelligence community estimates that Iran could make a nuclear weapon? The more likely years? [2]
- Earliest: _____ • More likely: _____
- (q) Could the longest-range nuclear-capable ballistic missile Iran has tested reach the U.S.? [1]
- (r) Could it reach Europe? [1]
- (s) Could it reach Israel? [1]

9. History of U.S. missile defense programs [20]

Each of the following questions are worth [1] point.

- (a) In what decade did the United States first begin work on a defense against ballistic missiles?
- (b) When did the United States first declare a missile defense system “operational”?
- (c) How long did that system remain operational?
- (d) About how much did that system cost, in current U.S. dollars?
- (e) What is the current annual cost of the U.S. program to defend against ballistic missiles?
- (f) About how much, in 2008 dollars, has the United States spent so far on missile defenses?
- (g) Explain in one sentence “the fallacy of the last move”.
- (h) Many experts argued that the “Star Wars” program violated which treaty?
- (i) At the 1986 Reykjavik Summit, to be able to test the “Star Wars” weapons system in space before 1996 President Reagan rejected what arms control offer by Secretary Gorbachev?
- (j) We discussed in class several important lessons that were learned from the failure of the Star War’s program. Explain any four of them in complete sentences.
 -
 -
 -
 -
- (k) 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?
- (l) 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.

- (m) What was this panel’s criterion?
- (n) What was this panel’s basic assessment?
- (o) What is the range in km of the longest-range missile North Korea has successfully tested?
- (p) What is the range in km of the longest-range missile that Iran has successfully tested?
- (q) Does Iran currently have a solid-propellant missile program?

10. 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) Circle the goals listed below that the George W. Bush administration sought to achieve with the current missile defense program. [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 any devices and technologies that were 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 ground-base midcourse intercept system to defend against ballistic missiles using interceptor rockets based in Alaska and California. [9]
- i. What threat is this system supposed to counter?
- ii. What technology would this system use to attempt to intercept attacking warheads?
- iii. Circle the number of times the *current* system has been tested:
0 3 7 11
- iv. Were any of these tests conducted under realistic conditions?
- v. List two countermeasures an adversary could use to defeat this system
- -
- vi. How many of the two tests planned for 2008 were conducted?
- vii. How many of the six goals for 2008 were achieved?
- viii. Is this system now considered operational?
- (e) The United States is currently seeking to deploy a similar midcourse intercept defense system in Europe. [3]
- i. What threat is this system supposed to counter?
- ii. Has this system been tested?
- iii. List one reason Russia has objected to the U.S. plan to deploy this system.

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

- (a) What was the main reason for interest in boost-phase intercept for missile defense? [1]
- (b) List three supposed advantages of a boost-phase intercept missile defense system compared to a midcourse-intercept system and state whether each is truly advantageous. [6]
- i.
 - ii.
 - iii.
- (c) List three major challenges that would confront a boost-phase intercept system. [6]
- i.
 - ii.
 - iii.
- (d) How much time would boost-phase interceptors have to reach target ICBMs, using missile detection and tracking systems that could be deployed within the next ten years? [1]
- (e) The APS Study Group estimated the number of space-based interceptors that would be required to counter a single, solid-propellant ICBM. Underline their estimate. [1]
- | | | | |
|----|-----|-------|--------|
| 16 | 160 | 1,600 | 16,000 |
|----|-----|-------|--------|
- (f) By how much would the total annual U.S. space-launch capability have to be increased to deploy such a system, if it could be devoted entirely to this task? [1]
- | | | | |
|--------------------|----|-----|-----|
| no increase needed | x2 | x10 | x50 |
|--------------------|----|-----|-----|
- (g) For how many years has the Airborne Laser (ABL) boost-phase intercept system been under development and how much has it cost so far? [2]
- | | |
|-------------------|----------------|
| • Length of time: | • Cost so far: |
|-------------------|----------------|
- (h) How many successful missile intercepts has the ABL achieved to date? [1]
- (i) Defense Secretary Gates recently changed the ABL program to what type of program? [1]

12. 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 the first successful nuclear arms control treaty and list the year 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 and non-nuclear-weapon states-parties. Explain the main provision to which the nuclear-weapon states-parties agreed. [2]
- (i) Explain the main provision to which the non-nuclear-weapon states-parties agreed. [2]
- (j) Which of the following countries currently are *not* parties to the NPT? [circle them] [8]
Brazil China Pakistan India Iran Israel North Korea South Africa

13. Nuclear arms control – II [20]

- (a) What was the main motivation for the 1972 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]
- Year signed:
 - Signatories:
- (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:
 - Year:
 - States-parties:
- (f) What was the *specific* motivation for the Strategic Arms Reduction Treaty (START)? [1]
- (g) When was the START signed and which states signed it? [2]
- Year:
 - Signatories:
- (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]
- Year:
 - Signatories:
- (l) On what date do the SORT restrictions become binding? [1]
- (m) On what date does the SORT expire? [1]
- (n) Does the SORT have any verification provisions? (Yes or No) [1]

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

- (a) In our last reading assignment and class we considered some two dozen actions the United States could take to reduce the threat of nuclear weapons. For each category listed below, describe in a complete sentence a specific action we discussed. [8]
- i. Securing nuclear explosive materials —

 - ii. Reducing the threat of nuclear terrorism —

 - iii. Building leadership and commitment —

 - iv. Putting the United States' own house in order —
- (b) In our last reading assignment and class we considered ten unilateral steps the U.S. 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 U.S. is serious about addressing the grave threat posed by nuclear weapons. Use complete sentences to describe any three of these steps. [6]
- i.

 - ii.

 - iii.
- (c) In our last reading assignment and class we considered seven specific steps toward eliminating nuclear weapons proposed by President Obama in his April, 2009 speech in Prague. Describe any three of these seven steps in complete sentences. [6]
- i.

 - ii.

 - iii.

15. Writing skills [20]

- (a) When a student writing a paper paraphrases text from another source but uses words that differ substantially from those in the other source, the student does not need to cite the source at the end of the paraphrase. True or False? **[1]**
- (b) When a student writing a paper uses the same words as another author, it is not necessary to put the words in quotation marks if not too many words are used. True or False? **[1]**
- (c) What is passive voice? **[2]**

(d) Why should you avoid overusing passive voice? **[2]**

(e) Circle the passive voice construction in each of the following three sentences: **[6]**

Many nuclear bombs have been exploded since the nuclear era began on July 16, 1945.

The flight-security region in the Sahara is divided into Central, Blue, and Green Zones.

The conference was called by Secretary of State Henry A. Kissinger.

(f) Where in a paper is the thesis statement usually placed? **[2]**

(g) What is logically wrong with this argument: “We tortured prisoners in attempts to obtain information. We have not been attacked by terrorists since, so torture made us safe.” **[2]**

(h) Why is the phrase “war on terror” nonsensical? **[2]**

(i) Why is the phrase “war on terrorism” nonsensical? **[2]**