

# Physics 180

## Nuclear Weapons, Nuclear War, and Arms Control

Jeremiah D. Sullivan

Final Examination  
8:00 PM, May 10, 2000

Name \_\_\_\_\_

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

- This is a closed book examination; you have three hours to complete it.
- Answer all nine problems. The total number of points for a problem is designated by {X}, and the points for an individual part of a problem is designated by [Y].
- Write your answers in the spaces provided. If you need more room, use the back of the preceding page.

### SCORES

1. _____ {20}	6. _____ {20}
2. _____ {16}	7. _____ {18}
3. _____ {18}	8. _____ {12}
4. _____ {16}	9. _____ {14}
5. _____ {16}	TOTAL _____ {150}

**1. Acronyms 13 x [1] = {13}**

Spell-out the following acronyms.

(a) HOB

(b) GZ

(c) EMP

(d) LTBT

(e) SALT

(f) START

(g) TTBT

(h) PNET

(i) CTBT

(j) ABM

(k) NTM

(l) OSI

(m) NMD

(n) SDIO

2. The US nuclear weapons complex of the future will smaller than it was at the height of the Cold War, but is will still be extensive. Listed below are the majority of the sites that will remain active, in some cases with new or modified responsibilities {14}

Fir each of the sites listed, name the **state** in which it is located, and **one key responsibility (activity)** that will take place at that site under current plans.

(a) Las Alamos National Laboratory. [2]

(b) Lawrence Livermore National Laboratory. [2]

(c) Sandia National Laboratories. [2]

(d) Oak Ridge National Laboratory [2]

(e) Savannah River Plant [2]

(f) PANTEX Facility [2]

(g) Nevada Test Site [2]

2. Nuclear doctrine and nuclear war are much argued during the Cold War and discussions continue even today.

(a) The vocabulary of nuclear doctrine is populated with numerous arcane terms. Two of these are **counterforce** and **countervalue** targeting. Briefly explain in simple English what these two terms mean.

(b) If a single nuclear weapon (say, 1 Mton yield) is exploded over a large city, what is the **approximate number of deaths** that can be expected.

(c) If Russia make an all-out nuclear attack on the strategic nuclear forces (and nothing else) of the US, what is **approximate number of US deaths** that can be expected? (You may give a range if you prefer.)

3. Consider the four main forms in which energy is expressed in a **surface explosion** of a nuclear weapon. { }

(a) Fill out the table below: [ ] (In any case where two or more choices of physical units are in common use, a single correct answers is all that's required. In the column titled 'Weather Dependent' answer 'Yes' if the effect on a distant observer/target depends on atmospheric conditions, including day/night. Otherwise answer 'No'.

	Name	Percentage of Yield	Physical Units	Weather Dependent
Form 1				
Form 2				
Form 3				
Form 4				

(b) If a nuclear explosion occurs at an altitude high enough that the fireball does not touch the ground, what is the **most profound change** that occurs from the point of view of human exposure?

(c) Briefly explain the difference between **ionizing** and **non-ionizing** radiation.

(d) For ionizing radiation, explain the difference between the **physical dose** and the **biological dose** and the **units** used for each.

(e) Briefly explain the difference between an **acute** and a **chronic** exposure to radiation.

(f) A common way to estimate deaths due to acute exposures to ionizing radiation is use a number commonly denoted by  $LD_{50}$ . Briefly **explain the meaning** (concept) of  $LD_{50}$ . (You need not specify its numerical value.)

b3. The questions below refer to the Comprehensive Nuclear Test Ban Treaty {XX}

(a) Answer the following three questions Yes or No: (i) Has the US **signed** the treaty? Has the US **ratified** the treaty? (iii) Is the treaty in force? (If you want to qualify or explain your answer in any case, feel free to do so, but this is not required.)

(b) Under the terms of the treaty, what is the **maximum nuclear yield** that permitted for any nuclear explosion or nuclear explosion test? [2] (*Give answer in kt (kilotons).*)

(c) What is the **length of duration** (in years) of the treaty? [2]

(d) Name the **four basic technologies** that will comprise the international verification networks associated with monitoring compliance with the treaty. (All that required is that you give names, or alternatively, describe what phenomena each technology detects; a detailed explanation is not requested.) [8]

(e) Briefly describe what kinds of **technical programs and activities** the US will carry out to maintain confidence in the **safety and reliability** of nuclear weapons remaining in the active stockpile in the absence of nuclear testing? [4]

(f) There is a substantive connection

4. Consider the ABM Treaty along with the Protocol to that Treaty. **{16}**
- (a) **When** did the treaty come into being? (Give year of signing, year of ratification, year treaty went into force, or name of US presidential administration that negotiated the treaty.) **[2]**
- (b) What were the **basic technical assumptions** about ABM systems at the time the treaty was signed? **[2]**
- (c) What were the **basic policy assumptions** concerning ABM systems at the time the treaty was signed? (Hint: it was not MAD.) **[2]**
- (d) What are the **key provisions** of the ABM treaty (including the protocol)? (What's allowed and what's forbidden?) **[6]**
- (e) Did the US ever **deploy** an ABM system? Is so, **what** did (does) it defend? **[2]**
- (f) Did the Soviet Union/Russia ever **deploy** an ABM system? Is so, **what** did (does) it defend? **[2]**

5. The questions below refer to the Nuclear Non Proliferation Treaty. **{16}**

(a) Describe the **primary obligations** under the treaty from the **perspective of a non-nuclear weapon state**. **[4]**

(b) Describe the **primary obligations** under the treaty from the perspective of a **nuclear weapon state**. **[4]**

(d) The year **1995 was special** for this treaty. Briefly describe what happened that year and its important to the treaty? **[3]**

(e) Did India and Pakistan **violate the treaty** when they conducted underground nuclear tests in May 1998? Briefly explain your answers. **[2]**

(f) When non-nuclear weapons states review the performance of the nuclear weapons states under the treaty, the preamble to the treaty is often cited in **criticisms made of the nuclear weapons states**. What associated actions, or lack thereof, are the non-nuclear states are criticizing? **[3]**



6. The questions below pertain to the US nuclear weapons complex. {20}

During the Cold War when the complex was is in full operation, explain briefly —give a short phrase or two—the primary function of the following sites of the complex:

(a) Las Alamos National Laboratory (LANL). [2]

(b) Lawrence Livermore National Laboratory (LLNL) [2]

(c) Sandia National Laboratories (SNL) [2]

(d) Rocky Flats Plant (Colorado) [2]

(e) Oak Ridge National Laboratory (Tennessee) [2]

(f) Paducah Plant (Kentucky) [2]

(g) Hanford Site (Washington) [2]

(h) Savannah River Plant (So. Carolina) [2]

(i) PANTEX Facility (Texas) [2]

(j) Nevada Test Site [2]

7. The questions below pertain to the Russian (former Soviet) nuclear weapons complex. **{18}**

(a) Which site of the Russian complex most closely resembles in function the LANL? **[2]**

(b) Which site of the Russian complex most closely resembles in function the LLNL? **[2]**

(c) Name one site of the Russian complex where final weapon assembly took place. **[2]**

(d) What kinds of activity took place at the Novya Zemlya site of the complex? **[2]**

(e) Name one site of the complex where **production of fissile material** took place. (You need not specify whether it was HEU or Pu). **[2]**

(f) The majority of the site of Russian complex are referred to as **closed cities** (or formerly closed cities). Explain briefly what this means and how it **impacted the scientists and engineers** who worked at such locations. **[4]**

(g) The US Government has a number of programs designed to help scientists and engineers of the (formerly) closed cities of the Russian complex. **Explain what these programs are intended to achieve and describe one of them.** (It is not important that you give the official program name.) **[4]**

8. The final class meeting contained a discussion of many items on the “unfinished agenda of arms control,” many of which we were also discussed in earlier class meetings.

Choose **one item on the unfinished arms control agenda** that you see as particularly urgent (whether or not it came up in class) and briefly explain what the item is about and why accomplishing as soon as possible is in the

best interests of the US and the world. A reply of 2-3 paragraphs will suffice. (Feel free to use short bulleted lists as part of your response.) [12]

***Do not pick as your choice any of the programs designed to help scientists and engineers of the (formerly) closed cities of the Russian complex—the subject matter of part (g) of the previous problem.***

9. The following questions pertain to defense against ballistic missiles. {14}

(a) The US is scheduled to make a decision within a year on whether or not to proceed with the development and deployment of a strategic missile defense system known by the acronym NMD. What is the **stated purpose** of NMD? (Namely what area (or areas) is to be defended and against what kinds of missile threats from what kinds of countries?) [3]

(b) The NMD is scheduled to use interceptors that are designed for “hit-to-kill.” Briefly explain what “hit-to-kill” means, the **advantages** of hit-to-kill over fragmenting warheads (such as used by the interceptors of the Patriot system in the Gulf War), and why hit-to-kill technology is **especially challenging to develop**. [3]

(c) The terms “exoatmospheric” and “endoatmospheric” are commonly used when referring to missile defenses. Briefly explain what these two terms mean. [4]

(d) Name **two theater missile defense systems** the US now has under active development. (If you don't remember the exact names, describe where the interceptors will be based (air, sea, space, etc.) and whether the missile warhead intercepts are to take place within or above the atmosphere. [2]

(e) Name **two characteristics of the targets (warheads)** that a ballistic missile defense system is designed to defeat that make building such defenses more challenging technically than building air defenses. [2]