

**HERO 101 Winter 2015**  
**Proctors: Zhuyu Long and Shan**  
**Shigetzu**  
**Time Limit: 50 Minutes**

**Name:** \_\_\_\_\_  
**Grader: Zha Tess**

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### **Introductory Survey and Aptitude Exam**

#### **Instructions:**

- This exam contains six pages (not including the cover page). Make sure that you have all the pages before beginning. If not, tell the proctors.
- You are not allowed any electronics during this exam.
- No notes allowed.
- If you need more space, the proctors will provide you with extra paper. Be sure to staple this extra paper to the back of the exam.
- Show your work. Providing only an answer will result in deduction of points.
- Failure to comply with any of the above conditions will result in punishment and automatic zero on the exam.

Problem	Points	Score
1	5	
2	10	
3	10	
4	20	
5	25	
6	30	
Total:	100	

**Signature:** \_\_\_\_\_

These questions test your ability to recall facts about what was presented. There will be no partial credit given.

**Question 1** *Fill in the blanks or in the blank spaced provided, write down the correct answer.*

A) *En Zhang uses \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ as weapons.*

B) *Zha Tess' \_\_\_\_\_ stat was the only one with a bar.*

C) *Shan Shigetzu manipulates gravity and \_\_\_\_\_ as his other power.*

D) *\_\_\_\_\_ was the lowest value displayed for all stats.*

E) *\_\_\_\_\_ is known as the "false archer".*

F) *List the names of all the people covered in the slides.*

G) *What type of clothing was Zha Tess wearing in the video?*

These problems cover mathematics. It is not expected for you to answer all questions shown.

**Question 5** *You may assume theorems without proof unless it is asked for. Any lemmas or intermediate results originating from known theorems should have proofs accompanying them.*

A) *Using the definition of a limit, prove that  $\frac{d}{dx} \ln(x) = \frac{1}{x}$ .*

B) *Let  $a_n$  be a convergent sequence. Prove that the sequence  $a_n$  converges to 0 if and only if the sequence  $\lim_{n \rightarrow \infty} \frac{1}{a_n} = \infty$ .*

C) *Give clear and precise statements of:*

*(a) Riemann's mapping theorem*

*(b) Riemann's theorem on removable singularities.*

*(c) Schwarz's lemma.*

D) *Let  $f(x) = x^n - 1$ .*

*(a) Prove that the Galois group of  $f(x)$  over the field of rational numbers is an abelian group.*

*(b) Find the smallest  $n$  such that the Galois group is not cyclic.*

E) *Let  $M^{n-1} \subset \mathbb{R}^n$  be a hypersurface and denote by  $V \rightarrow M$  its normal line bundle. Show that  $V$  is trivial if and only if  $M$  is orientable. What can you say for a hypersurface in a non-orientable manifold?*

These questions cover chemistry. It is not expected for you to answer all questions shown.

**Question 6** *If there is not enough room, use the back or if needed, use additional paper.*

- A) *If you have 200mL of .5M hydrosulfuric acid, how many mL of ammonia do you need to neutralize it?*
- B) *Explain the theory of entropy.*
- C) *Draw a theoretical path for the polymerization of lactic acid into polylactic acid. Explain rate limiting steps.*
- D) *Which catalyst would you use to create ethylene from ethanol?*
- E) *In catalysis processes using nickel, what is the catalyst; Ni, Ni<sup>+</sup>, or Ni<sup>2+</sup>? Why?*