2017 Holt Invitational

Wind Power Test

School / Team Name (Please remember to indicate if you are an A or B team from your school if appropriate):

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Team # \_\_\_\_\_\_\_

Student name(s):

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Part I Low Speed Power Score \_\_\_\_\_÷ \_\_\_\_\_x 25 = \_\_\_\_\_\_\_\_

Part I High Speed Power Score \_\_\_\_\_÷ \_\_\_\_\_x 25 = \_\_\_\_\_\_\_\_

Part II (Exam) Score (50 pts) \_\_\_\_\_÷ \_\_\_\_\_x 50 = \_\_\_\_\_\_\_\_

Total Score (100 pts) \_\_\_\_\_\_\_\_\_

Final Ranking: \_\_\_\_\_\_

**(Tiebreaker: #1 – highest high speed voltage; #2 highest low speed voltage)**

**Design Questions (2 points per problem):**

1) Determine the type of wind turbine in each image, and record 2 advantages and 2 disadvantages for each.



Image A type: \_**HAWT (horizontal axis)**\_ Image B type:\_**VAWT (vertical axis)**\_\_\_\_\_

Advantages: Advantages:

a) **Efficiency (all blades face the wind)** a) **always faces wind direction**

**needs less material**

b) **Better in high winds** b) **Ground level components**

**works in smaller locations (rooftops, etc.)**

Disadvantages: Disadvantages:

a) **More material/heavier** a) **lower (less wind)**

**less efficient**

b) **need to be higher in the air/harder to reach parts** b) **Hard to repair/tend to be less sturdy**

2) How is the solidity of a rotor calculated?

**Solidity for rotors is the ratio of the blade area to the area swept out by the blades (the area of the circle made by the tips).**

3) What numerical value is Betz’s Limit? \_**59%**\_or **16/27**

Why isn’t it 100%?

**If a blade arrangement absorbed 100% of the energy of the air moving through it, the air would stop and no new air could move through the blades. Betz predicted the maximum energy would occur at a specific ratio of air speed in to air speed out, which generates the 16/27 value.**

4) Explain how the terms “self-directing” or “self-governing” relate to wind turbines, and why they are considered advantageous features. Use appropriate terminology when applicable.

**”Self-directing” means that the blades will rotate direction on their own to face the wind (or make the most optimal use of the wind)**

**”Self-governing” means that the speed of operation will automatically adjust in high wind conditions to avoid damage to the machine**

5) Explain how the arrangement of wind turbines on a wind farm is a factor in generating energy. Be specific. Use appropriate terminology when applicable.

**”Wake effect”, or the effect of wind disturbances on blades located behind other blades, is a major factor in wind farm efficiency. Computer simulatins suggest a staggered arrangements. Some use a checkerboard approach, while others suggest something more elaborate.**

**Generator questions (2 points per problem):**

6) A wind turbine with a blade radius of 80 meters is turned by an 11 m/s wind with a density of 1.2 kg/m3. If the turbine generates 12 MW of power, what percent is its efficiency?

**12000000/(0.5 x π x 802 x 113 x 1.2 = .747 = 74.7%**

7) If you did the previous problem correctly, why is your answer not reasonable?

**The efficiency is greater than Betz’s Limit of 59%**

8) A wind turbine has a 5 ohm resistor connected in series with the CD motor, and the voltage

measured across the resistor is 100 mV. What is the power generated by the CD motor?

**100 mV \* 20 mA = 2 mW**

9) How does geothermal power generate energy?

**Geothermal (earth heat) takes heat energy from underground sources by sinking pipes into the earth and running liquid or gas (usually water or steam) through them. This heat energy is cycled back to the surface and runs a steam turbine, which in turn generates electricity by rotation and electromagnets**

10) What is the purpose of a gearbox in a wind tower (or any generator)?

**To change rotational speed (and sometimes direction). Blades have low speed and high torque, and the power generator uses a high speed low torque approach.**

**Storage questions (2 points per problem):**

11) What type of power storage accounts for about 96% of the total storage capacity of the United States?

A) Biofuel B) Flow battery C) Molten salt D) **Pumped Hydroelectric**

12) Concentrating solar plants capture heat and store it in which of the following:

A) air B) steel C) vacuum D) **water**

13) CAES works as a generation storage technology, and require an underground reservoir for storage. What does CAES stand for?

**Compressed Air Energy Storage**

14) This electric energy storage system includes a cylinder with a shaft that can spin rapidly within an enclosure.

**Flywheel**

15) Name 4 types of **mechanical** energy storage.

a) **Compressed Air Energy storage (CAES)**

b) **Flywheel**

c) **Gravitational potential energy (water pumping or other mass)**

d) **Hydraulic accumulator / spring**

**Transmission questions (2 points per problem):**

16) A 70 km long electrical power line carries power from Palo Verde to Phoenix. The line supplies

750 MW on a 500 KV line. The line has a resistance of 0.1 ohms per km. Assume all values are

RMS and only pure resistive effects. What is the voltage drop between the ends of the line?

**Answer: 750 MW / 500 KV = 1,500 A 1,500 A \* 70 \* 0.1 = 10.5 kV**

17) What is the difference between AC and DC? Explain how they both relate to electricity in the home.

**Alternating current (AC) is the way power is transmitted into the home and is easier to transmit over long distance. Outlets and the objects that plug into them operate on AC.**

**Direct current (DC) is how batteries work, or chargers for things you don’t plug in, like your phone or laptop. An adaptor changes the AC from the outlet into DC for your device.**

18) Match the approximate voltage values to the different locations as electrical power travels from a power station generator to your in-home appliances such as a TV or lamp, assuming you live in the U.S.:

voltage when generated: \_\_**D**\_\_\_ A) 120 volts

voltage when leaving power station: \_**E**\_\_\_\_ B) 240 volts

voltage when leaving substation: \_\_**C**\_\_\_ C) thousands of volts

voltage when entering your house: \_**B**\_\_\_ D) tens of thousands of volts

voltage when leaving an outlet:\_**A**\_\_\_ E) hundreds of thousands of volts

19) What is the primary cause of power outages in the U.S.?

A) Grid overload B) Outdated technology **C) Severe Weather** D) Terrorist attacks

20) What are the Eastern Interconnection and the Western Interconnection?

**The two main (AC) electrical grids in the United States**

**History (2 points per problem):**

21) Who was responsible for the first wind turbine used to produce electricity, and where was it built?

**James Blyth** at **Glasgow Scotland**

22) Name both of the two functions that the world’s first windmills were generally used for.

**Grinding grain** and **water pumping**

23) Which part of the U.S. has the greatest mean annual wind speed at a height of 80 meters?

A) East Coast   **B) Midwest** C) West Coast  D) They are all about the same

24) What type of orientation is a panemone windmill and who first designed it?

**A) Vertical/Persians** B) Horizontal/Chinese C) Vertical/Dutch D) Horizontal/French

25) By 2014, what percent of the world’s power came from commercial-sized wind turbines?

A) 1% **B) 4%** C) 10% D) 20%