Wind Power Prelim Test

Written by ABRHS

Name _____KEY_____

Grade (circle one): 9 10 11 12

Score: ___90__ / 90 ⇒ __50___ / 50

Notes:

- If a question has an answer line, please write your final answer on it. This goes for computations as well; do work in the space provided, but write your final answer on the provided line.
- Appropriate significant figures and units should be used.

1) What are the two main types of wind turbines? I (2 pt; 1 ea)

_____HAWT_____ _____VAWT_____

2) Classify the following types of turbines and turbine designs into the two categories you listed above. I, V (5 pt; 1 ea)

   a) Panemone _____VAWT_____

   b) Savonius _____VAWT_____

   c) Darrieus _____VAWT_____

   d) Postmill _____HAWT_____

   e) MOD-2 _____HAWT_____

3) Which notable wind turbine was built in 1957, and by whom? V _____Gedser_____ (3 pt)

_____Johannes Juul__(2 pt)

4) What is the theoretical maximum amount of power that the CD-mounted blade assembly could generate in a 10.0 m/s wind, if the air density is 1.225 kg/m^3? Give your answer in W. I (5 pt)

___22.3 W___

½ * 1.225 kg / m^3 * (14 cm)^2 π * (10 m / s)^3 * (m / 100cm)^2 * 1 W / (kg * m^2/s^3) * 16/27 =
^ maximum radius of CD-mounted blade 22.3 W

No conversion to watts → 4 pt
blade radius wrong → 3 pts
No Betz limit → 2 pts (answer 37.7 W)

5) When was solar power first used in space? II, V (2 pt) _____1958___

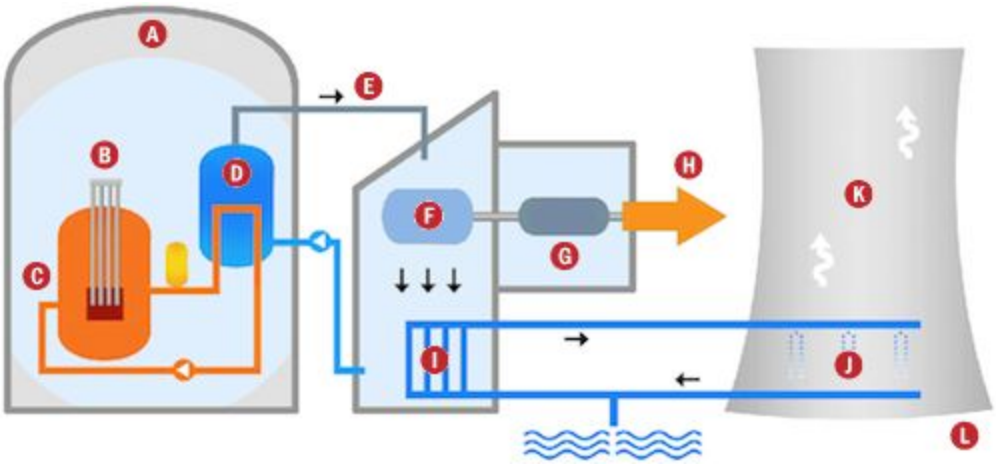
6) Why do wind turbines rotate clockwise? V (3 pt)

After the Tvind turbine was created, blade supplier Økær began creating clockwise-turning blades in order to differentiate itself from Tvind. Because Økær supplied for many companies that eventually became very successful, clockwise-turning turbines became the standard.

7) What is the optimal tip-speed ratio for a three-bladed wind turbine? I (3 pt)

___6 - 8___

8) Label the following parts of a nuclear reactor: II (6 pt; 0.5 ea)



a) __Containment Structure_
b) __Control Rods___
c) ___Reactor Core__
d) __Steam Generator__
e) __Steam Line____
f) ___Steam Turbine__
g) ____Generator____
h) ____Electricity to Consumers___
i) ____Condensor____
j) _Spray_____
k) _____Water Vapor___
l) _____Cooling Tower_____

9) Which is more commonly used for power transmission, HVAC or HVDC, and why? IV (4 pt)

HVDC. Fewer overhead lines, costs less, can interconnect power systems, lower losses, no length limit, more controllable

(need at least 3 of these points, either from above or a different one that is easily verifiable)

10) Electricity travels through a power transmission line at 450. MV and 60.0 A. If 5.00% of the power is lost in transmission, what is the resistance of the line? IV (4 pt)

___375000 Ω or 375 kΩ___

P = IV = 27 GW; 5% of 27 GW = 1.35 GW = I^2R
R = 1.35 GW / (60 A)^2 = 375 x 10^3 Ω = 375 kΩ
if 7,500,000 Ω or 7.5 MΩ, 2 pt (forgot 5%)

11) What is the largest-capacity wind turbine, and what is its capacity? V (4 pt)

____Vestas V164____, ____8 MW___

12) Which of the following batteries are primary batteries? (There may be more than one.) III (2.5 pt, 0.5 for each correct)

Lead Acid **Lithium** Lithium Ion **Poggendorff** **Silver Oxide**

13) Pumped-storage hydroelectricity has an energy efficiency of ____70 - 87___%. III (2.5 pt)
(anywhere in that range is acceptable)

14) What do wind, nuclear, coal, gas, and hydroelectric power generators have in common? II (2 pt)

All use turbines.

15) A flywheel has an angular velocity of 40 rad/s and stores 100 kJ of energy. If the velocity is increased to 80 rad/s, how much energy is the flywheel storing? III (5 pt)

__400 kJ___

Energy stored $\propto$ (angular vel.)^2 $\rightarrow$ E_{new} = 100 kJ * (80 / 40)^2 = 400 kJ
answer is 25 kJ $\rightarrow$ 1 pt

16) The energy from the flywheel (after the increase in velocity) is transferred to hydrogen energy storage at a 97% efficiency rate. The hydrogen is to be held in a cubic storage container. If the density of hydrogen is 0.08988 g/L, how long is the side of the container? III (4 pt)

__33.0 m__

Energy transferred: .97 * 400 kJ = 388 kJ
388 kJ * (kg / 120 MJ) * 10^6 MJ / 10^3 kJ * (L/0.08988g) * (1000g / kg) = 3.60 x 10^7 L
3.60 x 10^7 L x 1 m^3 / 1000 L = 3.60 x 10^4 m^3 ; (3.60 x 10^4)$^{1/3}$ = 33.0 m
if #15 is wrong, multiply that answer by 89.93 for the volume; and take cube root of that to get new correct answer getting volume but not side length = 3 pts

17) According to Wikipedia, how many major power outages has the USA had from the beginning of 2005 to the end of August 2016? IV (1 pt)

A) less than 10

B) 10 - 19

C) 20 - 29 (actual number 23)

D) 30 or more

18) Explain why wind turbines cannot extract 100% of the wind's energy. I, II (5 pt)

if all of the energy was taken out of the wind, the wind exiting the turbine would not be able to go anywhere and thus block more air from going through the turbine

19) Name and describe two reasons for power loss in transmission lines. IV (6 pt, 3 ea)

Ohmic Heating: resistance of the wire turns some of the electricity into heat

Dielectric loss: high-frequency electric fields cause insulating material to absorb energy

20) A lead-acid battery has a rated discharge time of 7.00 hours at a rate of 10.0 A. If instead the battery were discharged in 8.50 hours, by how much would the capacity increase or decrease? Assume the Peukert constant is 1.2. III (4 pt)

__+2.3 Ah__

$t = H (C/IH)^k$
C = 70.0 Ah
$8.5 = 7 (70 / (I * 7))^{1.2} \rightarrow I = 8.51$ A
new capacity = 8.51 A * 8.5 h = 72.3 Ah; increase of 2.3 Ah 1 pt per correct step

21) A transformer has a turn ratio of 1.70. If a 450 kV signal is inputted into the transformer, what voltage is the output? IV (4 pt)

__765 kV___

450 kV * 1.7 = 765 kV (264.7 kV → 2 pt)

22) Which of the two voltages in the previous problem is commonly used in US transmission lines? IV (2 pt)

___765 kV (the answer)__

23) How much energy is estimated to be harvestable by tidal power worldwide? II (3 pt)

___1 TW___

24) Where were the first windmills developed? V (3 pt)

____Persia/Iran___

25) Which continent had the most installed wind power capacity in 2015? II (3 pt)

___Asia__

Note: Questions are assigned a number I through V based on the criteria from the rules manual:

a. The test must consist of at least 5 questions from each of the following areas:
    i. Wind power rotor/fan blade design (e.g., types of designs, pros/cons of designs, ways to improve designs, sources of loss)
    ii. Power generator general questions (e.g., generator design for wind, nuclear, coal, gas, solar, or hydroelectric power plants)
    iii. Power storage questions (e.g., how is the power stored during charging and how is it used during discharge, concepts relating to methods of power storage)
    iv. Power transmission questions (e.g., ways electricity is transmitted, how power is lost in transmission, ways to reduce power loss)
    v. Historical wind power designs (e.g., types of windmills, usage, design pros/cons)

Question/point distribution for each section

Section	Questions						Total pts
I	1	2	4	7	18		18
II	5	8	14	18	23	25	21
III	12	13	15	16	20		18
IV	9	10	17	19	21	22	21
V	2	3	5	6	11	24	19

(the total points do not add up to 90 as some questions fall into more than one category)