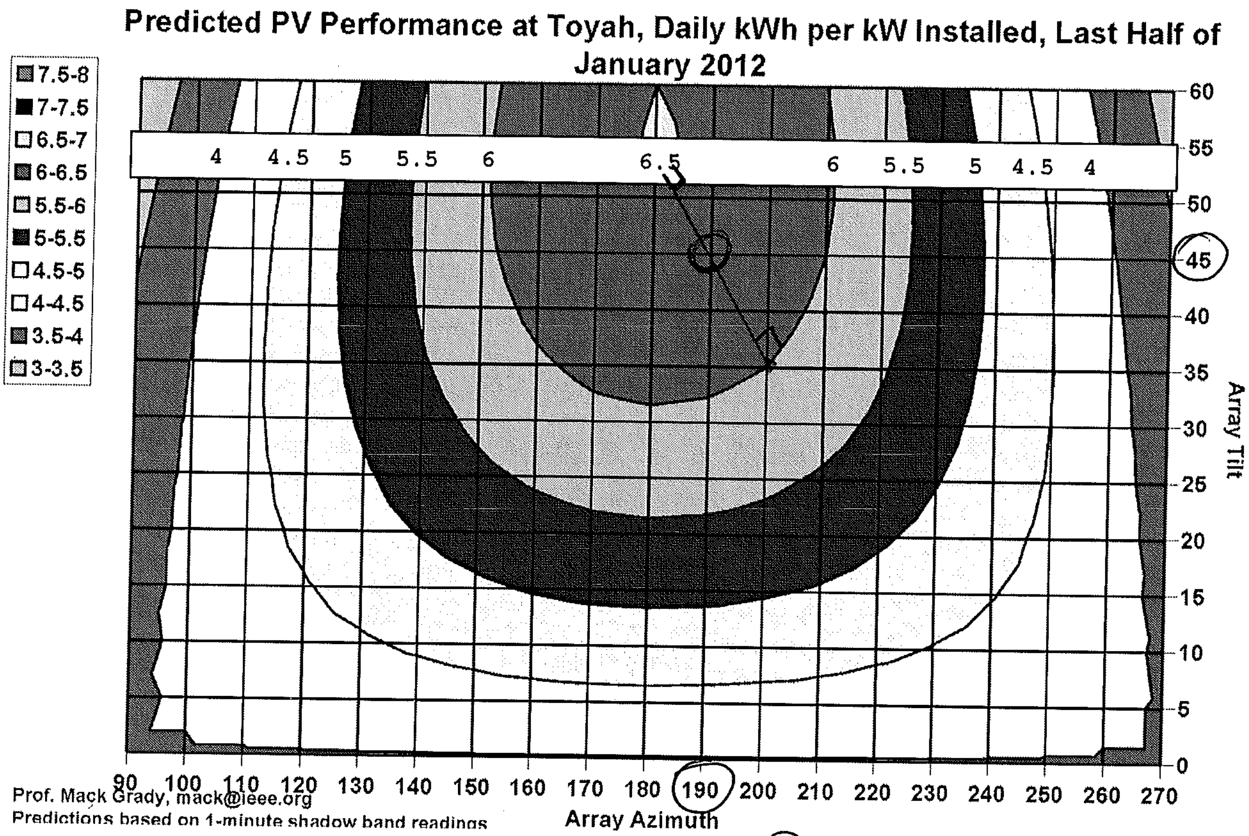
EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: KEY ⓐ
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 1. Use interpolation on the Toyah, TX, harvest contour graph to estimate the expected daily kWh produced by a 1kW-rated photovoltaic (PV) array. The array has fixed tilt = 45°, and azimuth = 190°. To help, contour boundaries are shown in the narrow text box near the top.

- Show the point on the graph that corresponds to your PV array, and
- Justify your interpolated kWh per kW result.


Predicted PV Performance at Toyah, Daily kWh per kW Installed, Last Half of January 2012

Prof. Mack Grady, mack@ieee.org
Predictions based on 1-minute shadow band readings

About $\frac{6}{10}$ of the distance from 6.0 to 6.5

$$6.0 + 0.6(6.5-6) = 6.0 + (0.6)(0.5) = \boxed{6.3 \text{ kWH/kW}}$$

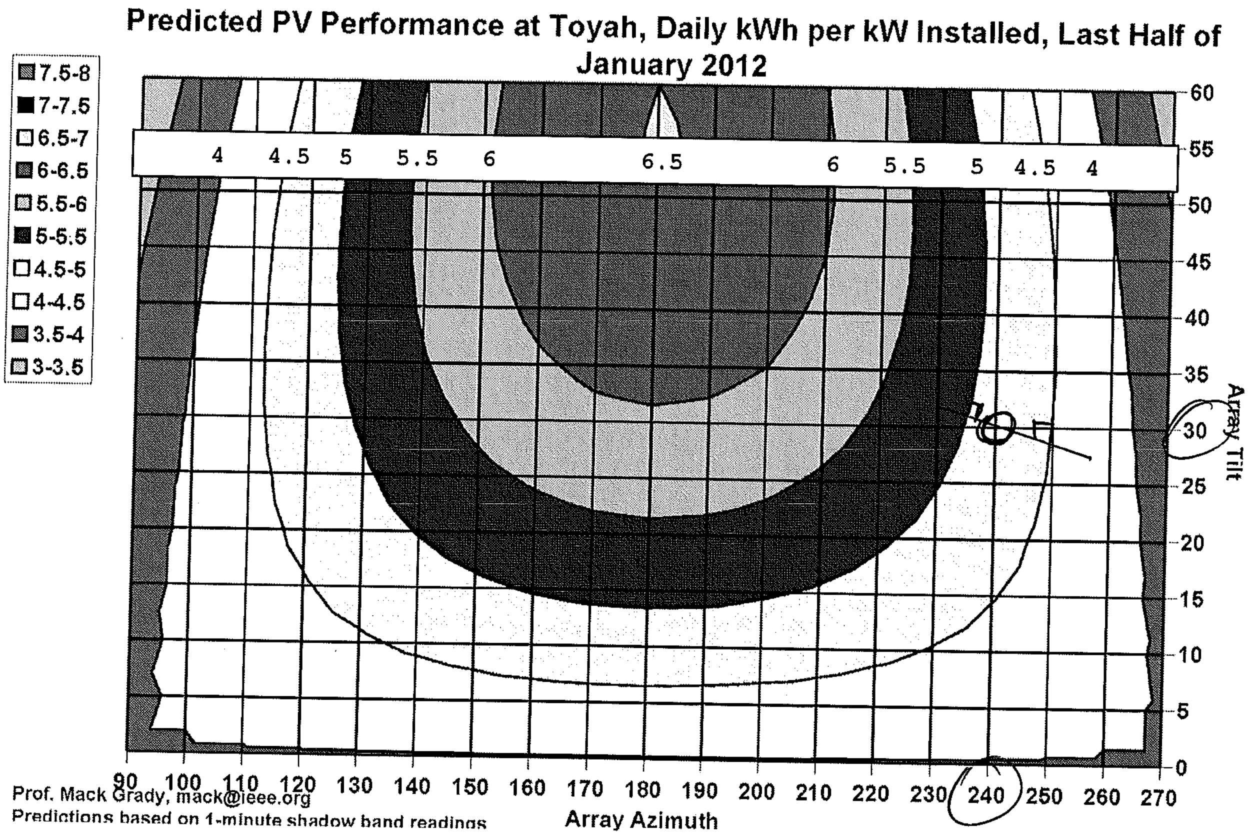
EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: KEY

b

You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 1. Use interpolation on the Toyah, TX, harvest contour graph to estimate the expected daily kWh produced by a 1kW-rated photovoltaic (PV) array. The array has fixed tilt = 30°, and azimuth = 240°. To help, contour boundaries are shown in the narrow text box near the top.

- Show the point on the graph that corresponds to your PV array, and
- Justify your interpolated kWh per kW result.



About $\frac{2}{3}$ the distance from 4.5 to 5

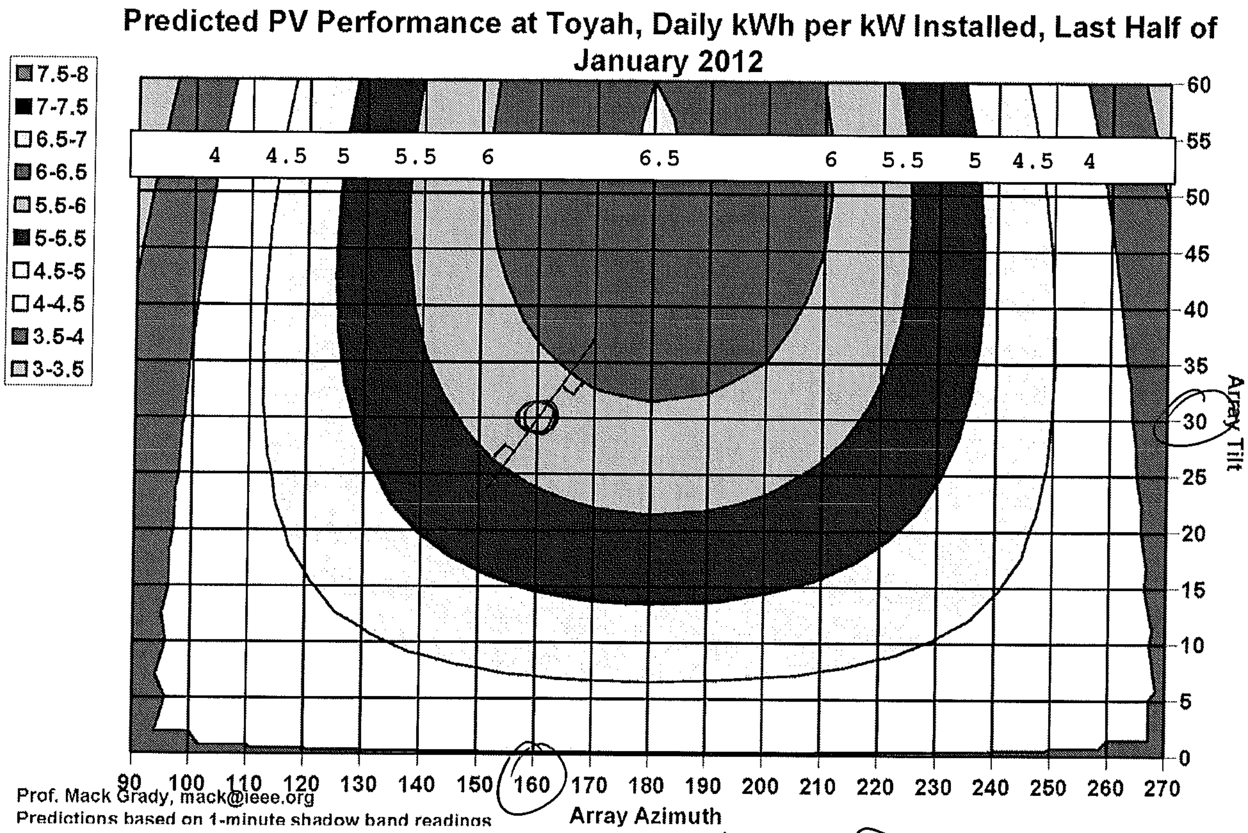
$$4.5 + \frac{2}{3}(5-4.5) = 4.5 + \frac{\cancel{2}}{3}\left(\frac{1}{\cancel{2}}\right) = 4.5 + 0.33$$

Use $\boxed{4.8 \text{ KWH/kw}}$

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: KEY (C)
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 1. Use interpolation on the Toyah, TX, harvest contour graph to estimate the expected daily kWh produced by a 1kW-rated photovoltaic (PV) array. The array has fixed tilt = 30°, and azimuth = 160°. To help, contour boundaries are shown in the narrow text box near the top.

- Show the point on the graph that corresponds to your PV array, and
- Justify your interpolated kWh per kW result.



About half-wave the ⊥ line from 5.5 + 6.0

$5.5 + \frac{1}{2}(6.0 - 5.5) = 5.5 + 0.25$

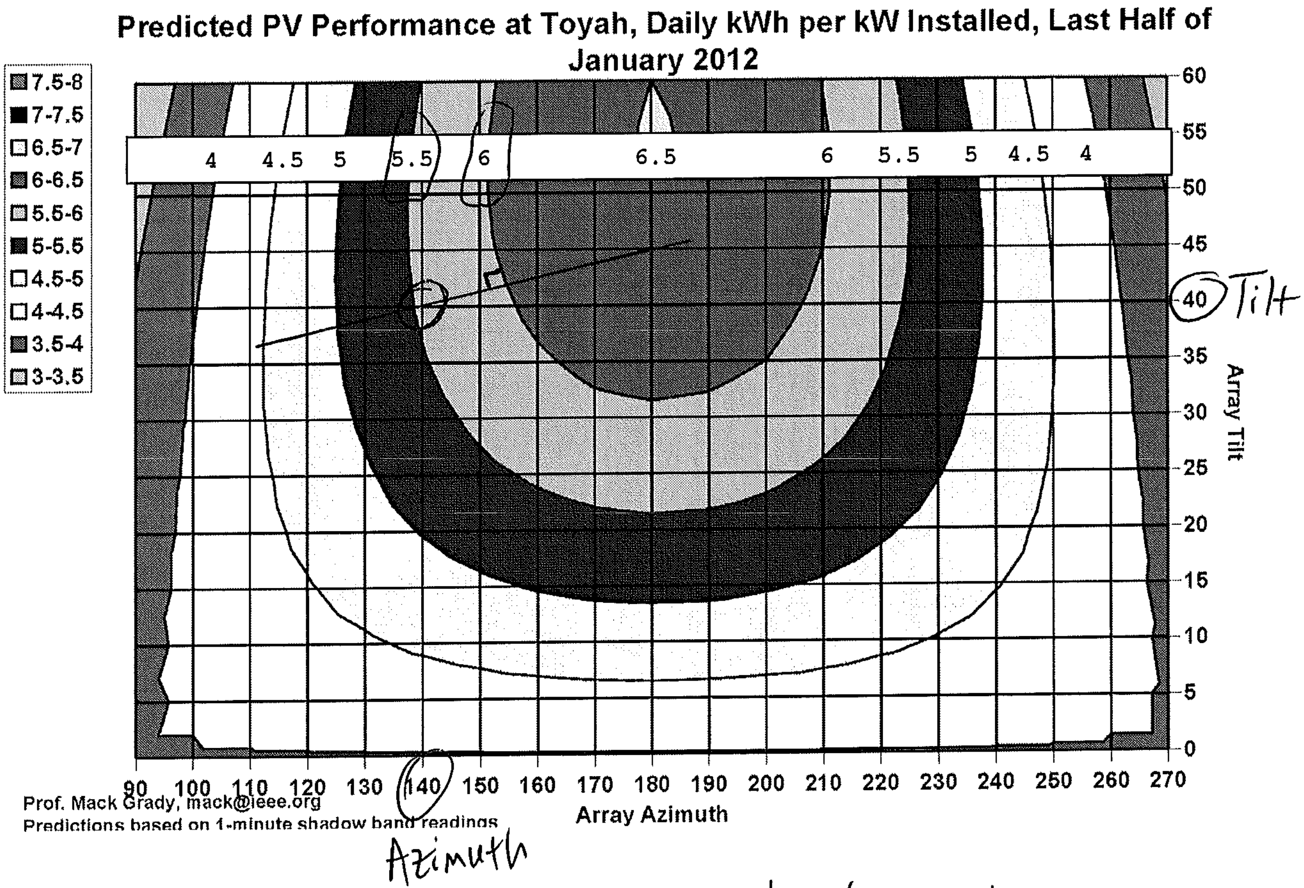
Use $\boxed{5.8 \text{ KWH/KW}}$

R1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: KEY ⓓ

must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 1. Use interpolation on the Toyah, TX, harvest contour graph to estimate the expected daily kWh produced by a 1kW-rated photovoltaic (PV) array. The array has fixed tilt = 40°, and azimuth = 140°. To help, contour boundaries are shown in the narrow text box near the top.

- Show the point on the graph that corresponds to your PV array, and
- Justify your interpolated kWh per kW result.



Appox. $\frac{1}{10}$ the distance ⊥ to both contours

$5.5 + \frac{1}{10}(6-5.5) = 5.5 + \frac{0.5}{10} = \boxed{5.55 \text{ KWH/KW}}$

$\boxed{\text{5.6 is accurate enough}}$ (one decimal place is 5 steps between contours)

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: (a)
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

APPLIANCE	WATTS	HOURS/DAY	WATT HOURS/DAY
Microwave oven average size	1260	1/4	315
Microwave, small, with timer knob	900	1/4	225
Food blender or processor	200	1/20	10
Toaster	1200	1/10	120
Clothes washer standard	700	3/4	525
Clothes washer	200	3/4	150
Vacuum Cleaner	550	1/4	138
Electric blanket	180	4	720
DC power bed-warmer	60	4	240
Refrigerator/freezer, standard			1500
Small apartment refrigerator 4 cu. ft.			945
12/24 volt RV NovaKool 4 cu. ft. with added insulation			300
10 cu. ft. freezer, standard			1000
Window air conditioner smallest	660	6	4000
Ceiling fan AC	60	6	360
Ceiling fan 12/24 volt DC	5 - 20	6	30 - 120
Water well pump 120 volt AC 100 gal/day	1000	1/3	350
Water well pump DC, 100 gal/day	100	1	100
Standard 60 watt light (not recommended)	60	4	240
Compact fluorescent bulbs equal to 60 watt	15	4	60
Computer	100	4	400
HP laser jet printer in operation	90	1/4	23
19" color TV	85	3	255
32" LCD TV	140	3	420
Satellite receiver	20	3	60
Quality stereo	40	4	160

More appliances are shown in books in back of this catalog, or see the label on each appliance.

945
60
420
60
1485 WH/day
=1,485 KWH/day

Problem 2. This problem builds upon Problem 1. The above table gives you an estimate of the daily Watt-hours needed for various loads. Add up the kWh for the boxed loads, and then determine the PV rating (in kW), for your tilt and azimuth angles, that will provide the daily kWh.

From Prob. 1, we expect $6.3 \frac{KWH}{KW \cdot day}$

$$6.3 \frac{KWH}{KW \cdot day} \cdot X(KW) = 1,485 \text{ KWH/day}$$

$$X = 0.236 \text{ KW} = \boxed{236 \text{ W rated panel}}$$

Check

$$\left(6.3 \frac{KWH}{KW \cdot day}\right)(0.236 \text{ KW}) = 1.487 \text{ KWH/day}$$ ✓

GR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________

must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

(b)

APPLIANCE	WATTS	HOURS/DAY	WATT HOURS/DAY
Microwave oven average size	1260	1/4	315
Microwave, small, with timer knob	900	1/4	225
Food blender or processor	200	1/20	10
Toaster	1200	1/10	120
Clothes washer standard	700	3/4	525
Clothes washer	200	3/4	150
Vacuum Cleaner	550	1/4	138
Electric blanket	180	4	720
DC power bed-warmer	60	4	240
Refrigerator/freezer, standard			1500
Small apartment refrigerator 4 cu. ft.			945
12/24 volt RV NovaKool 4 cu. ft. with added insulation			300
10 cu. ft. freezer, standard			1000
Window air conditioner smallest	660	6	4000
Ceiling fan AC	60	6	360
Ceiling fan 12/24 volt DC	5 - 20	6	30 - 120
Water well pump 120 volt AC 100 gal/day	1000	1/3	350
Water well pump DC, 100 gal/day	100	1	100
Standard 60 watt light (not recommended)	60	4	240
Compact fluorescent bulbs equal to 60 watt	15	4	60
Computer	100	4	400
HP laser jet printer in operation	90	1/4	23
19" color TV	85	3	255
32" LCD TV	140	3	420
Satellite receiver	20	3	60
Quality stereo	40	4	160

More appliances are shown in books in back of this catalog, or see the label on each appliance.

225
60
420
+60
765 wH/day

=0.765 KWH/day

Problem 2. This problem builds upon Problem 1. The above table gives you an estimate of the daily Watt-hours needed for various loads. Add up the kWh for the boxed loads, and then determine the PV rating (in kW), for your tilt and azimuth angles, that will provide the daily kWh.

From Problem 1, we expect $4.8 \frac{KWH}{KW \cdot day}$

$$4.8 \frac{KWH}{KW\text{-}day} \cdot X(kw) = 0.765 \frac{KWH}{day}$$

$$X = 0.1594\ KW = \boxed{159\ W \text{ of panel}}$$

Check

$$4.8 \frac{KWH}{KW \cdot day} \cdot 0.1594\ KW = 0.765 \frac{KWH}{day}\ \checkmark$$

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:______________________ (c)
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

APPLIANCE	WATTS	HOURS/DAY	WATT HOURS/DAY
Microwave oven average size	1260	1/4	315
Microwave, small, with timer knob	900	1/4	225
Food blender or processor	200	1/20	10
Toaster	1200	1/10	120
Clothes washer standard	700	3/4	525
Clothes washer	200	3/4	150
Vacuum Cleaner	550	1/4	138
Electric blanket	180	4	720
DC power bed-warmer	60	4	240
Refrigerator/freezer, standard			1500
Small apartment refrigerator 4 cu. ft.			945
12/24 volt RV NovaKool 4 cu. ft. with added insulation			300
10 cu. ft. freezer, standard			1000
Window air conditioner smallest	660	6	4000
Ceiling fan AC	60	6	360
Ceiling fan 12/24 volt DC	5 - 20	6	30 - 120
Water well pump 120 volt AC 100 gal/day	1000	1/3	350
Water well pump DC, 100 gal/day	100	1	100
Standard 60 watt light (not recommended)	60	4	240
Compact fluorescent bulbs equal to 60 watt	15	4	60
Computer	100	4	400
HP laser jet printer in operation	90	1/4	23
19" color TV	85	3	255
32" LCD TV	140	3	420
Satellite receiver	20	3	60
Quality stereo	40	4	160

More appliances are shown in books in back of this catalog, or see the label on each appliance.

525
60
420
60
1065 WH/day

Problem 2. This problem builds upon Problem 1. The above table gives you an estimate of the daily Watt-hours needed for various loads. Add up the kWh for the boxed loads, and then determine the PV rating (in kW), for your tilt and azimuth angles, that will provide the daily kWh.

$$1065 \frac{WH}{day} = 1.065 \frac{KWH}{day}$$

From problem 1, we expect 5.8 KWH/day/KW

$$5.8 \frac{KWH}{KW \cdot DAY} \cdot X_{KW} = 1.065 \frac{KWH}{day}$$

$$X = 0.1836 \, KW = \boxed{183.6W \text{ rated Panel}}$$

Check $\left(5.8 \frac{KWH}{KW \cdot day}\right)(0.1836 \, KW) = 1.065 \, KWH/day$ ✓

d

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:______________
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APPLIANCE	WATTS	HOURS/DAY	WATT HOURS/DAY
Microwave oven average size	1260	1/4	315
Microwave, small, with timer knob	900	1/4	225
Food blender or processor	200	1/20	10
Toaster	1200	1/10	120
Clothes washer standard	700	3/4	525
Clothes washer	200	3/4	150
Vacuum Cleaner	550	1/4	138
Electric blanket	180	4	720
DC power bed-warmer	60	4	240
Refrigerator/freezer, standard			1500
Small apartment refrigerator 4 cu. ft.			945
12/24 volt RV NovaKool 4 cu. ft. with added insulation			300
10 cu. ft. freezer, standard			1000
Window air conditioner smallest	660	6	4000
Ceiling fan AC	60	6	360
Ceiling fan 12/24 volt DC	5 - 20	6	30 - 120
Water well pump 120 volt AC 100 gal/day	1000	1/3	350
Water well pump DC, 100 gal/day	100	1	100
Standard 60 watt light (not recommended)	60	4	240
Compact fluorescent bulbs equal to 60 watt	15	4	60
Computer	100	4	400
HP laser jet printer in operation	90	1/4	23
19" color TV	85	3	255
32" LCD TV	140	3	420
Satellite receiver	20	3	60
Quality stereo	40	4	160

More appliances are shown in books in back of this catalog, or see the label on each appliance.

350
60
420
60
890 WH/day

Problem 2. This problem builds upon Problem 1. The above table gives you an estimate of the daily Watt-hours needed for various loads. Add up the kWh for the boxed loads, and then determine the PV rating (in kW), for your tilt and azimuth angles, that will provide the daily kWh.

890 WH/day = 0.890 KWH/day

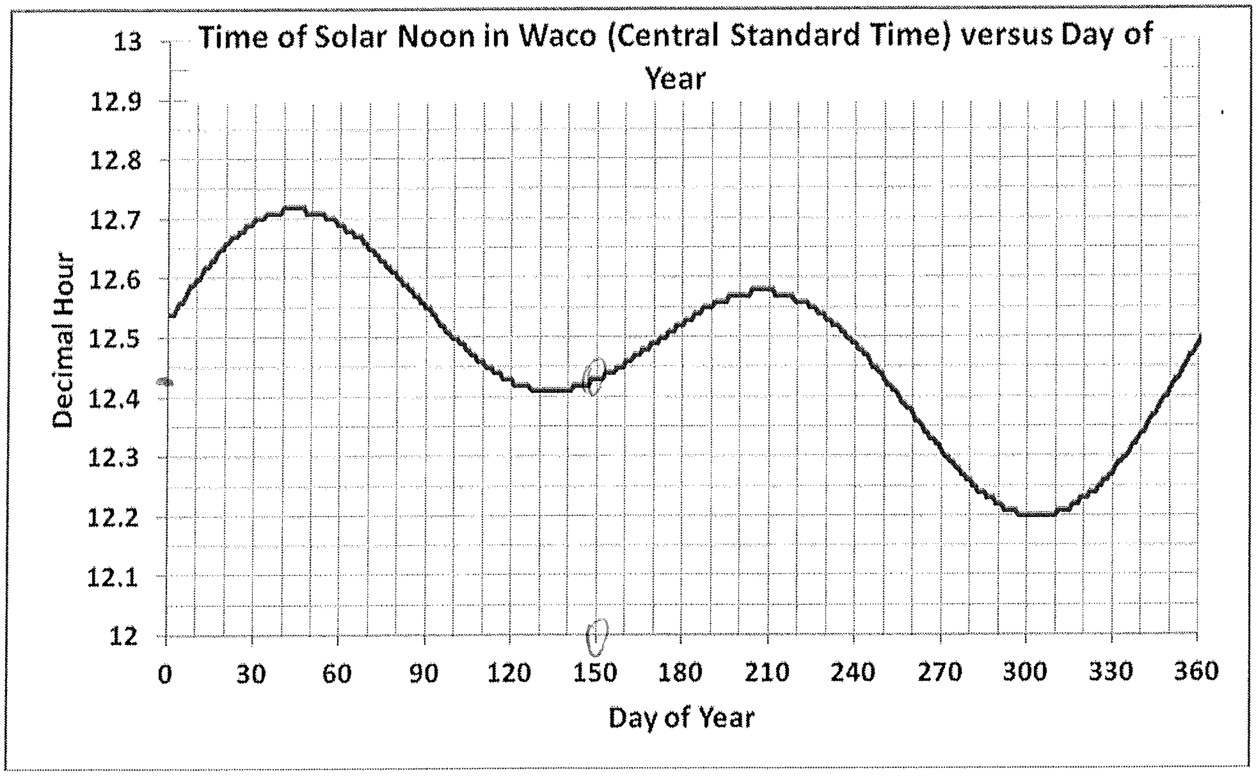
From Prob 1, we expect 5.6 KWH/KW/day

So, $5.6 \frac{KWH}{KW \cdot day} \cdot X \text{ KW} = 0.890 \text{ KWH/day}$

$X = 0.1589 \text{ KW} = \boxed{158.9 \text{ W of Rated panels}}$

Check $5.6 \frac{KWH}{KW \cdot day} \cdot (0.1589 \text{ KW}) = 0.890 \text{ KWH/day}$ ✓

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name: ⓐ
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.



Problem 3. Solar noon is the time at which the sun's azimuth angle is 180° (i.e., due south) and when the sun is at its highest point above the horizon. Use the above curve to determine the Central Standard Time of solar noon for Waco on June 1. Express your answer in clock format HOUR : MINUTE.

5(30) = 150 Approx DOY
↑
JAN-MAY

12.43 ⇒ 12: 0.43(60)

= 12:26

(b)

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:___________________________
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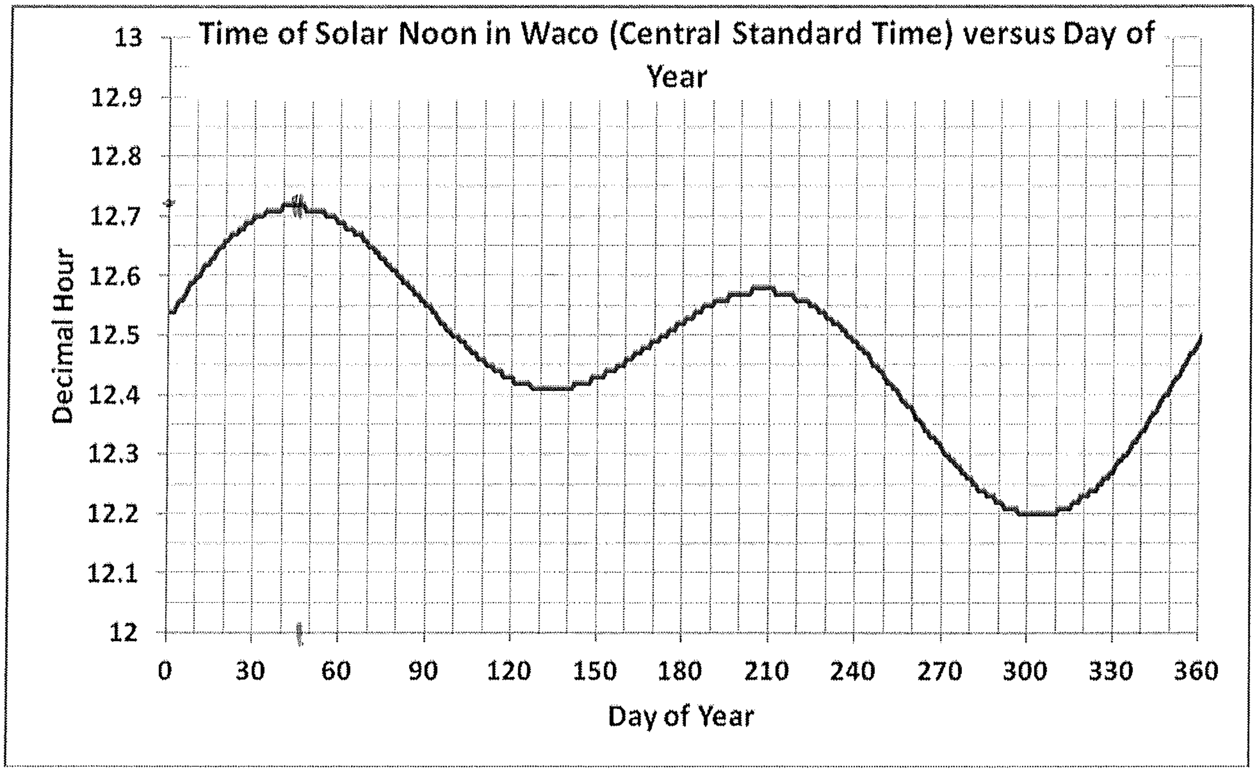

Problem 3. Solar noon is the time at which the sun's azimuth angle is 180⁰ (i.e., due south) and when the sun is at its highest point above the horizon. Use the above curve to determine the Central Standard Time of solar noon for Waco on Feb. 15. Express your answer in clock format HOUR : MINUTE.

DOY (31+15) = 46

$12.72 \Rightarrow 12$ $(0.72)(60) \rightarrow 12{:}43$

Ⓒ

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________
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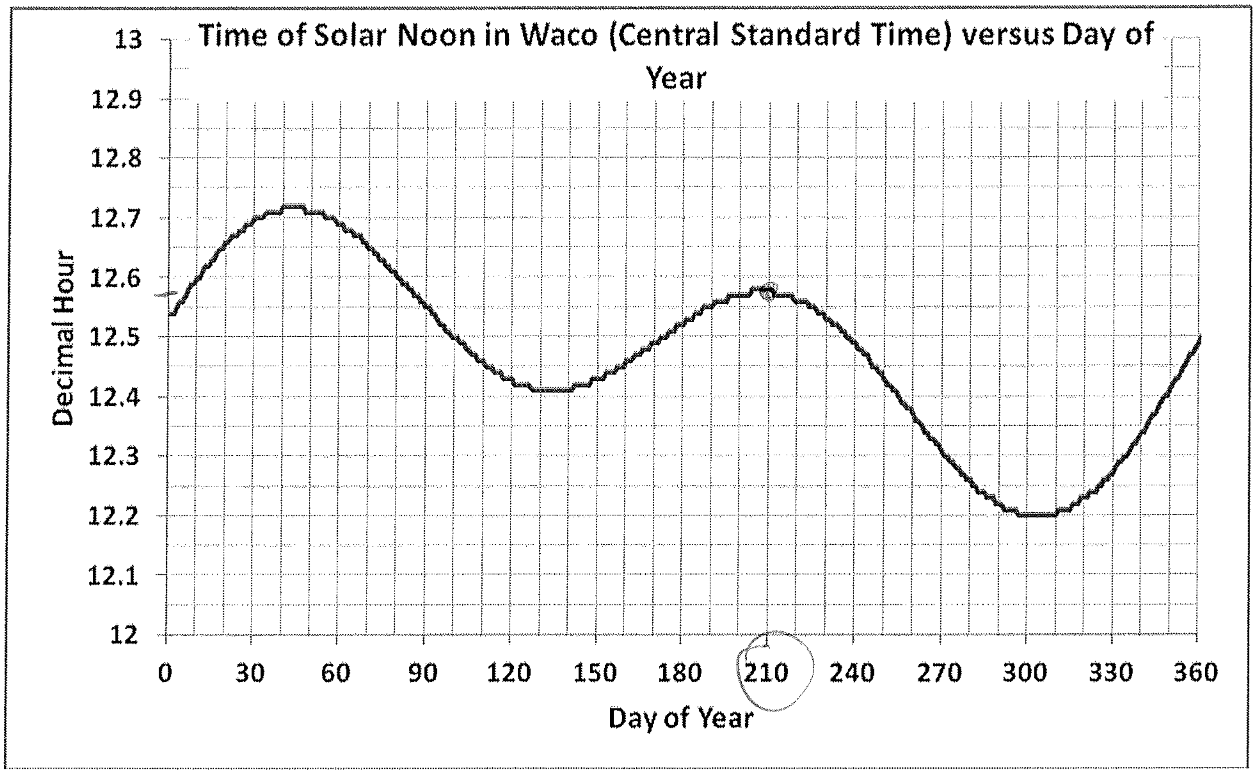


Problem 3. Solar noon is the time at which the sun's azimuth angle is 180^0 (i.e., due south) and when the sun is at its highest point above the horizon. Use the above curve to determine the Central Standard Time of solar noon for Waco on Aug. 1. Express your answer in clock format HOUR : MINUTE.

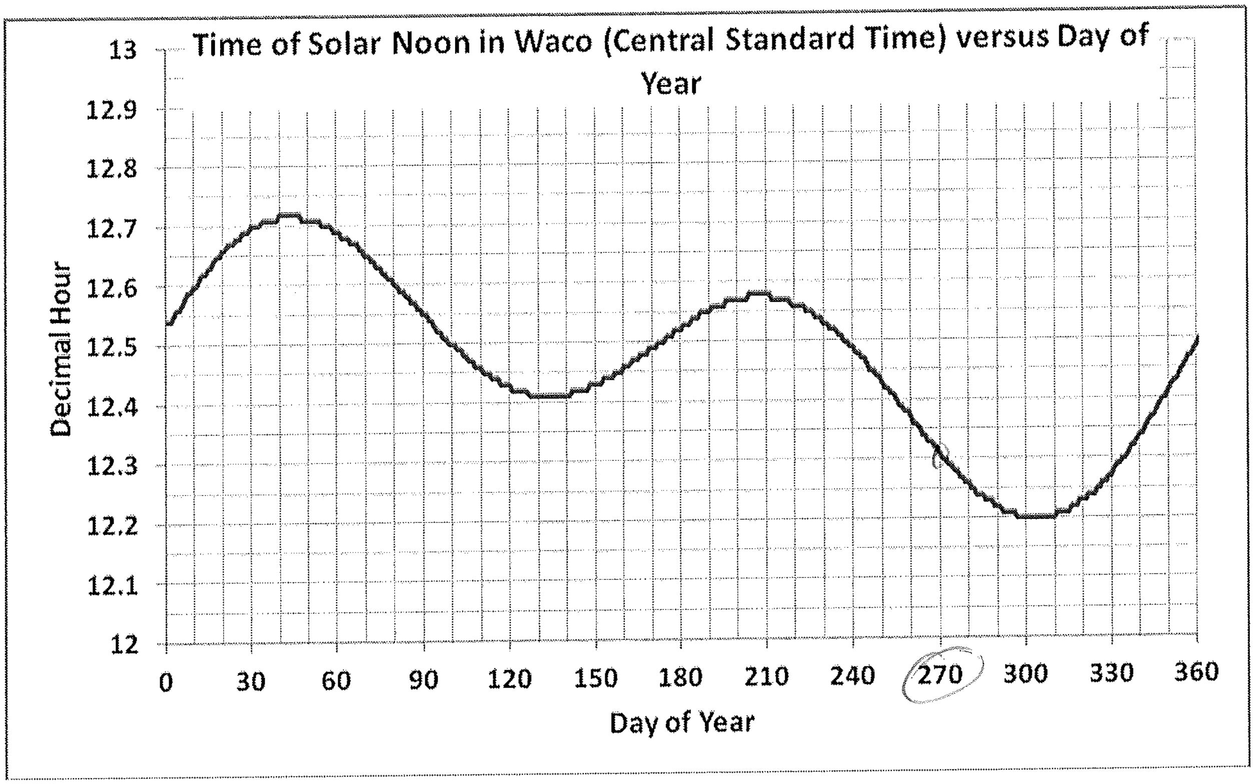
↑ Begins
Month 8

$7(30) = 210$
Approx day

$12.57 = 12 + 60(0.57) \Rightarrow 12:34$

d

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:____________________
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.



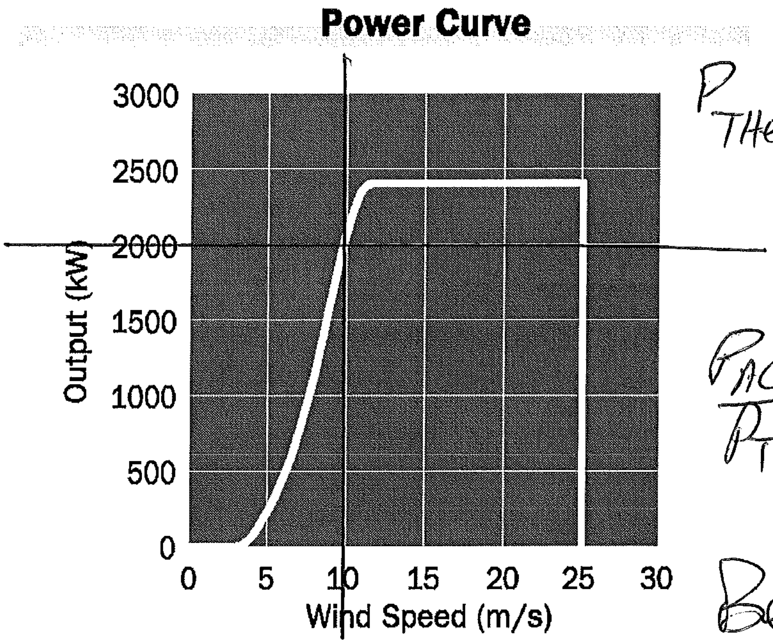
Problem 3. Solar noon is the time at which the sun's azimuth angle is 180^0 (i.e., due south) and when the sun is at its highest point above the horizon. Use the above curve to determine the Central Standard Time of solar noon for Waco on Oct. 1. Express your answer in clock format HOUR : MINUTE.

Oct 1 is Approx day (30)(9) = 270

Hour 12,3 = 12 + 0,3(60) ≈ 12:18

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:______ (a)
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 4. The product literature shown here is for a Mitsubishi 2.4 MW wind turbine. Swept area can be computed from the turbine diameter. Use the 10 m/s wind speed point on the Power Curve and determine the ratio of actual power output to theoretical "power in the wind" $P = \frac{1}{2}\rho A v^3$ Watts. Compare the ratio to the theoretical Betz Limit. Show all your work on this page, in the side margin.



- Air Density: 1.225 kg/m³
- Wind conditions with 10% turbulence
- Calculated at the output of inverter

$P_{THeo} = \frac{1}{2}(1.225)(8171)(10)^3$

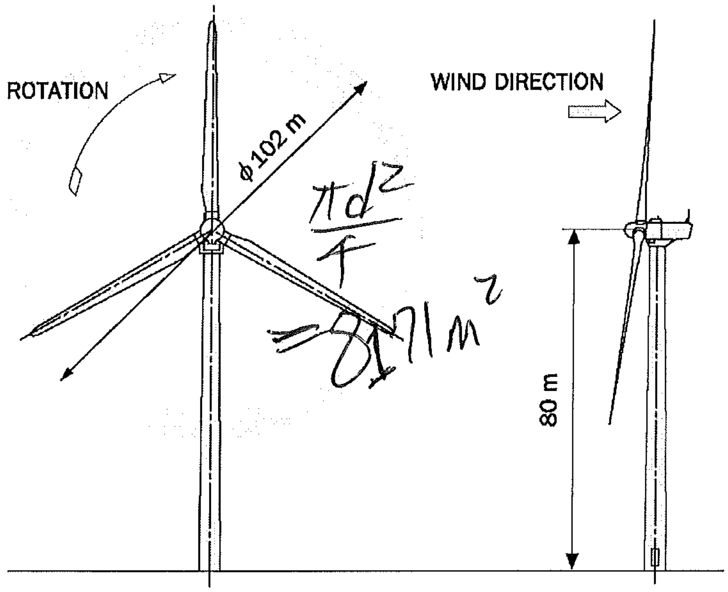
$= 5 MW$

2MW

$\frac{P_{ACT}}{P_{THeo}} = \frac{2}{5} = 0.40$

Betz = 0.6 ✓ Reasonable

$0.40 < 0.60$



$\frac{\pi d^2}{4}$

$= 8171 m^2$

⑥

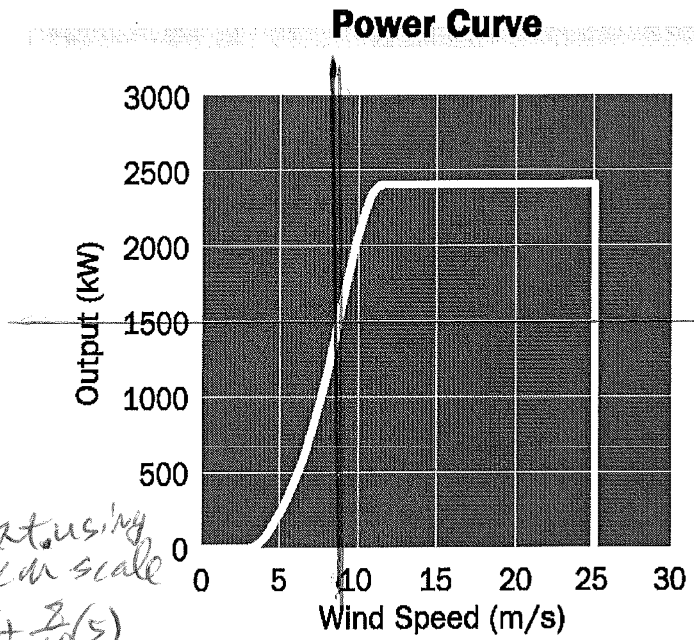
EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 4. The product literature shown here is for a Mitsubishi 2.4 MW wind turbine. Swept area can be computed from the turbine diameter. Use the 1500 kW point on the Power Curve and determine the ratio of actual power output to theoret~~ical~~ "power in the wind"

$P = \frac{1}{2}\rho A v^3$ Watts. Compare the ratio to the theoretical Betz Limit. Show all your work on this page, in the side margin.

$P_{THEO} = \frac{1}{2}(1.225)(8171)(9)^3$

$= 3.65\ MW$



Ext. using cm scale

$5 + \frac{2}{10}(5)$

$= 9 m/s$

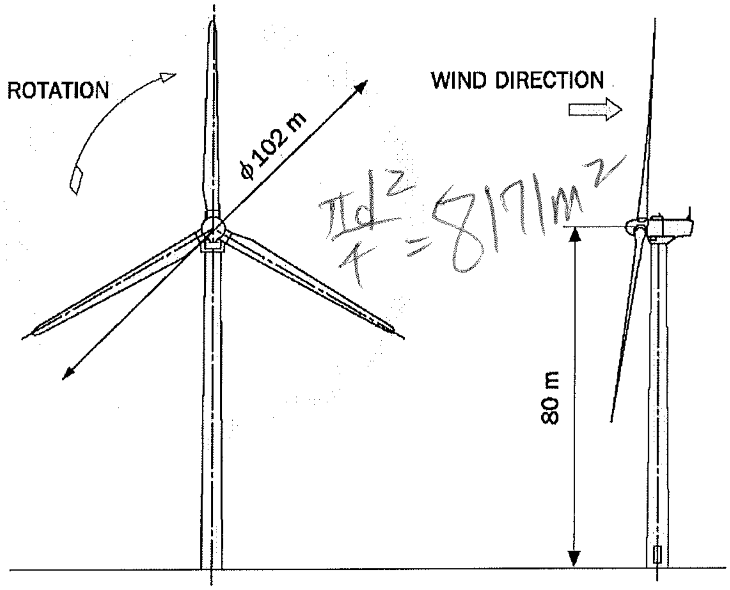
- Air Density: 1.225 kg/m³
- Wind conditions with 10% turbulence
- Calculated at the output of inverter

$\frac{P_{ACT}}{P_{THEO}} = \frac{1.5}{3.65} = 0.41$ OK

Betz is 0.60

$0.41 < 0.60$

Reasonable



$\frac{\pi d^2}{4} = 8171 m^2$

For 8 m/s

$P_{THEO} = 2.56\ MW$

$\frac{P_{ACT}}{P_{THEO}} = \cancel{2.56}\ \frac{1.5}{2.56}$

$= 0.59$ X

Can't be 8 m/s

C

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________
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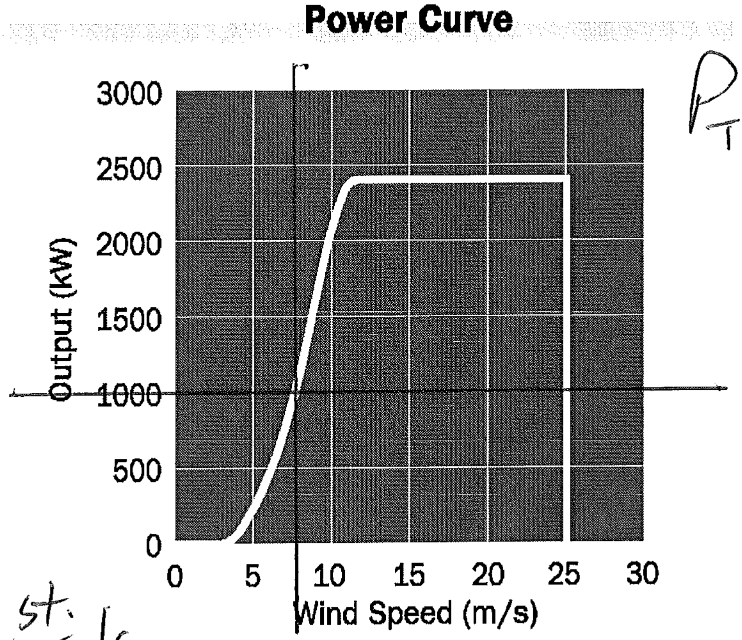
Problem 4. The product literature shown here is for a Mitsubishi 2.4 MW wind turbine. Swept area can be computed from the turbine diameter. Use the 1000 kW point on the Power Curve and determine the ratio of actual power output to theoretical "power in the wind" $P = \frac{1}{2}\rho A v^3$ Watts. Compare the ratio to the theoretical Betz Limit. Show all your work on this page, in the side margin.



- Air Density: 1.225 kg/m³
- Wind conditions with 10% turbulence
- Calculated at the output of inverter

est. 7.5 m/s using cm ruler

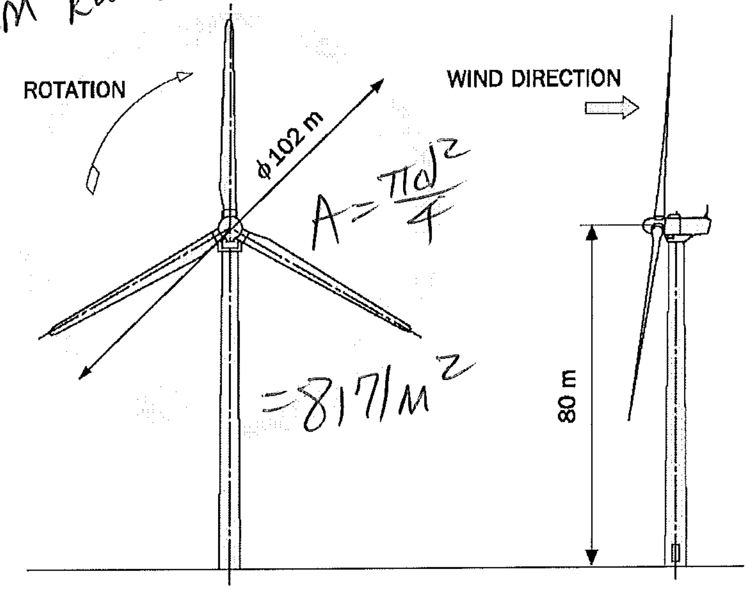
$P_{THEO} = \frac{1}{2}(1.225)(8171)(7.5)^3$

$= 2.11$ MW

$\frac{P_{ACT}}{P_{THEO}} = \frac{1000}{2110} = 0.47$

Betz Limit $= 0.6$

$0.47 < 0.6$, reasonable

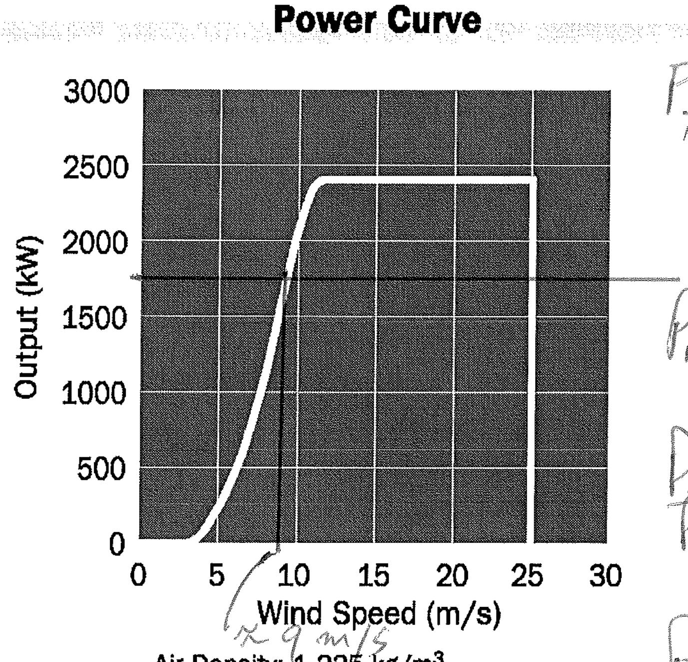


$A = \frac{\pi d^2}{4}$

$= 8171 m^2$

ⓓ

Problem 4. The product literature shown here is for a Mitsubishi 2.4 MW wind turbine. Swept area can be computed from the turbine diameter. Use the 1750 kW point on the Power Curve and determine the ratio of actual power output to theoretical "power in the wind" $P = \frac{1}{2}\rho A v^3$ Watts. Compare the ratio to the theoretical Betz Limit. Show all your work on this page, in the side margin.



- Air Density: 1.225 kg/m³
- Wind conditions with 10% turbulence
- Calculated at the output of inverter

$P_{THEOR.} = \frac{1}{2}(1.225)(8171)9^3$

$= 3.65 MW$

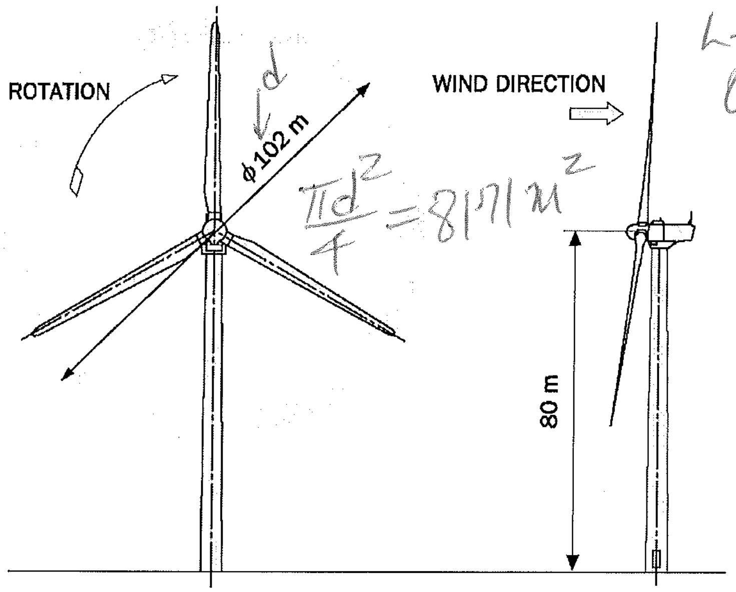
$P_{ACTUAL} = 1.750 MW$

$\frac{P_{ACTUAL}}{P_{THEO}} = \frac{1.75}{3.65} = 0.480$

↕

Betz Limit = 0.60

Actual is 0.4-0.5, Less than Betz, OK



$\frac{\pi d^2}{4} = 8171 m^2$

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:______ⓐ______

You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 5. Suppose that you simultaneously deposit \$10,000 in two different bank accounts. One account has 3% annual interest rate compounded quarterly. The other account has 3% annual interest compounded continuously. How much better (in \$) is continuous compounding after 5 years? Recall that the continuous compounding equation is $F = Pe^{Nr}$, where r is the interest rate, and N is the number of time periods at that rate. The, the conventional compounding equation is $F = P(1+r)^N$

Compounding Quarterly

$$F = P\left(1+\frac{r}{4}\right)^{N\cdot 4} = P\underbrace{\left(1+\frac{0,03}{4}\right)^{5\cdot 4}}_{1.1612}$$

Corresponds to \$11,612

Continuously Compounding

$$F = Pe^{Nr} = Pe^{5\cdot 0.03} = P\underbrace{e^{0.15}}_{1,1618}$$

Corresponds to \$11,618

(6 bucks better, wow!)

(b)

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________

You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 5. Suppose that you simultaneously deposit \$10,000 in two different bank accounts. One account has 3% annual interest rate compounded quarterly. The other account has 3% annual interest compounded continuously. How much better (in \$) is continuous compounding after 10 years? Recall that the continuous compounding equation is $F = Pe^{Nr}$, where r is the interest rate, and N is the number of time periods at that rate. The, the conventional compounding equation is $F = P(1+r)^N$

Quarterly

$$F = P\left(1+\frac{r}{4}\right)^{4N} = P\left(1+\frac{0.03}{4}\right)^{4\cdot 10} = P(1,3483)$$

\$13,483

Continuous

$$F = Pe^{Nr} = P\left(e^{10\cdot 0,03}\right) = P(1,3499)$$

\$13499

\$16 better

C

EGR1301, Test 1, Sept. 27, 2012. One sheet of notes permitted. Name:________________________
You must clearly show your work to receive credit. Do not unstaple. Five equally-weighted problems.

Problem 5. Suppose that you simultaneously deposit $10,000 in two different bank accounts. One account has 2% annual interest rate compounded quarterly. The other account has 2% annual interest compounded continuously. How much better (in $) is continuous compounding after 4 years? Recall that the continuous compounding equation is $F = Pe^{Nr}$, where r is the interest rate, and N is the number of time periods at that rate. The, the conventional compounding equation is $F = P(1+r)^N$

Compounding Quarterly ✓

$$F = P\left(1+\frac{r}{\underset{\substack{\uparrow \\ \text{quarterly}}}{4}}\right)^{\overset{\text{years}}{N}\cdot 4} = P\underbrace{\left(1+\frac{0,02}{4}\right)^{4\cdot 4}}_{1,0831}$$

Yields $10,831

Compound Continually

$$F = Pe^{Nr} = P\underbrace{e^{4\cdot 0,02}}_{1,0833}$$

Yields $10,833

(huge $2 more)

(d)

Problem 5. Suppose that you simultaneously deposit $10,000 in two different bank accounts. One account has 2% annual interest rate compounded quarterly. The other account has 2% annual interest compounded continuously. How much better (in $) is continuous compounding after 6 years? Recall that the continuous compounding equation is $F = Pe^{Nr}$, where r is the interest rate, and N is the number of time periods at that rate. The, the conventional compounding equation is $F = P(1+r)^N$

Compound Quarterly

$$F = P\left(1+\frac{r}{\underset{\text{Quarterly}}{4}}\right)^{\overset{\text{Years}}{6}\cdot 4} = P\underbrace{\left(1+\frac{0.02}{4}\right)^{6\cdot 4}}_{1.1272}$$

Corresponds to $ 11,272

Continuously

$$F = Pe^{Nr} = P\underbrace{e^{6\cdot 0.02}}_{1.1275}$$

Corresponds to $ 11,275

Whopping $ 3 more!