MESA
Mathematics
Engineering
Science
Achievement

MESA OLYMPICS
LEVEL 3 KEY
APRIL 30, 2011

Campus _____
Name 1 _____
Name 2 _____
Name 3 _____
Name 4 _____

Each Question is worth up to 2 points

1. A line goes through the point (4, -6) and is perpendicular to the line $y = 4x + 10$. What is the equation of the line?

   Answer is: $y = -\frac{1}{4}x - 5$ Q2, pg. 4-9; A2, pg 4-12

2. What is the equation of the circle passing through the (x, y) points (0, 0), (0, 4) and (-4, 0)?

   Answer is: $y = -\frac{1}{4}x - 5$ Q8, pg. 4-10; A8, pg 4-14

   $$(x+2)^2 + (y-2)^2 = 8$$

3. If the log_{10} of 4 is $0.703x$, what is the log_{10} of 1/4?

   Answer is: $-0.703x$ Q11, pg. 5-11; A11, pg 5-15 (2010)

4. Four fair coins are tossed at once. What is the probability of obtaining three heads and one tail?

   Answer is: 1/4 Q1, pg. 6-7; A1, pg 6-9

5. What is the probability of picking an orange ball and a white ball out of a bag containing seven orange balls, eight green balls, and two white balls?

   Answer is: 0.10 Q4, pg. 6-7; A4, pg6-10

6. What are the minimum and maximum values, respectively, of the equation $f(x) = 5x^3 - 2x^2 + 1$ on the interval (-2, 2)?
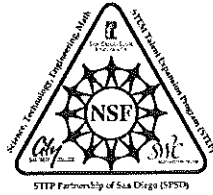
   Answer is: -47, 33 Q1, pg. 7-7; A1, pg7-10

7. Evaluate dy/dx for the following expression.

   $$y = e^{-x} \sin(2x)$$

   Answer is: $e^{-x}(2\cos(2x) - \sin(2x))$ Q4, pg. 7-7; A4, pg7-11 (2010)

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Each Question is worth up to 2 points

8. What is the partial derivative $\partial v/\partial y$ of the following function?

$$v = 3x^2 + 9xy - \frac{y}{\ln(z)} + \cos(z^2 + x)$$

Answer is: $9x - \dfrac{1}{\ln(z)}$ Q6, pg. 7-8; A6, pg7-11

9. What is the approximate area bounded by the curves $y = 8 - x^2$ and $y = -2 + x^2$?

Answer is: 29.8   Q11, pg. 7-8; A11, pg7-12

10. What is the slope of the curve $y = 10x^2 - 3x - 1$ when it crosses the positive part of the x – axis?

Answer is: 7   Q16, pg. 7-9; A16, pg7-13

11. Solve the following differential equation.

$$y'' + 4y' + 4y = 0$$
$$y(0) = 1$$
$$y'(0) = 0$$

Answer is: $y = (1 + 2x)e^{-2x}$ Q1, pg. 8-7; A1, pg8-9 (2010)

12. What is the correct general solution for the following differential equation?

$$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + 2y = 0$$

Answer is: $y = e^{-x}(C_1 \cos x + C_2 \sin x)$ Q2, pg. 8-7; A2, pg8-10

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Mathematics
Engineering
Science
Achievement

Each Question is worth up to 2 points

13. What is the partial fraction expansion of $\mathcal{L}(s)$?

$$\mathcal{L}(s) = \frac{s(s+10)}{(s+5)(s+15)}$$

Answer is: $\mathcal{L}(s) = 1 - \frac{2.5}{s+5} - \frac{7.5}{s+15}$ 　　　Q9, pg. 8-8; A9, pg8-11

14. Using your answer to #13, what is the inverse Laplace transform of $\mathcal{L}(s)$?

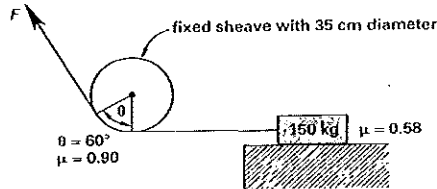$$\mathcal{L}(s) = \frac{s(s+10)}{(s+5)(s+15)}$$

Answer is: $C_1 + C_2 e^{-5t} + C_3 e^{-15t}$ 　　　Q10, pg. 8-8; A10, pg8-12

15. What is the complete solution to the following differential equation?

$$y' + 8y = 16$$
$$y(0) = 5$$

Answer is: $y(x) = 3e^{-8x} + 2$ 　　　Q18, pg. 8-9; A18, pg8-14(2010)

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Mathematics Engineering Science Achievement

Each Question is worth up to 2 points

Problems 16 & 17 refer to the following illustration.

16. A block with a mass of 150 kg is pulled over a horizontal surface by a cable guided by a fixed sheave as shown. The coefficients of friction are 0.58 between the surface and the block, and 0.90 between the cable and the pulley. What force, F, must be applied to the cable for the block to move?

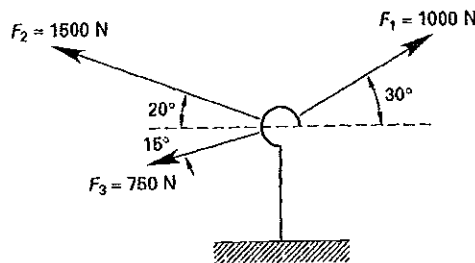Answer is: 2200N   Q2, pg. 12-7; A2, pg 12-9

17. What total torque is applied to the pulley?

Answer is: 230 N•m   Q3, pg. 12-7; A3, pg 12-10
(close aprox. or roundoff are acceptable)

18. Three forces act on a hook. Determine the magnitude of the resultant of the forces. Neglect hook bending.

Answer is: 1509 N   Q4, pg. 10-10; A4, pg 10-14

MESA
Mathematics
Engineering
Science
Achievement

MESA OLYMPICS
LEVEL 3 KEY
APRIL 30, 2011

Campus _____
Name 1 _____
Name 2 _____
Name 3 _____
Name 4 _____

Each Question is worth up to 2 points

19. The loading shown requires a resisting moment of 20 N·m at the support. Calculate the value of force F.
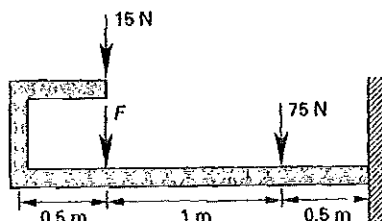
Answer is: 26.7 N (up) Q5, pg. 10-10; A5, pg 10-14

20. The velocity (in m/s) of a falling ball is described by the equation $v = 32 + t + 6t^2$. What is the acceleration at time $t = 2$ s?

Answer is: 25 m/s^2 Q1, pg. DE-V1; A1, pg DE-V3(2010)

21. The elevator in a 12-story building has a mass of 1000 kg. Its maximum velocity and maximum acceleration are 2 m/s and 1 m/s^2, respectively. A passenger with a mass of 75 kg stands on a bathroom scale in the elevator as the elevator ascends at its maximum acceleration. What is the scale reading just as the elevator reaches its maximum acceleration?

Answer is: 811 N Q6, pg. DE-V1; A6, pg DE-V4

22. A cannonball of mass 10 kg is fired from a cannon of mass 250 kg. The initial velocity of the cannonball is 1000 km/h. All of the cannon's recoil is absorbed by a spring with a spring constant of 520 N/cm. What is the maximum recoil distance of the cannon?

Answer is: 0.77N Q10, pg. 15-7; A10, pg 15-10

(Give or take up to .1 is also acceptable for 1 point)

![MESA Mathematics Engineering Science Achievement logo]

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Each Question is worth up to 2 points

23. Traffic travels at 100 km/h around a banked highway curve with a radius of 1000m. What banking angle is necessary such that friction will not be required to resist the centrifugal force?

Answer is: 4.50°   Q5, pg. 16-6; A5, pg 16-9

Give or take up to .1 is also acceptable for 1 point

24. A hockey puck traveling at 30 km/h hits a massive wall at an angle of 30° from the wall. What are its final velocity and deflection angle if the coefficient of restitution is 0.63?
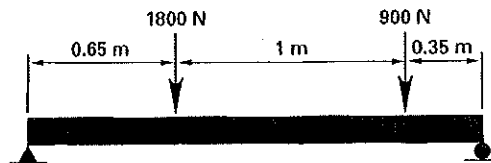
$28 km/h @ 20°$

Answer is: 19.99°   Q5, pg. 17-6; A5, pg 17-8 (2010)

Give or take up to .1 is also acceptable for 1 point

25. Referring to the simply supported beam shown below, what is the maximum shear?

Answer is: 1372.5 N   Q4, pg. 20-7; A4, pg 20-10

26. A square steel column with a solid cross section is pinned at both its base and top. The column is 5 m in height and supports a load of 3.5 MN. The modulus of elasticity of the steel is 210 GPa. What is the minimum cross-sectional size to avoid buckling?

Answer is: 15 cm x 15 cm   Q6, pg. 21-4; A6, pg 21-6

(.15 m or 15 cm is also acceptable for full credit)

27. What is the valence (oxidation state) of carbon in sodium carbonate (Na_2CO_3)?

Answer is: +4   Q2, pg. DE-XI-1; A2, pg DE-XI-3

MESA
Mathematics
Engineering
Science
Achievement

MESA OLYMPICS
LEVEL 3 KEY
APRIL 30, 2011

Campus _____
Name 1 _____
Name 2 _____
Name 3 _____
Name 4 _____

NSF

STLP Partnership of San Diego (SPSD)

Each Question is worth up to 2 points

28. What is the mass of 0.01 gram-moles of Na_2SO_4?

    Answer is: 1.421g   Q4, pg. DE-XI-1; A4, pg DE-XI-3(2010)
    Give or take up to .01 is also acceptable for 1point

29. What is the molarity of a solution obtained by dissolving 25 g of NaCl in enough water to produce 4 L of solution?

    Answer is: .107 mol/L   Q11, pg. DE-XI-2; A11, pg DE-XI-5
   Give or take up to .01 is also acceptable for 1point

30. In a laboratory experiment, a student analyzed a substance with 2.7626 g of lead, 0.00672 g of hydrogen, and 0.8534 g of oxygen. What is the empirical formula for the substance?

    Answer is: Pb_2O_8H Q4, pg. 33-9; A4, pg 33-11

31. A given sample of radioactive material has 80% of the original substance remaining after 10 years. How much will remain after 90 additional years?

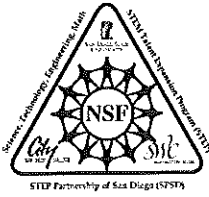   Answer is: 0.107 or 11%   Q14, pg. 33-10; A14, pg 33-13

32. Balance the following reaction.

    $\_HBrO_3 + \_HBr \rightarrow \_H_2O + \_Br_2$
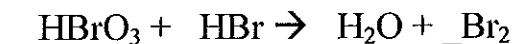
Answer is: $HBrO_3 + 5HBr \rightarrow 3H_2O + 3Br_2$ Q1, pg. 34-7; A1, pg 34-9 (2010)

33. What family of compounds is produced from the reaction between an alcohol and a carboxylic acid?

    Answer is: esters   Q5, pg. 34-8; A5, pg 34-10

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Mathematics
Engineering
Science
Achievement

Each Question is worth up to 2 points

34. Without your knowledge, an old classmate applies to the company you work for. Knowing that you recently graduated from the same school, the director of engineering asks your opinion and shows you the application and resume that your friend submitted. It turns out that your friend has exaggerated his participation in campus organizations, even claiming to have been an officer in an engineering society that you are sure he was never in. On the other hand, you remember him as being a highly intelligent student and believe that he could really help the company. How should you handle the situation?

Answer is: see below, for best answer Q14,pg.DE XVI-3;A14, pg DE XVI-5 (2010)
An engineer's is ethically obligated to be truthful. You should recommend the applicant, but qualify your recommendation by pointing out that you think he may have exaggerated some details on his resume. This answer is about truth-other answers that focus on truth are accepted for full credit.

35. A survey crew is hired by the general contractor on a large government project to verify pertinent data on the owner-supplied plans. While performing their functions, the suvery crew is approached by a subcontractor who wants them to perform some work for him on the same project. He states that he will pay for this additional work and notes that it will be easy for the survey crew to perform both services at the same time. What should the survey crew do?

Answer is: see below, for best answer   Q12,pg.DE XVI-2;A12, pg DE XVI-4
It is legal and ethical for the survey crew to work for more than one party on the same project as long as the circumstances are fully disclosed and agreed to by all interested parties, and neither of the parties are adversely affected-similar answer that convey the same meaning are acceptable.

36. Complete the following sentence: "It is generally considered unethical to moonlight as a consulting engineer while you are working for your primary engineering employer because…

Answer is: see below, for best answer   Q6,pg.DE XVI-1;A6, pg DE XVI-6
You can't do a good job for your primary employer if you come to work in the morning tired- This is what most ethical codes use to discourage moonlighting.

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

Mathematics Engineering Science Achievement
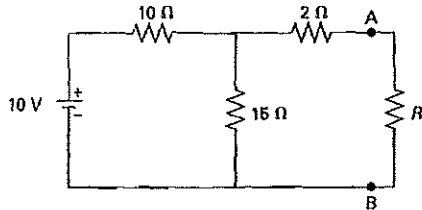
Each Question is worth up to 2 points

37. Find the equivalent capacitance between terminals A and B.
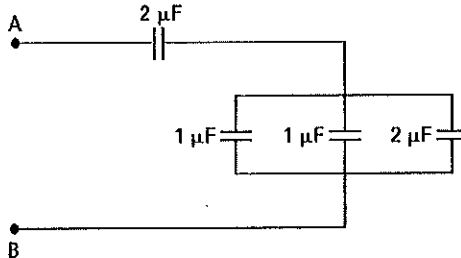
Answer is: 1.33 µF   Q1, pg. 40-9; A1, pg 40-14 (2010)

38. Size the resistor R_L to allow maximum power transfer through terminals A and B.

Answer is: 8 Ω   Q4, pg. 40-10; A4, pg 40-15

39. A 10 kV power line 5 km long has a total resistance of 0.7 Ω. The current flowing is 10 A. What is the power dissipated in the line resistance?

Answer is: 70 W   Q7, pg. 40-10; A7, pg 40-15

40. The reactances of a 10 mH inductor and a 0.2 µF capacitor are equal when the frequency is what?

Answer is: 3559 Hz or 3.56 kHz   Q1, pg. 41-9; A1, pg 41-11

41. An operating system is being developed for use in the control unit of an industrial machine. For efficiency, it is decided that any command to the machine will be represented by a combination of four characters, and that only eight distinct characters will be supported. How many bits are required to represent one command?

Answer is: 12   Q8, pgDE XIV-3; A8, pgDE XIV-5
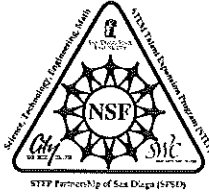
Mathematics Engineering Science Achievement

Each Question is worth up to 2 points

MESA OLYMPICS

LEVEL 3 KEY

APRIL 30, 2011

Campus _____

Name 1 _____

Name 2 _____

Name 3 _____

Name 4 _____

42. A 256K-word memory uses 16-bit words. How many parallel data lines are required to pass data to the CPU for processing?

Answer is: *16*   Q4, pg43-7: A4, pg43-9

All questions and answers are taken from the FE review manual, by Michael R. Lindeburg, PE and published by Professional Publications, Inc, 2004.