THE UNIVERSITY OF HONG KONG

BACHELOR OF ENGINEERING

FACULTY OF ENGINEERING

ENGG1300: FUNDAMENTAL MECHANICS

DATE: Dec 17, 2018 TIME: 2:30 PM – 4:30 PM (2 hours)

Answer ALL questions

Questions in Section A carry 2 marks each and -0.5 mark for each wrong answer.
Questions in Section B carry 6 marks each and -1.5 marks for each wrong answer.

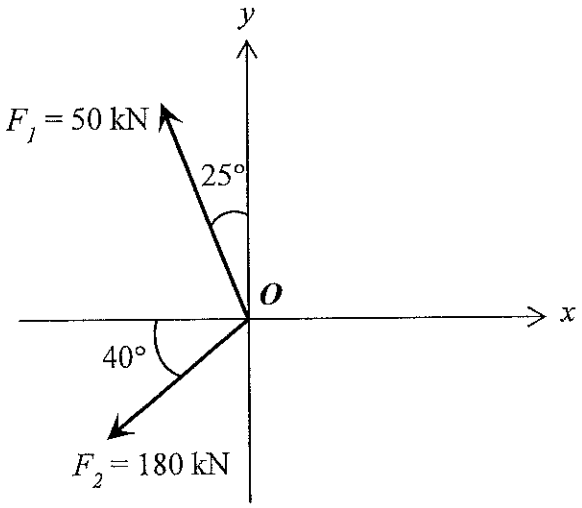
Mark the answers on the computer-readable answer sheet using HB pencil

Use of Calculators:

Only approved calculators as announced by the Examinations Secretary can be used in this examination. It is candidates' responsibility to ensure that their calculator operates satisfactorily, and candidates must record the name and type of the calculator used on the front page of the examination script.

SECTION A

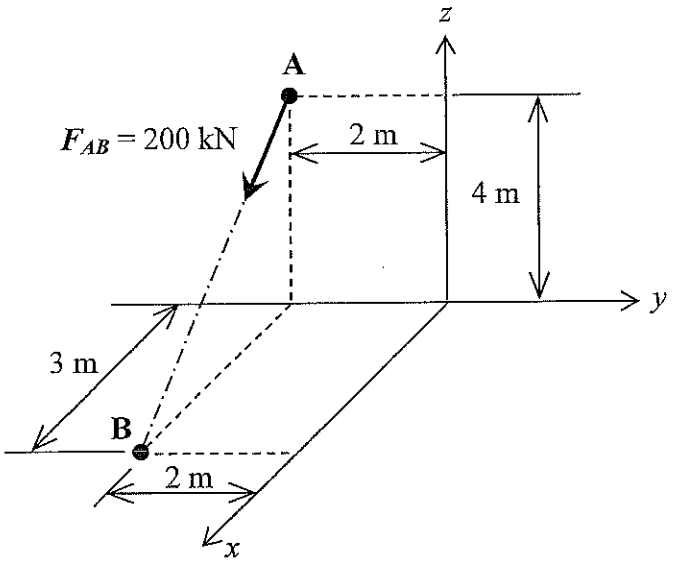
1.



What is the resultant force at point ***O***?

A. $\{-159.0\,\boldsymbol{i} - 70.39\,\boldsymbol{j}\}$ kN
B. $\{-161.0\,\boldsymbol{i} - 116.8\,\boldsymbol{j}\}$ kN
C. $\{-70.39\,\boldsymbol{i} - 159.0\,\boldsymbol{j}\}$ kN
D. $\{-116.8\,\boldsymbol{i} - 161.0\,\boldsymbol{j}\}$ kN
E. None of the above

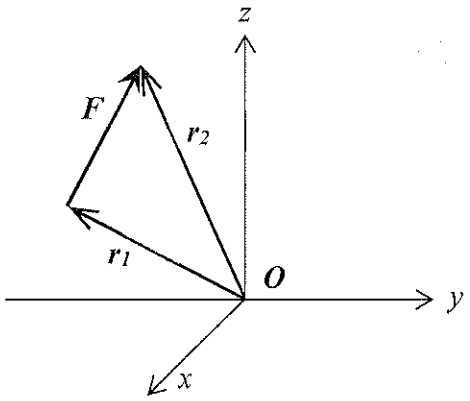
2.



What is force $\boldsymbol{F}_{AB}$ in Cartesian vector form?

A. $\{124.9\,\boldsymbol{i} + 0\,\boldsymbol{j} - 93.70\,\boldsymbol{k}\}$ kN
B. $\{200.0\,\boldsymbol{i} + 0\,\boldsymbol{j} - 200.0\,\boldsymbol{k}\}$ kN
C. $\{120.0\,\boldsymbol{i} + 0\,\boldsymbol{j} - 160.0\,\boldsymbol{k}\}$ kN
D. $\{93.70\,\boldsymbol{i} + 0\,\boldsymbol{j} - 120.0\,\boldsymbol{k}\}$ kN
E. None of the above

3.

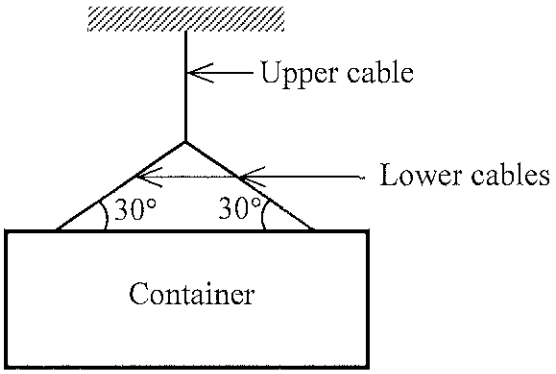


Force $\boldsymbol{F}$ is acting on the y-z plane, $\boldsymbol{r_1}$ is the position vector to the tail of $\boldsymbol{F}$ from point $\boldsymbol{O}$, and $\boldsymbol{r_2}$ is the position vector to the head of $\boldsymbol{F}$ from point $\boldsymbol{O}$. Which of the following is (are) correct?

(1) The direction of moment generated by $\boldsymbol{F}$ about $\boldsymbol{O}$ is pointing to the positive x axis.
(2) The magnitude of the moment generated by $\boldsymbol{F}$ about $\boldsymbol{O}$ is equal to the cross product $\boldsymbol{r_1} \times \boldsymbol{F}$.
(3) The magnitude of the moment generated by $\boldsymbol{F}$ about $\boldsymbol{O}$ is equal to the cross product $\boldsymbol{r_2} \times \boldsymbol{F}$.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only
E. None of the above

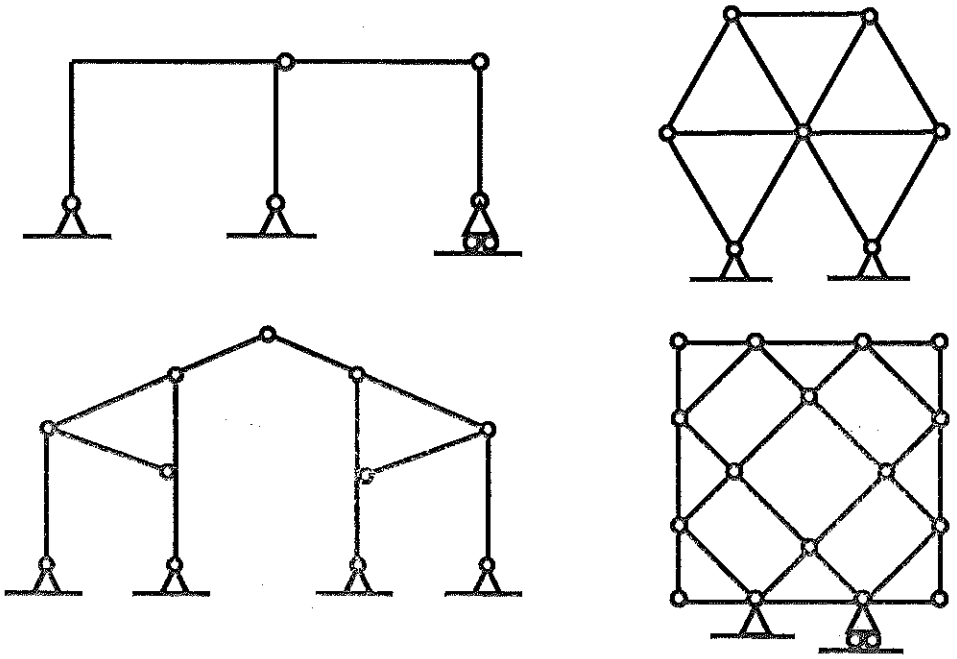
4.



A container is supported by the upper and lower cables. If the system is in static equilibrium and the tension in the lower cables is 120.0 kN. What is the weight of the container? Assume the weight of the cables is negligible.

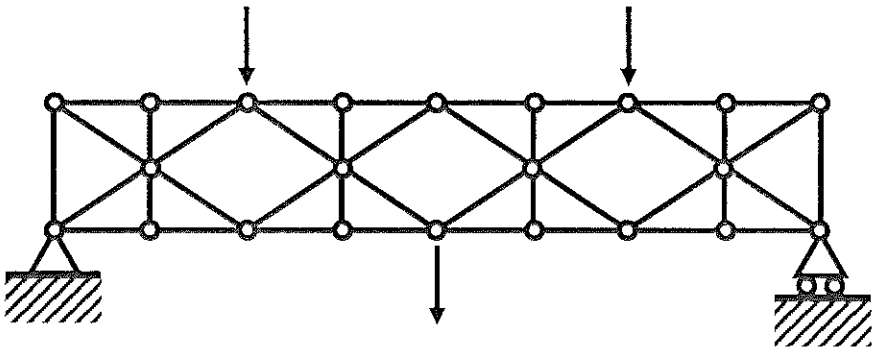
A. 60.00 kN
B. 103.9 kN
C. 120.0 kN
D. 163.9 kN
E. None of the above

5. How many stable structure(s) are shown below?



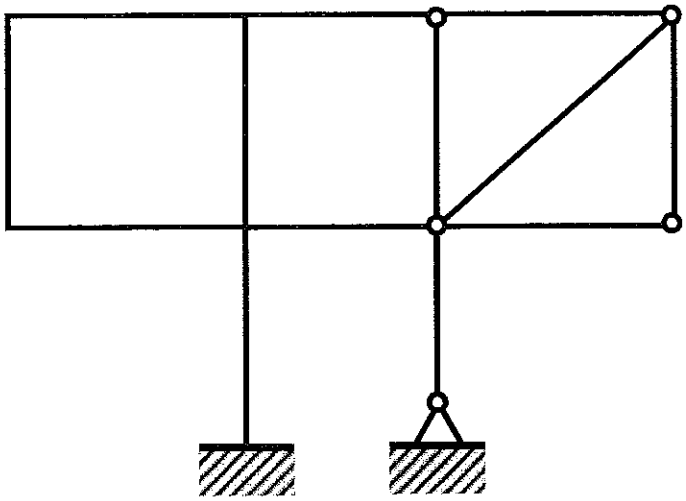
A. 0
B. 1
C. 2
D. 3
E. 4

6. Determine the number of zero-force members for the following truss.



A. 8
B. 10
C. 12
D. 22
E. None of the above

7. Determine the degrees of indeterminacy of the following structure.

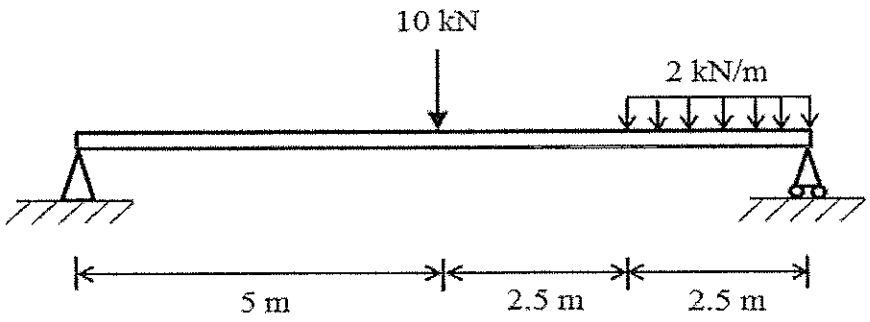


A. 4
B. 5
C. 6
D. 7
E. None of the above

8. Which of the following formulas is the correct definition of Poisson's ratio, where ε_a is the axial strain and ε_l is the lateral strain?

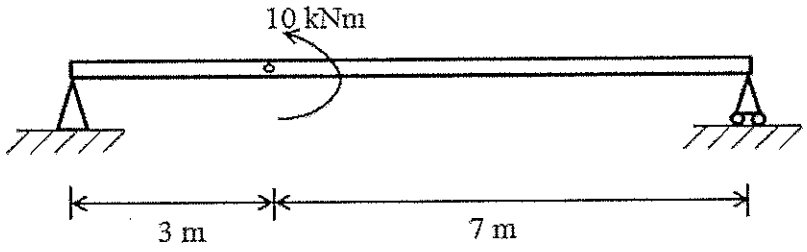
A. $\varepsilon_a/\varepsilon_l$
B. $\varepsilon_l/\varepsilon_a$
C. $-\varepsilon_a/\varepsilon_l$
D. $-\varepsilon_l/\varepsilon_a$
E. $\varepsilon_a \times \varepsilon_l$

9. What is the maximum shear force in the following beam?



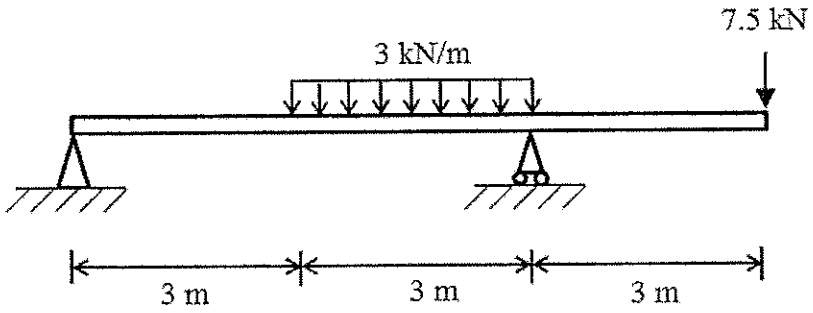
A. 5.000 kN
B. 10.000 kN
C. 5.625 kN
D. 9.375 kN
E. None of the above

10. What is the maximum bending moment in the following beam?



A. 3.0 kNm
B. 5.0 kNm
C. 7.0 kNm
D. 10.0 kNm
E. None of the above

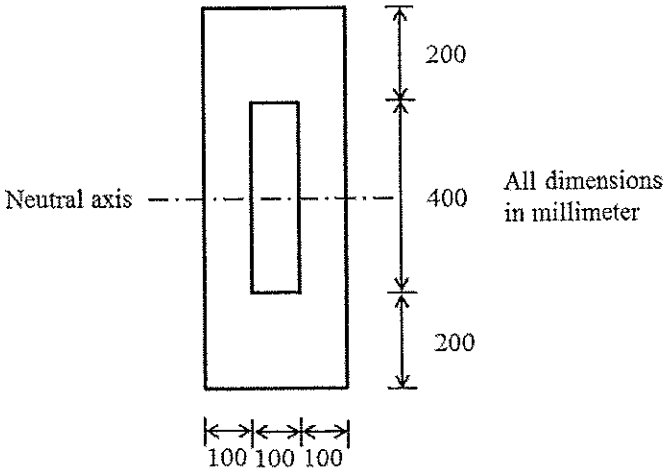
11. What is the maximum hogging moment in the following beam?



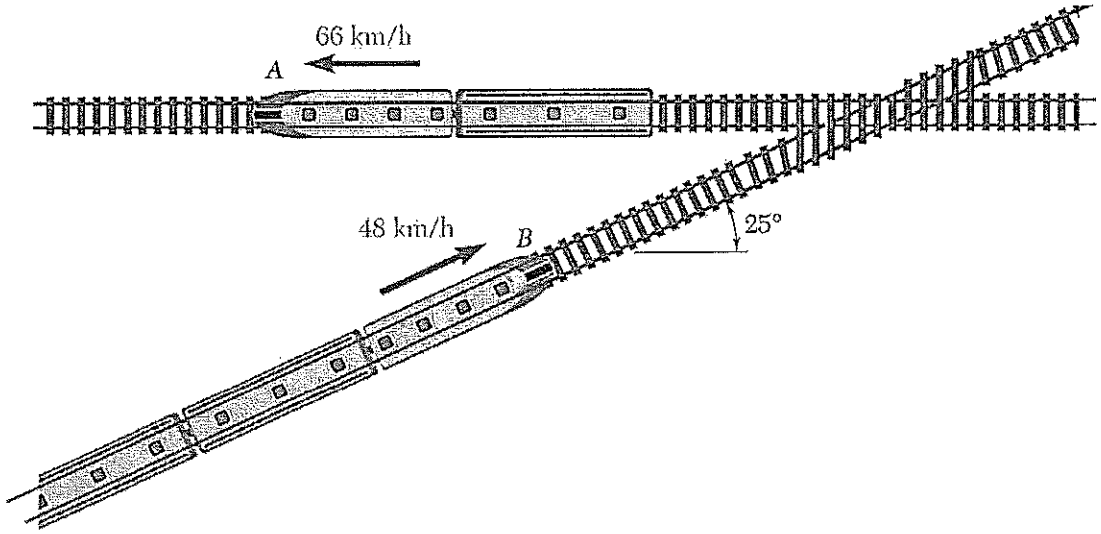
A. 30.0 kNm
B. 9.0 kNm
C. 22.5 kNm
D. 27.0 kNm
E. None of the above

12. What is the second moment of area of the following section?

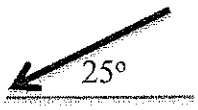
A. 0.53×10^9 mm^4
B. 5.30×10^9 mm^4
C. 12.80×10^9 mm^4
D. 12.27×10^9 mm^4
E. None of the above



13. Two trains (A and B) are traveling along crossing rails with 25 degrees angle, as shown in the figure. Speeds of the trains are 66 km/h west for train A, and 48 km/h northeast for train B. If you are sitting in train B looking out of the window, select the most suitable direction in which train A is moving in your own view.



A. 

B. 

C. 

D. 

E. 

14. For an object travelling in a perfect circle, which of the following is always true?

A. The e_r direction is identical to the e_n direction.
B. The e_q direction is perpendicular to the e_n direction for both polar coordinates and normal-tangential coordinates.
C. The e_q direction could be parallel to the e_r direction, depending on the reference system.
D. The Cartesian coordinate system could not be used for a circular motion.
E. Only the polar coordinate system should be used for a circular motion.

15. The rectilinear motion of a particle is described as:

$$s = t^3 - 10.5t^2 + 30t + 4$$

where s is the displacement in meters, and t is the time in seconds. Determine which of the following statement is true, between $t = 0$ and $t = 4$ s.

A. Displacements at $t = 0$ and $t = 4$ s are 0 m and 16 m.
B. Displacements at $t = 0$ and $t = 4$ s are 4 m and 20 m.
C. There are two turning points where the particle changes direction of motion during the given period.
D. The turning points are: $t = 2$ s, and $t = 3.8$ s.
E. The turning points are: $t = 1$ s and $t = 3.6$ s.

16. A car travels on a Norwegian road on Christmas Eve, at a constant speed of 110 km/hr with tyres of 355 mm radius. A reindeer appeared suddenly in the middle of the road, the driver hit the brakes, generating a constant deceleration of 2.5 m/s^2. For the very instant the brake was just applied, determine which of the following is true:

    A. The angular velocity and acceleration of the car's wheels are 86.1 rad/s and -7.0 rad/s^2, respectively.
    B. The angular velocity and acceleration of the car's wheels are 81.6 rad/s and 6.3 rad/s^2, respectively.
    C. The angular velocity and acceleration of the car's wheels are -81.6 rad/s and -6.3 rad/s^2, respectively.
    D. The angular velocity and acceleration of the car's wheels are -86.1 rad/s and 7.0 rad/s^2, respectively.
    E. None of the above.

17. A circular disc flywheel of 200 g weight and 2 cm radius accelerates from 0 to 2000 rev/min in 8 s. What is the average angular acceleration, and what was the average power needed for the acceleration?

    A. 276 rad/s^2 and 1.2 W
    B. 250 rad/s^2 and 1 W
    C. 79.2 rad/s^2 and 0.89 W
    D. 52.4 rad/s^2 and 0.43 W
    E. 26.2 rad/s^2 and 0.11 W

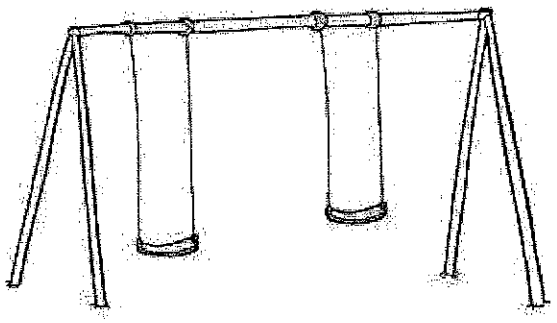
18. A thin-walled circular cylinder rotating around its axis has mass 160 kg and radius 0.34 m. It was used as an energy storage flywheel. In order to accelerate the device from 10000 rpm to 18500 rpm in 10 s, what is the minimum force required, to be applied at the edge of the cylinder?

    A. 500N
    B. 1200N
    C. 2400N
    D. 4800N
    E. 5600N

19. A 1400 kg car driving the above flywheel slows from a speed of 20 m/s to 10 m/s, and the rotational speed of the connected flywheel is increased from 10 000 rpm to 18 500 rpm. What percentage of the car's kinetic energy change is funneled into the flywheel?

    A. 5.7%
    B. 6.6%
    C. 12.2%
    D. 54.4%
    E. 87.3%

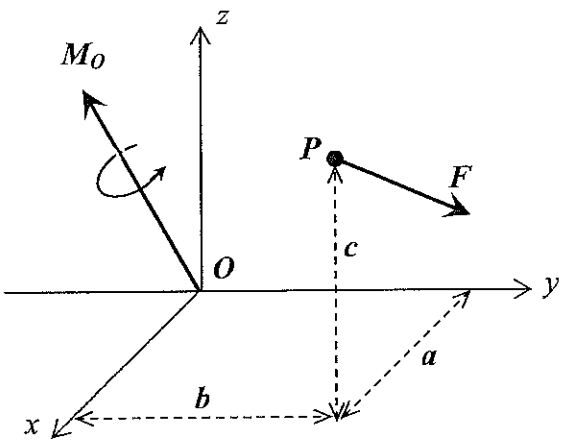
20. Consider the two swings in a community park. The string length of the left (longer) swing is 1.2 times of the right (shorter) string. The left swing has a child of 20 kg and the right swing has another child of 24 kg. Assuming small swinging angles, which of the following statements is true:



A. The two swings will be moving with the same frequency.
B. The left swing will have 1.1 times lower frequency than the right swing.
C. The left swing will have 1.1 time higher frequency than the right swing.
D. The left swing will have 1.2 times higher frequency than the right swing.
E. The left swing will have 1.2 times lower frequency than the right swing.

SECTION B

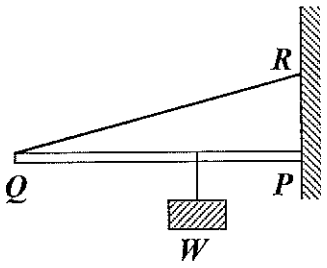
21.



The force $\boldsymbol{F} = \{-5\boldsymbol{i} + 3\boldsymbol{j} - 4\boldsymbol{k}\}$ kN creates a moment about point $\boldsymbol{O}$ of $\boldsymbol{M_O} = \{-17\boldsymbol{i} - 3\boldsymbol{j} + 19\boldsymbol{k}\}$ kNm. If the force passes through point $\boldsymbol{P}$ having a z coordinate of $\boldsymbol{c}$ = 3 m, determine the x and y coordinates of the point $\boldsymbol{P}$, i.e. the values of $\boldsymbol{a}$ and $\boldsymbol{b}$.

A. $\boldsymbol{a}$ = 3 m, and $\boldsymbol{b}$ = 2 m
B. $\boldsymbol{a}$ = 2 m, and $\boldsymbol{b}$ = 3 m
C. $\boldsymbol{a}$ = 2 m, and $\boldsymbol{b}$ = 2 m
D. $\boldsymbol{a}$ = 3 m, and $\boldsymbol{b}$ = 3 m
E. None of the above

22.

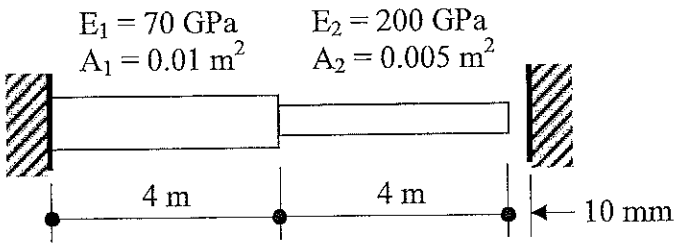


A light rigid rod $\boldsymbol{PQ}$ is hinged smoothly to the wall at one end while the other end is connected by an inextensible string to a point $\boldsymbol{R}$ directly above $\boldsymbol{P}$. A weight $\boldsymbol{W}$ is suspended from a point on the rod. If the rod remains horizontal, which of the following change(s) would **increase** the tension in the string?

(1) Shifting the weight towards $\boldsymbol{Q}$
(2) Replacing the string with a shorter one and connecting it to the mid-points of $\boldsymbol{PQ}$ and $\boldsymbol{PR}$
(3) Replacing the string with a longer one and connecting it to a point higher than $\boldsymbol{R}$

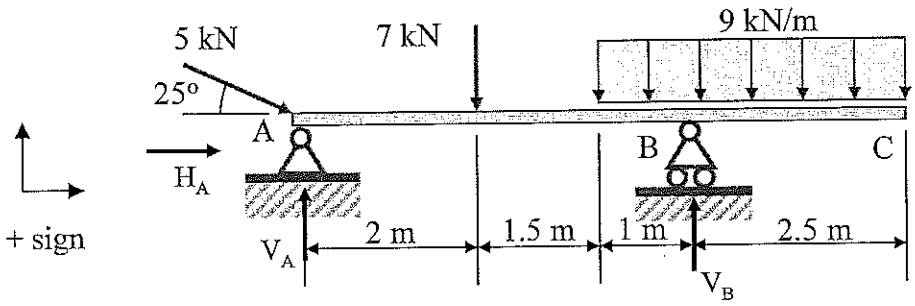
A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only
E. (1), (2) and (3)

23. A bar with two different sections is shown below. Determine the axial force required to close the 10 mm gap.



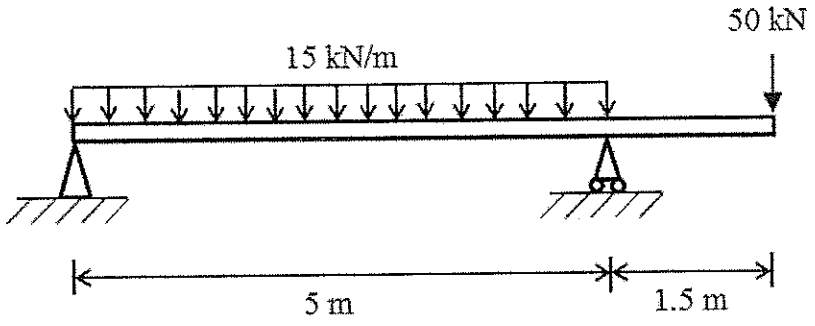
A. 380 kN
B. 830 kN
C. 1030 kN
D. 1300 kN
E. None of the above

24. Determine all the reactions of the beam as shown below.



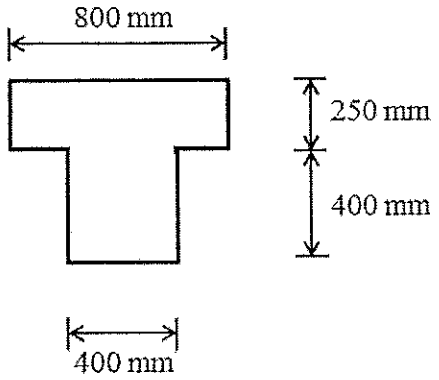
A. $H_A = 4.5$ kN, $V_A = -0.8$ kN and $V_B = 38.7$ kN
B. $H_A = -1.3$ kN, $V_A = 2.0$ kN and $V_B = 38.7$ kN
C. $H_A = -1.3$ kN, $V_A = 2.0$ kN and $V_B = 39.9$ kN
D. $H_A = -4.5$ kN, $V_A = 0.8$ kN and $V_B = 38.7$ kN
E. $H_A = -4.5$ kN, $V_A = 0.8$ kN and $V_B = 39.9$ kN

25. What are the absolute values of maximum shear force and maximum sagging moment in the following beam?



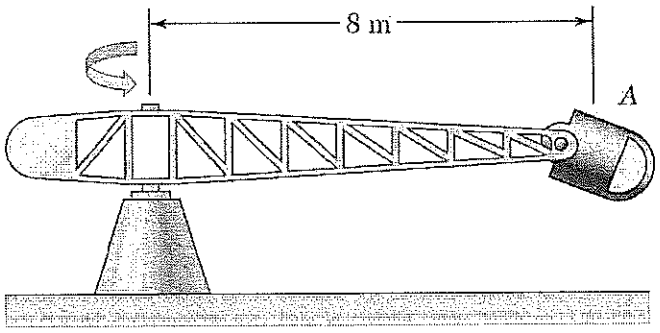
A. 72.5 kN and 16.875 kNm
B. 52.5 kN and 16.875 kNm
C. 72.5 kN and 33.750 kNm
D. 52.5 kN and 33.750 kNm
E. None of the above

26. What are the absolute values of maximum tensile stress and maximum compression stress in the following section, which is subjected to a sagging moment of 50 kNm?



A. 1.51 MPa and 1.07 MPa
B. 1.27 MPa and 1.07 MPa
C. 1.27 MPa and 1.79 MPa
D. 1.99 MPa and 1.79 MPa
E. None of the above

27. A centrifuge cab with 8 m radius rotates within a horizontal plane perpendicular to the paper. The tangential acceleration of the cab is $a_t = 0.5t$ (m/s^2), where t is the time in seconds. Starting from rest with zero initial velocity, which one of the following best describes the tangential velocity and the total acceleration magnitude at $t = 10$ s:

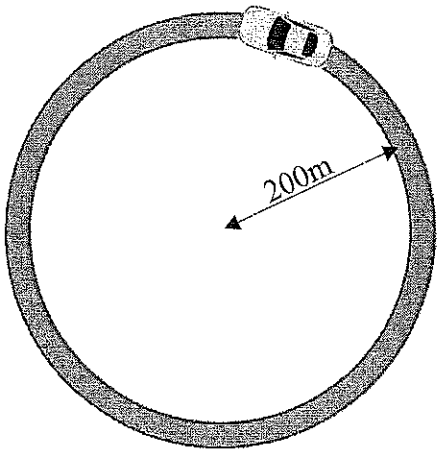


A. 25 m/s and 5 m/s^2
B. 2.5 m/s and 78.125 m/s^2
C. 25 m/s and 78.3 m/s^2
D. 2.5 m/s and 83.125 m/s^2
E. 2.5 m/s and 5 m/s^2

28. A sports car starts accelerating from rest, following the relationship of:

$$a = 3 - 0.001v^2$$

It travels around a circular track with a radius of 200 m. Determine the velocity of the car after traveling halfway around the track, and the maximum possible speed.



A. 41.4 m/s and 105.7 m/s
B. 27.1 m/s and 83.4 m/s
C. 49.2 m/s and 57.1 m/s
D. 46.3 m/s and 54.8 m/s
E. 47.8 m/s and 105.8 m/s

29. A jet plane of mass 7.5×10^3 kg takes off from an aircraft carrier that sails with a speed of 50 km/h. The jet plane engine's thrust in the horizontal direction varies with the following function:

$$F = 2 \text{ kN for } 0 \leq t \leq 2,$$
$$F = 10 \text{ kN for } 2 \leq t \leq 10,$$

where t is time in seconds. Which of the following is closest to the plane's initial linear momentum, and the horizontal speed after 5 s?

A. 1.04×10^5 Ns and 66.32 m/s
B. 1.04×10^5 Ns and 18.5 m/s
C. 3.75×10^4 Ns and 48.6 m/s
D. 3.75×10^4 Ns and 13.5 m/s
E. 3.75×10^4 Ns and 66.4 m/s

30. A driver is driving a car weighing 500 kg at 72 km/hr on a straight road. The maximum braking force of the car, when the brake is fully applied, is 10 kN. After seeing a reindeer in the far distance, the driver took 0.8 s to respond, after which he applied the brake fully to stop the car.

(a) Determine the minimum distance the car travelled between the first moment the driver saw the reindeer, and the moment it came to a complete stop.
(b) If the car was traveling at 108 km/h, will the driver still be able to stop the car within the same distance, if he had responded more quickly?

A. (a) 187.2 m and (b) Yes
B. (a) 187.2 m and (b) No
C. (a) 26 m and (b) Yes
D. (a) 10 m and (b) No
E. (a) 26 m and (b) No

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