國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：基礎熱傳學【機電系碩士班甲組】

－作答注意事項－

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
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- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：基礎熱傳學【機電系碩士班甲組】　　題號：438003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. (10%) For a porous medium (**Fig. 1**), determine the range of the "effective" thermal conductivity (k_{eff}). (ε: Volume fraction of fluid, k_s: Solid thermal conductivity, and k_f: Fluid thermal conductivity.)

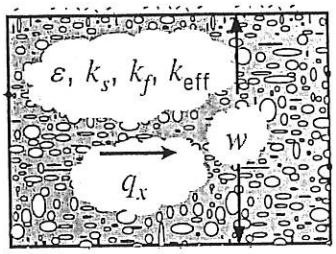

Fig. 1

2. (10%) A steam pipe is wrapped with insulation of inner and outer radii, r_i and r_o, respectively. At a particular instant, the temperature distribution in the insulation is known to be of the form.

$$T(r) = C_1 \ln\left(\frac{r}{r_o}\right) + C_2 \qquad (C_1 \text{ and } C_2 \text{ are constants.})$$

   (a) (4%) Are the conditions steady-state or transient?
   (b) (6%) How do the heat flux and heat rate vary with radius?

3. (10%) A thin electrical heater is attached to a plate and backed by insulation, as shown in **Fig. 2**. The heater and plate are initially at the temperature of the ambient air, T_∞. Suddenly, the power of the heater is activated, yielding a constant heat flux, q_e'' at the inner surface of the plate.
   (a) (7%) Sketch, as functions of x, and label the temperature distributions: initial, steady-state, and at two intermediate times.
   (b) (3%) Sketch the temperature at the outer surface, $T(L, t)$, as a function of time.

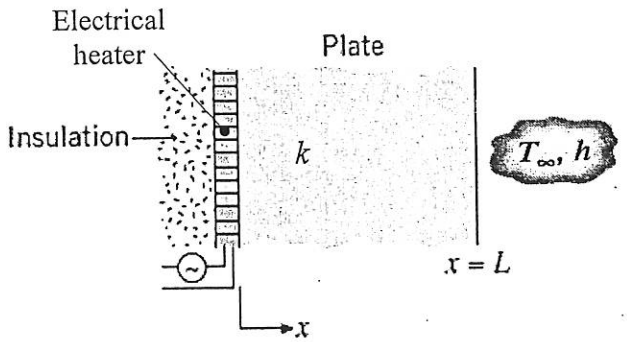

Fig. 2

4. (20%) Derive the temperature distribution and fin efficiency for a pin fin, as shown in **Fig. 3**, with adiabatic boundary at $x=L$. The pin base temperature ($x=0$) is T_b. (Write down your assumption and derivation in detail.)

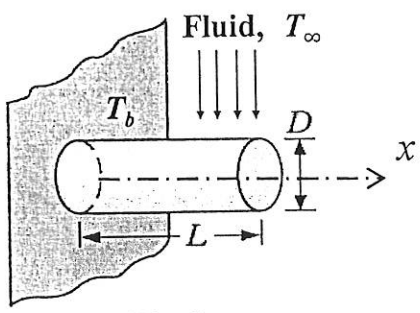

Fig. 3

5. (20%) For a heat transfer problem, the energy equation can be simplified and expressed as $\frac{\partial\theta}{\partial t}=\frac{\partial^2\theta}{\partial x^2}$ non-dimensionally, and the boundary and initial conditions are $\frac{\partial\theta}{\partial x}(0,t)=0$, $\frac{\partial\theta}{\partial x}(L,t)=0$ for all $t\geq 0$, and $\theta(x,0)=cos\frac{2\pi}{L}x$. Solve the non-dimensional temperature θ.

6. (15%) In a two-dimensional cylindrical configuration, the radial (Δr) and angular ($\Delta\phi$) spacings of the nodes are uniform. The inner boundary at $r=r_i$ is of uniform temperature T_i. The boundaries in the radial direction are adiabatic (insulated) and exposed to surface convection (T_∞, h), as illustrated in **Fig. 4**. Derive the finite-difference equations for (i) node 1, (ii) node 2, and (iii) node 3.

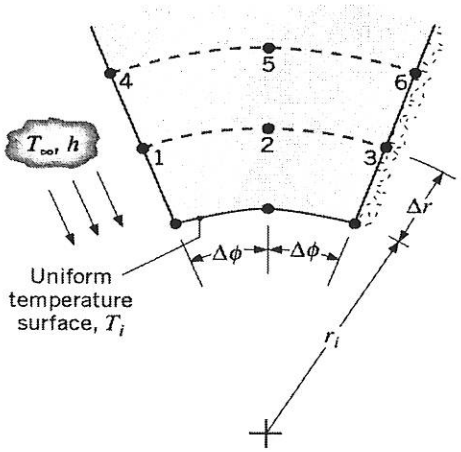

Fig. 4

7. (15%) A thin rod of diameter D, shown in **Fig. 5,** is initially in equilibrium with its surroundings, a large vacuum enclosure at temperature T_{sur}. Suddenly, an electrical current I (Ampere) is passed through the rod having an electrical resistivity ρ_e ($\Omega\cdot$ m) and emissivity ε. Other pertinent thermophysical properties are identified in **Fig. 5**. Derive the transient, finite-difference equation for node m. (P.S.: The resistance $R=\rho_e\frac{l}{A}$; l: Length, A: Area)

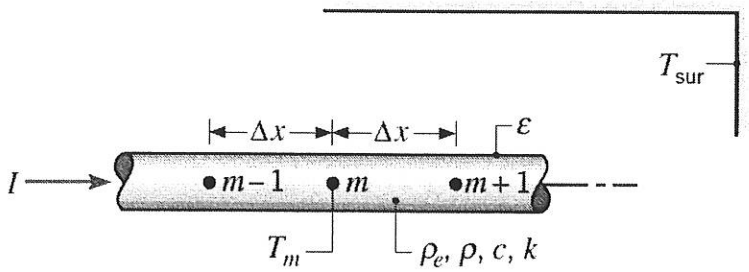

Fig. 5

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：應用力學(含靜力學及動力學)【機電系碩士班乙組】

—作答注意事項—

考試時間：100分鐘

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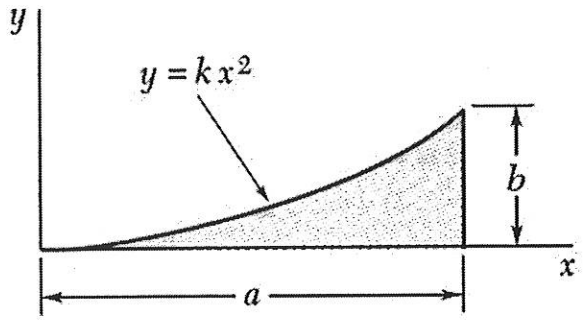
國立中山大學 110 學年度碩士暨碩士專班招生考試試題

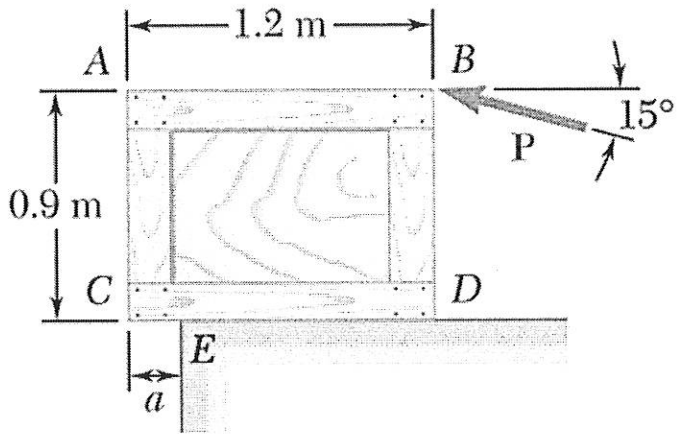
科目名稱：應用力學(含靜力學及動力學)【機電系碩士班乙組】　　題號：438008

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）(問答申論題)　　

1. **(15%)** Determine **by direct integration the location of the centroid of a parabolic spandrel**.



2. **(20%)** A worker slowly moves **a 50-kg crate** to the left along a loading dock by applying **a force P** at corner B as shown. Knowing that the crate starts to tip about the edge E of the loading dock when ***a* = 200 mm**, determine (a) **the coefficient of kinetic friction** between the crate and the loading dock, (b) the corresponding **magnitude P of the force**.



國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：應用力學(含靜力學及動力學)【機電系碩士班乙組】　　題號：438008

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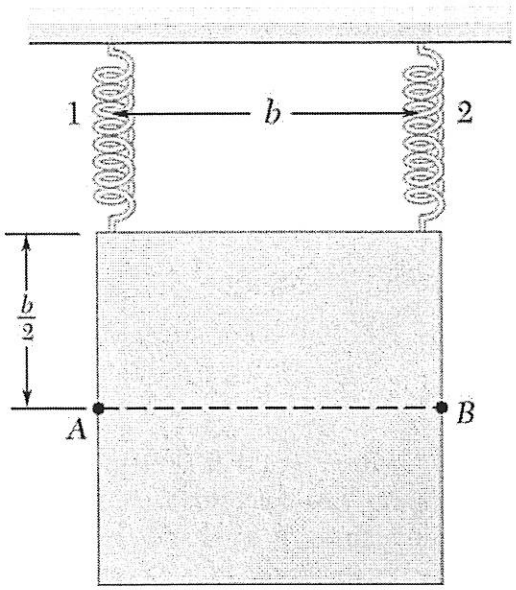
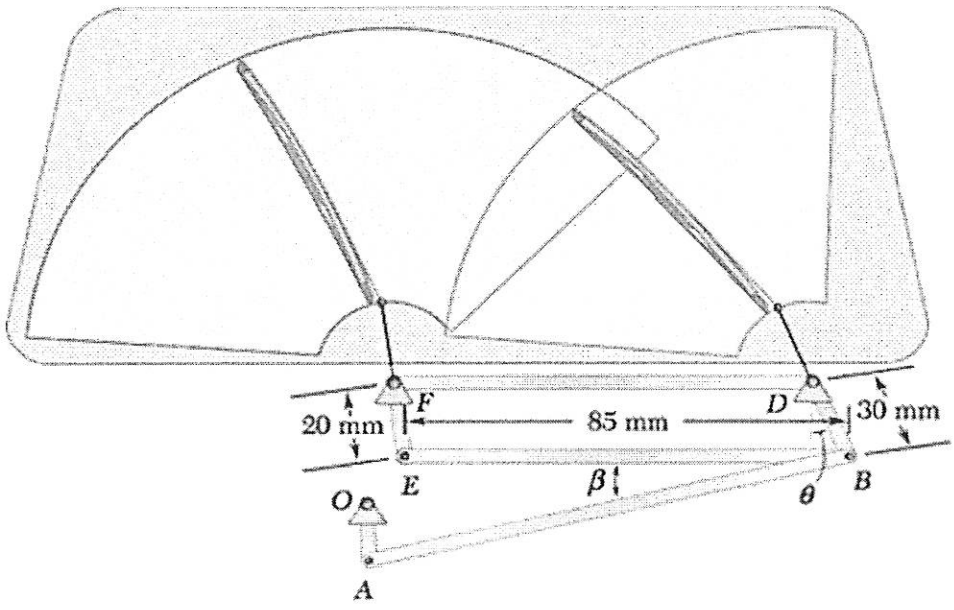
3. **(15%) A thin plate of the shape** (A square plate of side b) indicated and of **mass *m*** is suspended from **two springs** as shown. If **spring 2 breaks**, determine **the acceleration at that instant (a) of Point A, (b) of Point B**.

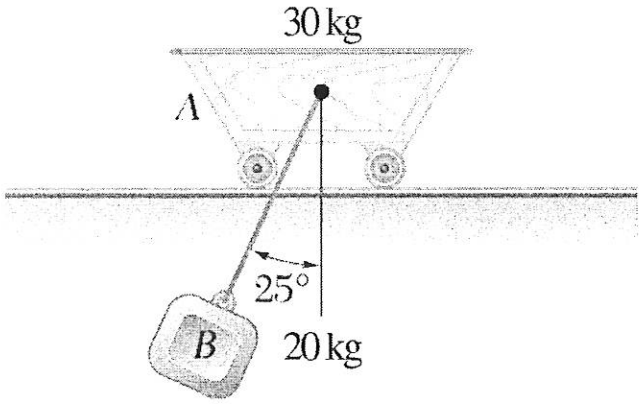


4. **(15%)** Linkage *DBEF* is part of a windshield wiper mechanism, where points *O*, *F* and *D* are fixed pinned connections. At the position shown, $\boldsymbol{\theta = 60°}$ and link *EB* is horizontal. Knowing that link *EF* has **a counterclockwise angular velocity of 4 rad/s** at the instant shown, determine **the angular velocity of links *EB* and *DB***.

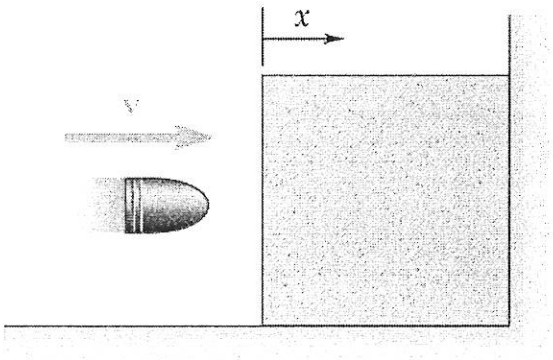


試題請隨卷繳回，請留意背面是否有題

5. **(15%) A 30-kg block** rests on top of **a 20-kg block** supported by, but not attached to, a **spring of constant 40 N/m**. The upper block is suddenly removed. Determine **(a) the maximum speed** reached by **the 20-kg block**, (**b) the maximum height** reached by the **20-kg block**.



6. **(20%)** A projectile enters a resisting medium at $x = 0$ with an initial velocity $v_0 = 270$ **m/s** and travels **100 mm** before coming to rest. Assuming that the velocity of the projectile is defined by the relation $v = v_0 - kx$, where v is expressed in **m/s** and x is in **m**, determine **(a) the initial acceleration of the projectile**, **(b) the time required** for the projectile to penetrate **97.5 mm** into the resisting medium.



國立中山大學 110 學年度
碩士暨碩士專班招生考試試題

科目名稱：材料力學【機電系碩士班乙組】

－作答注意事項－

考試時間：100 分鐘

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國立中山大學 110 學年度碩士暨碩士專班招生考試試題

科目名稱：材料力學【機電系碩士班乙組】　　題號：438006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

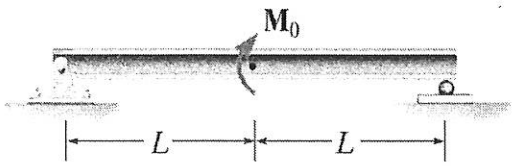
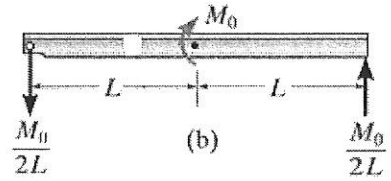
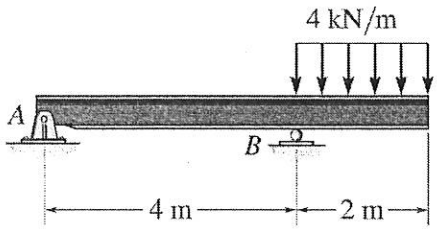
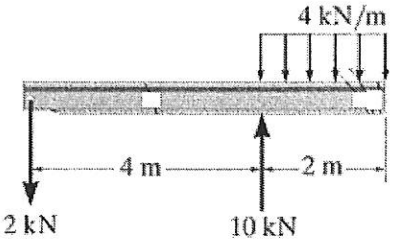
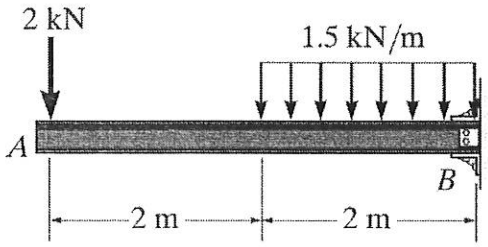
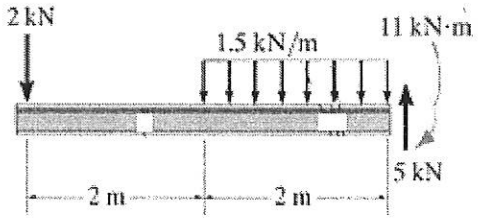
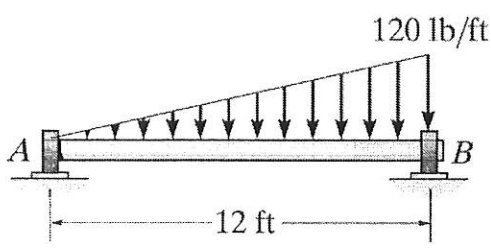
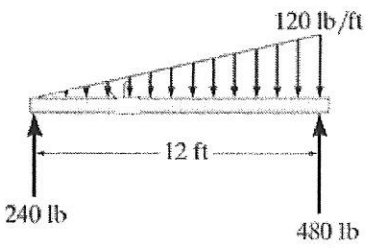
Prob. #1 (20 %)

簡答題：請以中文解釋（或回答）

(a) Draw the general state of plane stress at a point. (4 %)
(b) What's the difference between normal and shear strain? (4 %)
(c) Anisotropic material. (2 %)
(d) Axially loaded bar. (2 %)
(e) Factor of safety. (2 %)（請利用公式說明）
(f) How to define *thin wall?* (2 %)
(g) What's the benefit of using Mohr's circle? (2 %)
(h) Statically determinate problem. (2 %)

Prob. #2 (20 %)

Draw the shear and moment diagrams for the following beams.（請清楚標示相關參數及數值、畫出 **V-及M-Diagram**，不必說明如此標示或畫圖的理由；每小題錯一個扣一分，扣至5分為止）

編號	Beams	F.B.D.
(1) (5%)		
(2) (5%)		
(3) (5%)		
(4) (5%)		

Prob. #3 (30 %)

The assembly consists of two posts *AB* and *CD* each made from material 1 having a modulus of elasticity of E_1 and a cross-sectional area A_1, and a central post made from material 2 having a modulus of elasticity E_2 and cross-sectional area A_2. If a load **P** is applied to the rigid cap, determine the force in each material. （請注意：Free body diagram、Equilibrium equations 以及 Compatibility都必須清楚標示出來）

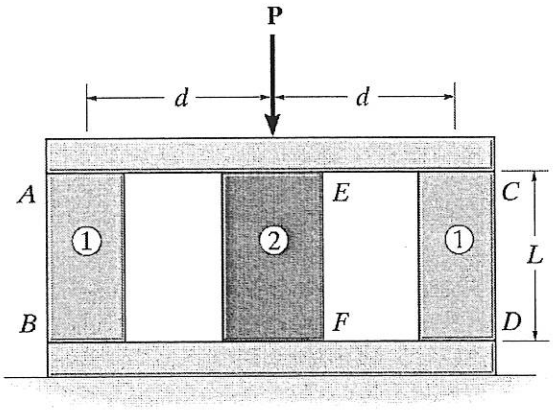
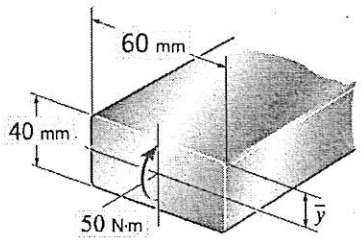


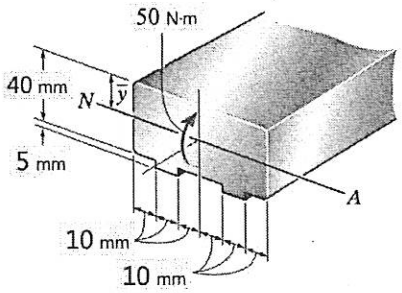
Figure 1 **Prob. #3**

Prob. #4 (30 %)

The member shown in Figure 2(a) having a rectangular cross section is designed to resist a moment of 50 N · m. In order to increase its strength and rigidity, the engineer is planning to add two small ribs at its bottom, Figure 2(b). Is this a good idea? Answer this question by determining and comparing the maximum normal stress in the member for both cases.



(a)



(b)

Figure 2 **Prob. #4**

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：工程數學【機電系碩士班乙組、丙組】

—作答注意事項—

考試時間：100分鐘

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國立中山大學 110 學年度碩士暨碩士專班招生考試試題

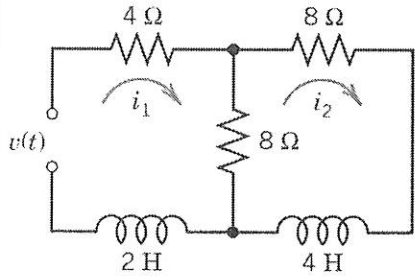
科目名稱：工程數學【機電系碩士班乙組、丙組】　　題號：438001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. Find the general solution of the first-order ODE: $(2x^3 + y^3)dx - 3xy^2dy = 0$. (10%)

2. Given a system of ODE: $y_1' = y_1 + 2y_2 + e^{2t} - 2t$, $y_2' = -y_2 + 1 + t$, $y_1(0) = 14$, $y_2(0) = -4$.
(a) Represent it as a vector equation $\mathbf{y}' = \mathbf{Ay} + \mathbf{g}$. (5%)
(b) Find the eigenvalues and eigenvectors of $\mathbf{A}$. (5%)
(c) Find the general solution of the system. (5%)
(d) Find the particular solution. (5%)

3. Using Laplace transforms, find the current $i_1(t)$ and $i_2(t)$ in the following figure, where $v(t) = 390\cos(t)$ and $i_1(0) = i_2(0) = 0$.



(a) Set up the model. (5%)
(b) Find $I_1(s)$ and $I_2(s)$. (10%)
(c) Find $i_1(t)$ and $i_2(t)$. (5%)

4. Let

$$\mathbf{A} = \begin{bmatrix} 2 & -1 & 3 \\ -2 & 1 & 4 \\ 1 & 2 & -2 \end{bmatrix}, \quad \mathbf{B} = \begin{bmatrix} -1 & 3 & 0 \\ -3 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}$$

$$\mathbf{C} = \begin{bmatrix} 1 & 1 \\ -2 & 2 \\ 2 & 0 \end{bmatrix}, \quad \mathbf{a} = [-1 \quad -2 \quad 0], \quad \mathbf{b} = \begin{bmatrix} 3 \\ -1 \\ 1 \end{bmatrix}.$$

Calculate the following expressions or give reasons why they are undefined:
(a) $(3\mathbf{A} - 2\mathbf{B})^T$ (5%)
(b) $(3\mathbf{A} - 2\mathbf{B})^T\mathbf{a}^T$ (5%)

5. Find an eigenbasis and perform diagonalization on the following matrix. (10%)

$$\begin{bmatrix} -12 & 22 & 6 \\ 8 & 2 & 6 \\ -8 & 20 & 16 \end{bmatrix}$$

國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【機電系碩士班乙組、丙組】　　題號：438001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

6. Let **a** = [4, 7, 0], **b** = [3, −1, 5], **c** = [−6, 2, 0], and **d** = [1, −2, 8]. Find the angle between **a** and **c**. Between **b** and **d**. (10%)

7. Calculate this line integral by Stokes's theorem for the given **F** and **C**. Assume the Cartesian coordinates to be right-handed and the z-component of the surface normal to be nonnegative.
F = [0, z^3, 0], **C** the boundary curve of the cylinder $x^2 + y^2 = 1$, $x \geqq 0$, $y \geqq 0$, $0 \leqq z \leqq 1$ (10%)

8. Solve $y'' + \omega^2 y = r(t)$, where $|\omega| \neq 0, 1, 2, \cdots$. $r(t)$ is 2π-periodic and $r(t) = 3t^2$ $(-\pi < t < \pi)$. (10%)

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：自動控制【機電系碩士班丙組】

—作答注意事項—

考試時間：100分鐘

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國立中山大學 110 學年度碩士暨碩士專班招生考試試題

科目名稱：自動控制【機電系碩士班丙組】　　題號：438005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. A transfer function $G(s)$ is given as $\frac{Y(s)}{R(s)} = \frac{2}{(s+1)^2}$, where $R(s)$ and $Y(s)$ stand for the input and the output, respectively. Define $r(t) = \mathcal{L}^{-1}\{R(s)\}$ and $y(t) = \mathcal{L}^{-1}\{Y(s)\}$, where $\mathcal{L}$ represents the Laplace transform operator.
   (1) (10%) If $r(t) = 2\cos(t+\theta)$ and $y(t) = A\cos(t+45°)$, obtain values of θ and A.
   (2) (20%) Given a unit step input, it is known that $y(2) = 2 + e^{-2}$ and $\dot{y}(0) = 4$. Determine $y(t)$ using the inverse Laplace transform approach without solving differential equations.

2. Consider a unity feedback system with plant transfer function
$$G(s) = \frac{1}{(s+2)^2(s+10)}$$
and a proportional controller K, which is a positive gain.
   (1) (10%) The control objective is 2% settling time of the dominant poles needs to be 4 sec. Find the value of K to meet this requirement.
   (2) (10%) The control objective is damping ratio of the dominate poles is equal to 0.707. Design the value of K in order to reach this goal.

3. (26%) With $r(t)$ as the input and $y(t)$ as the output, this problem considers a linear system that can be represented by $Y(s) = (s+2)e^{-Ts}R(s)$ where $R(s)$ and $Y(s)$ are the Laplace transforms of $r(t)$ and $y(t)$, respectively. With $r(t) = \cos 2t$, it is known that the steady-state response of this system can be represented as $A\cos(\alpha t - \pi)$. Based on such information, please determine A, α, and T.

4. (24%) This problem considers six transfer functions $G1 = 1/(s+1)$, $G2 = 2/(s+2)$, $G3 = 1/(s^2+s+1)$, $G4 = 3/(s^2+s+3)$, $G5 = 2/(s^2+3s+2)$, and $G6 = (s+10)/((s^2+s+10)$. Their step responses (A1, A2 , ….., A6) are amplitude spectra (B1, B2 , ….., B6) are given in the figures shown in the following pages. Please pair each of the transfer functions to one of the step responses and one of the amplitude spectra. (That is, if you think A1 is the step response of G1 and B1 is the amplitude spectrum of G1, write your answer for G1 as G1-A1-B1. Please present your answers in this way for all the six transfer functions considered in this problem.

國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：自動控制【機電系碩士班丙組】　　題號：438005

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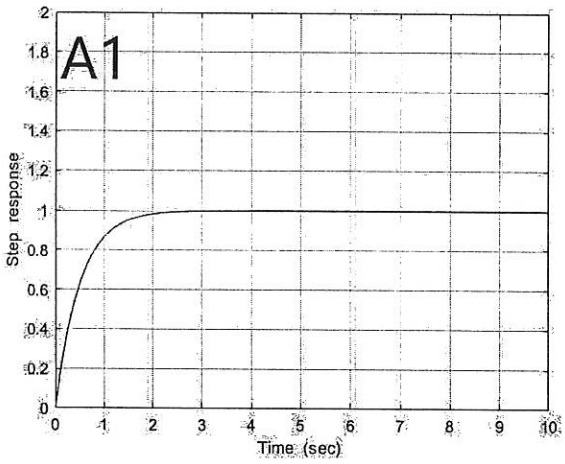

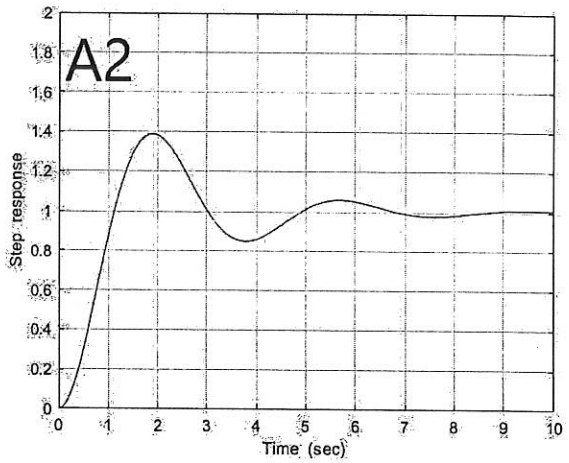

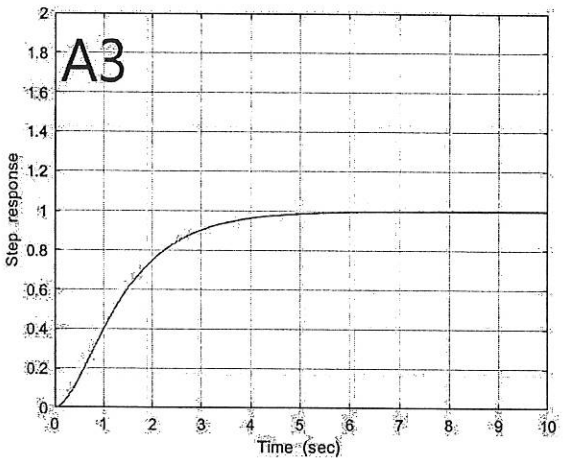

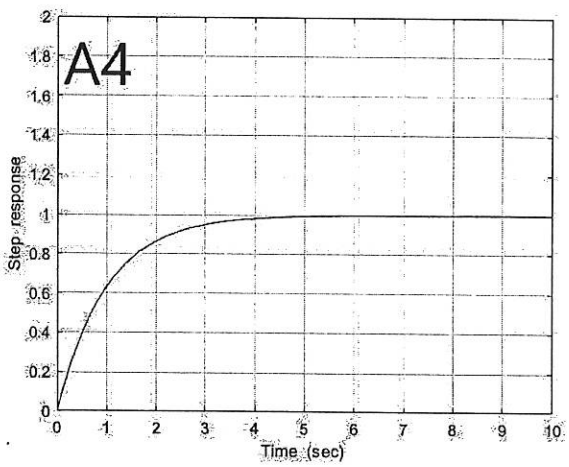

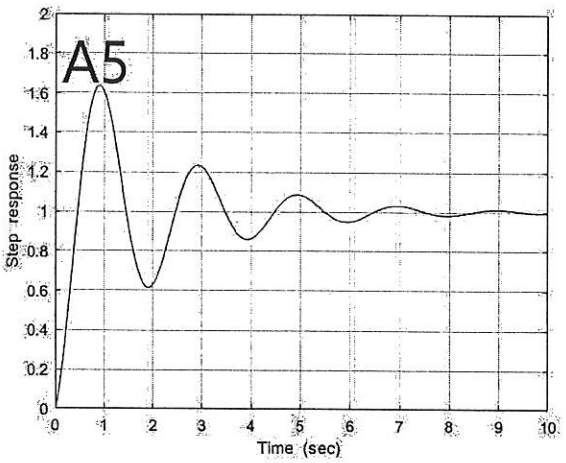

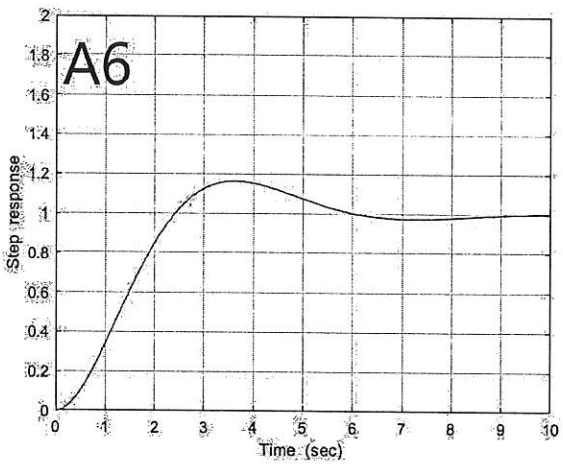

試題請隨卷繳回，請留意背面是否有題

國立中山大學 110 學年度碩士暨碩士專班招生考試試題

科目名稱：自動控制【機電系碩士班丙組】　　題號：438005

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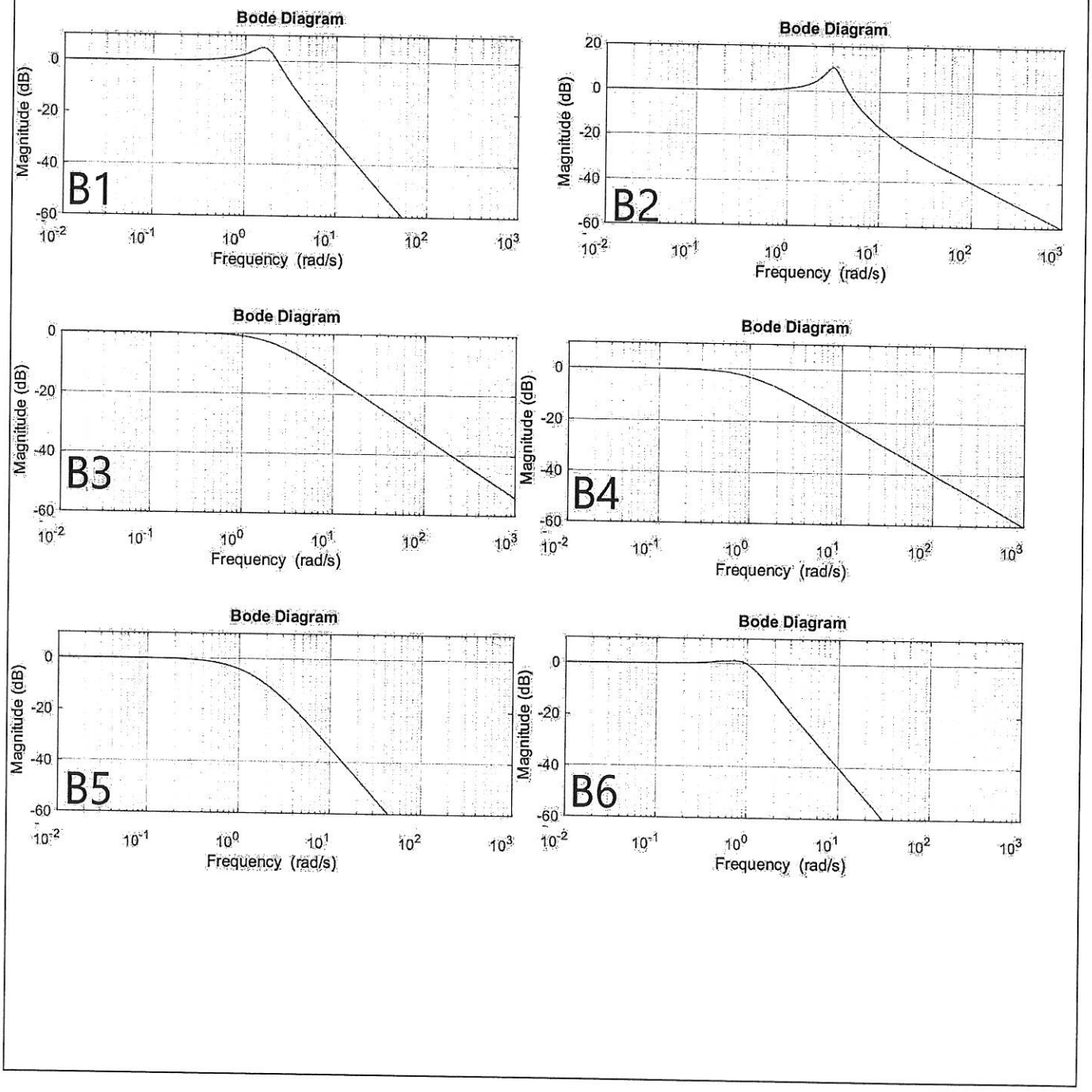

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：靜力學【機電系碩士班丁組】

—作答注意事項—

考試時間：100分鐘

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國立中山大學 110 學年度碩士暨碩士專班招生考試試題

科目名稱：靜力學【機電系碩士班丁組】　　題號：438004

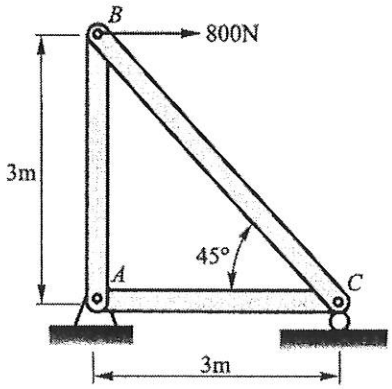
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1.Please explain the physical meanings of following things:

(a) Principle of transmissibility (5%)
(b) Rigid body (5%)
(c) Moment of inertia (5%)
(d) Centroids (5%)
(e) Center of gravity (5%)
(f) Force couple (5%)
(g)Virtual work (5%)

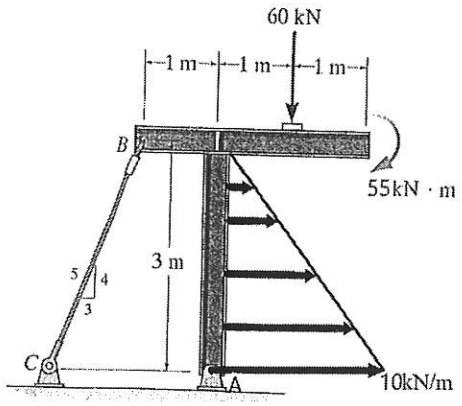
2. What conditions are required for a three-dimensional rigid body in equilibrium? (10%)

3. 如圖一所示(**Figure 1**)
Please find the forces on AB, AC, and BC. The pin and roller supporters are at A and C, respectively. Neglect the weight of all objects (15%)



圖一（**Figure 1**）

4. 如圖二所示(**Figure 2**)
A T-shaped frame is held in static equilibrium by a pin support at A and cable BC at B. The frame is loaded with a distrusted load, a point load (60 kN) and couple (55kN.m)
(a) Please find the equilibrium force for the distributed load and its distance from pin A. (5%)
(b) Plot the free body diagram of T-shaped frame. (5%)
(c) Find the tension force in cable BC and at pin A. (10%)



圖二（**Figure 2**）

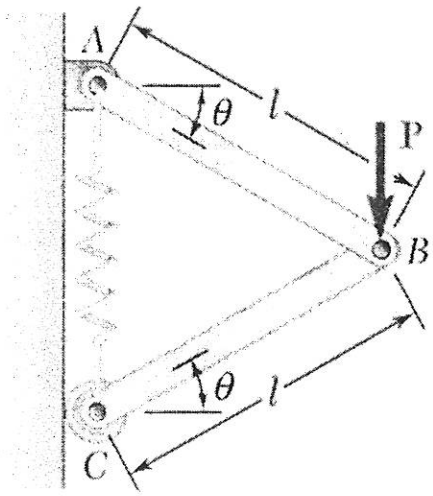
國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：靜力學【機電系碩士班丁組】　　題號：438004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

5. 如圖三所示(**Figure 3**)

Determine θ and the tension in the spring, which correspond to the equilibrium position of the spring. The unstretched length of spring is h and the constant of the spring is k. The pin and roller supporters are at A and C, respectively. The point load P works on B with the downward direction and neglect the weight of all objects. (20%)



圖三（**Figure 3**）

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：動力學【機電系碩士班丁組】

—作答注意事項—

考試時間：100分鐘

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國立中山大學 110 學年度碩士暨碩士專班招生考試試題

科目名稱：動力學【機電系碩士班丁組】　　題號：438007

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. As shown in Figure 1, a ball is thrown so that the motion is defined by the equations $x = 3t$ and $y = 2 + 6t - 3t^2$, where x and y are expressed in meters and t is expressed in seconds. Determine (a) the velocity at $t = 2$s, (b) the horizontal distance the ball travels before hitting the ground. (20%)

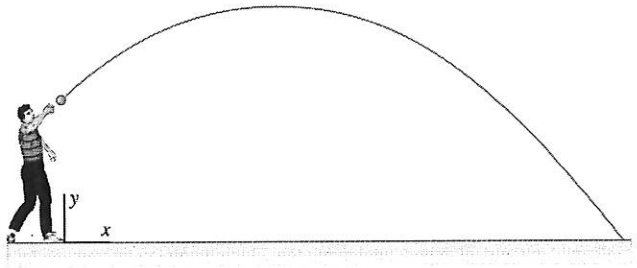

Figure 1.

2. In Figure 2, as the truck shown begins to back up with a constant acceleration of 0.6 m/s^2, the outer section B of its boom starts to retract with a constant acceleration of 0.24 m/s^2 relative to the truck. Determine (a) the **acceleration** of section B, (b) the **velocity** of section B when $t = 4$ s. (20%)

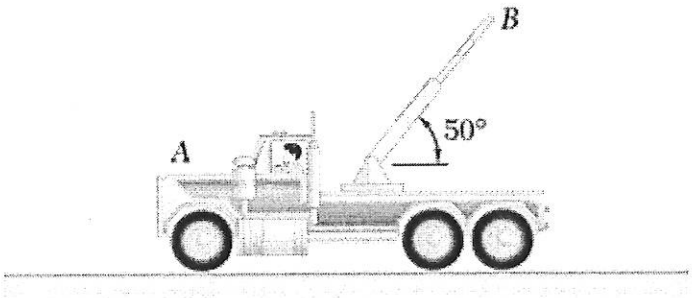

Figure 2.

3. Two rods AB and DE are connected as shown in Figure 3. Knowing that Point B moves downward with a velocity of 500 mm/s, determine (a) the **angular velocity** of each rod, (b) the **velocity** of Point E. (20%)

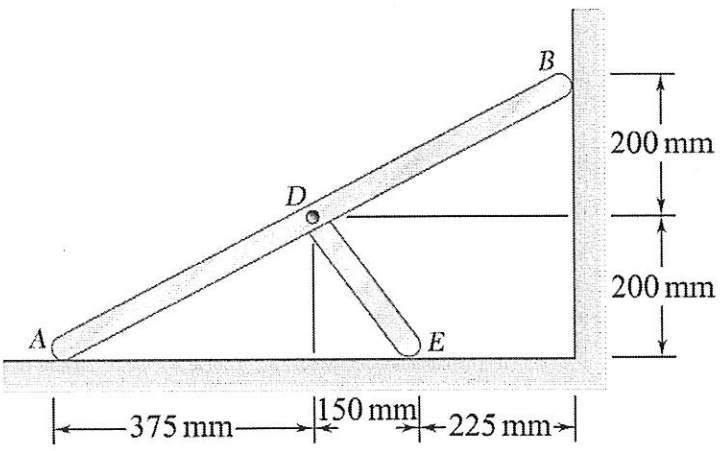

Figure 3.

4. A beam AB of length L and mass M is supported by two cables as shown in Figure 4. If cable BD breaks, determine at that instant the **tension** in the remaining cable as a function of its initial angular orientation θ. (20%)

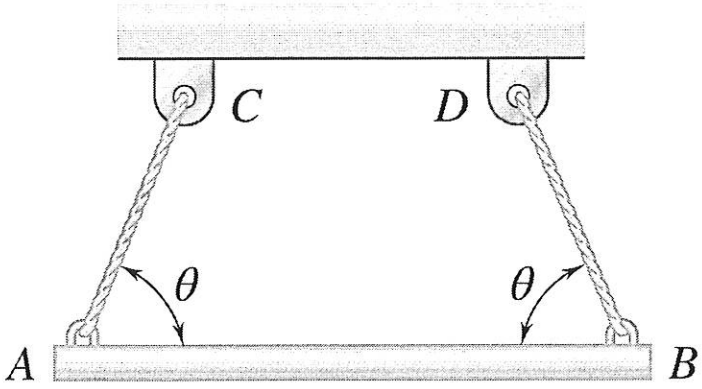

Figure 4.

5. As shown in Figure 5, a 1-kg block A is pushed up against a spring compressing it a distance x. The block is then released from rest and slides down the 20° incline until it strikes a 1-kg sphere B which is suspended from a 1-m inextensible rope. The spring constant k =800 N/m, the coefficient of friction between A and the ground is 0.2, the distance A slides from the unstretched length of the spring d =1.5 m and the coefficient of restitution between A and B is 0.8. Knowing the tension in the rope is 20 N when $\alpha = 20^\circ$, determine initial **compression** x of the spring. (20%)

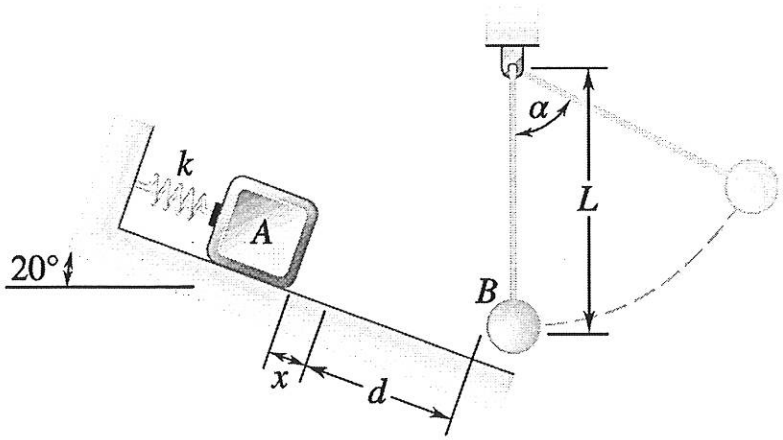

Figure 5.

國立中山大學110學年度
碩士暨碩士專班招生考試試題

科目名稱：科技英文【機電系碩士班戊組】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，不得另攜帶紙張，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，其後果由考生自行負擔。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學110學年度碩士暨碩士專班招生考試試題

科目名稱：科技英文【機電系碩士班戊組】　　題號：438002

※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

1. Please read the following article and answer the question below:

LIDAR, short for light detection and ranging, is a remote-sensing method that measures distances between objects through the use of pulsed laser light. The systems help autonomous vehicles maneuver. They're used in airports to monitor the flow of passengers in real-time, and by manufacturers to monitor supply chains. As the global pandemic continues, some manufacturers are realizing they can repurpose their LIDAR systems for monitoring employee distancing. For manufacturers, there is no remote work option. As they reopen in the face of COVID-19, they need to take extra precautions, including remote temperature sensing.

The CyLab researchers developed an algorithm to measure forehead temperatures on multiple faces. They fused data returned from multiple sensors and data sources, including thermal and visual, to find the desired accuracy. The new system reduces false negative and false positive detection results. It also self-calibrates its own measurements to include factors of distance and ambient temperature.

Please translate the following terms into Chinese **(3% for each)**

(A) remote-sensing
(B) real-time
(C) manufacturers
(D) global pandemic
(E) employee
(F) precautions
(G) algorithm
(H) fused data
(I) false negative
(J) ambient temperature

2. Translate the following two sentences into Chinese: **(10% for each)**

(A) IoT and digitization are not new, but I will say COVID-19 has accelerated that trend, it's making a lot of equipment manufacturers realize they need that connection.

(B) The machine data collected allows the firm to provide preventive maintenance. Local service teams can deliver the right spare part at the right time for faster fault resolution, saving costs associated with breakdowns and production loss.

3. Read the following article and fill in the correct "preposition" (介係詞) **(3% for each)**

The global supply chain is a finely tuned machine, funneling components __(A)__ across the globe to manufacturers who assemble them into finished products. It's built __(B)__ a foundation of lean manufacturing principles, and when it works, it provides high quality parts __(C)__ the lowest costs. In early 2020, that finely tuned machine ground to halt. Countries temporarily shut down factories and other business in order __(D)__ limit the spread __(E)__ COVID-19, leaving manufacturers __(F)__ the rest of the world without adequate stockpiles of components and other materials.

The global shutdown put the spotlight on China, the country first affected __(G)__ the coronavirus and where the great bulk of the world's goods are manufactured. China accounts __(H)__ a whopping 35 percent of global manufacturing output, according to consulting and research firm McKinsey Global Institute. When China stopped working to contain the virus, the shutdown cascaded across the world. __(I)__ instance, production of critical medical and personal protective equipment, which has been concentrated in Chinese factories, petered out or stopped altogether, leaving health care workers dealing __(J)__ shortages.

Reference prepositions: across, at, by, from, for, in, of, on, to, with, without

4. Translate the following two sentences into English: **(10% for each)**

(A) 工業自動化技術的發展，仰賴裝置於設備當中的各種感測元件，尤其是微型化感測器。

(B) 微機電製造技術承襲於半導體工業，目前已經用於生產微型壓力計、慣性感測器、光學感測器以及生醫感測器。