國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

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. Solve the following ODEs.
   (a) $(3y-2)dx + 4xdy = 0$ (5%)
   (b) $y'' - 2y' + y = x - 2$ (5%)
   (c) $x^2y'' - xy' + y = x^2 \ (x > 0)$ (5%)

2. (10%) Sketch the given curve. Guess what its orthogonal trajectories may look like. Find its orthogonal trajectories.

$$y = \sqrt{x + c}$$

3. (10%) Find the solution of the initial value problem (IVP) by using the Laplace transform. $y'' + 7y' + 12\,y = u(t-1) + \delta(t-2),\ y(0) = 0,\ y'(0) = 1$

4. (15%) Find the transient motion of the mass–spring system modeled by the ODE in Figure 1, where $m = 1, c = 2, k = 2,$ and $r(t) = 10\sin(2t)$ if $0 < t < \pi$ and $r(t) = 0$ if $t > \pi$.

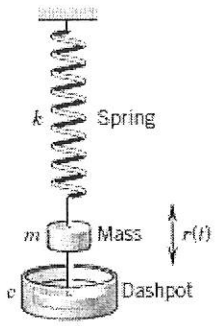


Figure 1.

5. (20%) Consider the one-dimensional heat problem modeled by a long metal bar as the figure shown below. The bar is perfectly insulated laterally so that heat flows in the x-direction only. Suppose the initial temperature in the bar at time $t = 0$ is $f(x)$. Please derive the solution by using separation of variables and Fourier series.

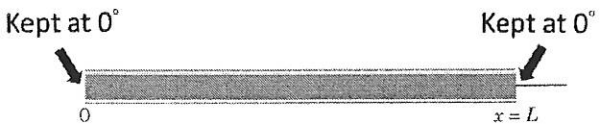


Figure 2. Bar under consideration.

[Hint: One-dimensional Heat equation: $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$
B.C.: $u(0,t) = 0, u(L,t) = 0\ for\ all\ t \geq 0.$
I.C.: $u(x,0) = f(x).$]

國立中山大學112學年度碩士班暨碩士在職專班招生考試試題

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. (15%) Suppose $\boldsymbol{F} = [x, y^2, z^3]$, S is the surface of the box $|x| \leq 3,\ |y| \leq 2, |z| \leq 1$.
Evaluate the surface integral $\iint_S \boldsymbol{F} \cdot \boldsymbol{n} dA$ by the divergence theorem of Gauss.

7. Given a periodic function $f(x) = \pi - |x|, -\pi < x < \pi$.
(a) Find the Fourier series of $f(x)$. (10%)
(b) Find the sum of $\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} \cdots$ (5%)

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

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(選擇題)　　

Single choice question (5% each)

1. The payroll office will send its employees the____form to give new service providers.
(A) update (B) updated (C) updates (D) updating (E) have updated

2. We are excited to announce that Ms. Elizabeth will take over as interim program director_____next Friday.
(A) begin (B) began (C) beginning (D) beginners (E) have begun

3. Homeowners are particularly in favor of____the property tax code to reduce financial burdens.
(A) revises (B) revising (C) revised (D) being revised (E) have revised

4. By reviewing the surveys_____by its Marketing Department, Bright Lights improves its customer satisfaction levels.
(A) conduct (B) conducts (C) have been conducted (D) conducted (E) have conducted

5. The company believes that the____shipment was likely delivered to the wrong address.
(A) misses (B) to miss (C) missing (D) missed (E) have missed

6. The business association____the dramatic rise in sales to population growth.
(A) was attributed (B) attributing (C) attribute (D) has attributed (E) have been attributed

7. Natural Spa takes every step____the quality of our services by listening to customer feedback.
(A) improves (B) will improve (C) improved (D) to improve (E) has improved

8. Ada Solutions provides companies with reliable marketing data_____sound decisions about sales strategies.
(A) to make (B) makes (C) making (D) being made (E) has made

9. Most of our investors are____about the possibility of inflation rising at a faster rate.
(A) concerns (B) concerning (C) concerned (D) to concern (E) have concerned

10. Because the boardroom is being painted, the meeting this afternoon will____in the conference room on the fourth floor.
(A) have held (B) be holding (C) hold (D) be held (E) have be held

11. Businesses on Ellory Avenue____early yesterday to allow work crews to repave the street.
(A) are closed (B) to close (C) closing (D) closed (E) have close

12. Akira Nakayama____delay the filming of his documentary in the rainforest when his equipment did not arrive on schedule.
(A) has to (B) will have to (C) having to (D) had to (E) have to

13. The delegation will depart from the embassy at 9 A.M. and___to the airport by the Minister of Sports.
(A) will accompany (B) accompanied (C) will be accompanied (D) being accompanied (E) have accompanied

14. The price of gold____at $1,000 per ounce over the past week, yet most financial experts agree that it is likely to rise due to a lack of investor confidence in the stock market.
(A) is stabilizing (B) will have stabilized (C) will be stabilizing (D) has stabilized (E) have stabilizing

15. The computer technician____tested the network to determine the source of the connectivity problem.
(A) systematically (B) exceedingly (C) increasingly (D) currently (E) ugly

16. New scientific____and improved production techniques were necessary components for developing a successful vaccine.
(A) drawing (B) findings (C) belongings (D) surroundings (E) paintings

17. Our talented chefs prepare a variety of____dishes from Northern Italy.
(A) authentic (B) consistent (C) projected (D) compatible (E) increasing

18. Thanks to good medical care, the condition experienced by Mr. Gardner has been ____with medication.
(A) deduced (B) mentioned (C) controlled (D) revised (E) understand

19. All restaurants must____with the new health safety rules issued by the government.
(A) observe (B) prevent (C) comply (D) decide (E) cure

20. Although Cheap Rides is still losing market share, its overall market position is expected to ____ stabilize.
(A) eventually (B) recently (C) exclusively (D) centrally (E) comply

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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。
- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

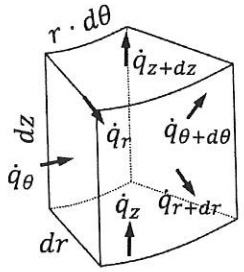
科目名稱：基礎熱傳學【機電系碩士班甲組】　　題號：438003

※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）　　

----- There are SIX (6) questions in this examination. -----

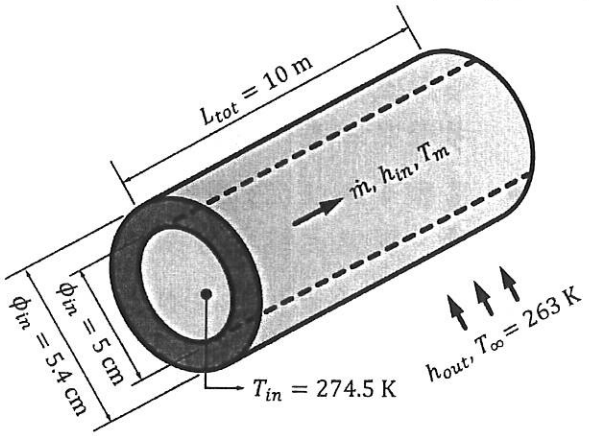
Question 1　**(15 points)**

Given a differential element cut out of a cylindrical shell. Starting with an energy balance, as well as the Fourier's Law, **derive the heat diffusion equation in cylindrical coordinate system**. Assume isotropic and homogeneous medium and a constant volumetric internal heat generation rate be $\dot{q}_g'''$.



Question 2　**(30 points)**

Consider a very long, outdoor water pipe with total length of $L_{total} = 10$ m, inner diameter of $\phi_{in} = 5.4$ cm and outer diameter of $\phi_{out} = 5.0$ cm on a calm winter day. Outdoor temperature is 263 K with no wind (i.e. quiescent air). Assume the thermal conductivity of the pipe be $k_{pipe} = 15$ W/m·K. Water, at a bulk fluid mean temperature of $T_m(x)$, is flowing at a mass flow rate of $\dot{m} = 0.01$ kg/s. At the inlet of the pipe, water temperature is $T_m(x) = T_{in} = 274.5$ K.



a) **Determine $\bar{h}_{in}$ and $\bar{h}_{out}$**, the convective heat transfer coefficients inside and outside of the pipe, respectively. Assume pipe wall is smooth and neglect entrance effects. For situation that is neither constant surface heat flux nor constant surface temperature, assume the Nusselt number be the averaged value of the two cases. (10 points)

b) **Find T_m, at the location ($x = L$) where water would start freezing** by using a thermal resistance network in the radial direction between T_m and T_∞. Note that water freezes first on the inner wall when its temperature becomes zero. (5 points)

c) **Prove that the variation of bulk fluid mean temperature, $T_m(x)$**, along the axial direction, x, **is given by**,

$$\frac{T_m(x) - T_\infty}{T_{in} - T_\infty} = \exp\left(-\frac{\pi \cdot \phi_{in} \cdot U \cdot x}{\dot{m} \cdot C_p}\right).$$

where U is the overall heat transfer coefficient and C_p is the specific heat of the fluid. (12 points)

d) Using the answer in *part c)*, **find $x = L$ for which water start freezes**. (3 points)

Question 3　**(10 points)**

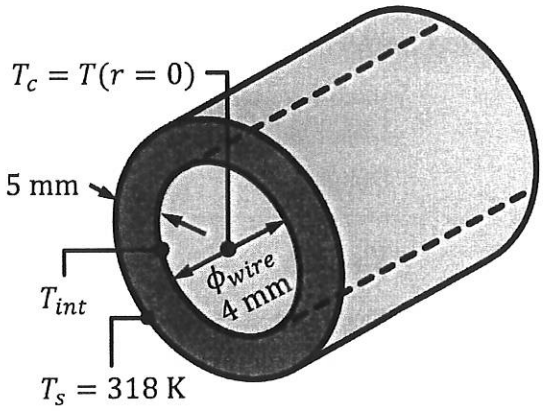
A sphere of 1 mm diameter is placed in a blowing air stream of unknown temperature. Assume the thermal conductivity be 35 W/m·K, the density of the sphere be 8500 kg/m^3, and the specific heat, C_p, be 320 J/kg·K. The convection heat transfer coefficient on the surface is 210 W/m^2·K. Let T_∞ be the free stream temperature and T_i be the initial temperature of the sphere. Let $\theta = \dfrac{T(t) - T_\infty}{T_i - T_\infty}$. **Find the time it takes for the sphere to cool down from a temperature of $\theta = 1$ to $\theta = 0.01$.**

Question 4 **(20 points)**

Consider a long metal wire with diameter of 4 mm and the thermal conductivity of the wire is 15 W/m·K. There is a constant, uniform internal heat generation $(\dot{q}''')$ of 50 MW/m^3 in the wire. The metal wire is encased by a 0.5 cm thick insulation cover with thermal conductivity of 1.2 W/m·K. The surface temperature of the insulation is 318 K. Assume steady state.

a) **Find the temperature at the wire-insulation interface T_{int}.** (8 points)

b) **Determine the centre-line temperature T_c.** (12 points)



Question 5 **(15 points)**

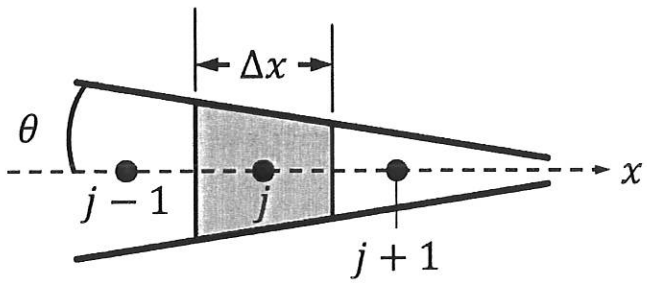
Consider a concentric tube counterflow heat exchanger where hot water of 373 K enters at a flow rate of 3 kg/s, cold water at 288 K enters at a rate of 0.25 kg/s and is heated to 318 K. The heat exchanger is rated with an overall heat transfer coefficient of 950 W/m^2·K.

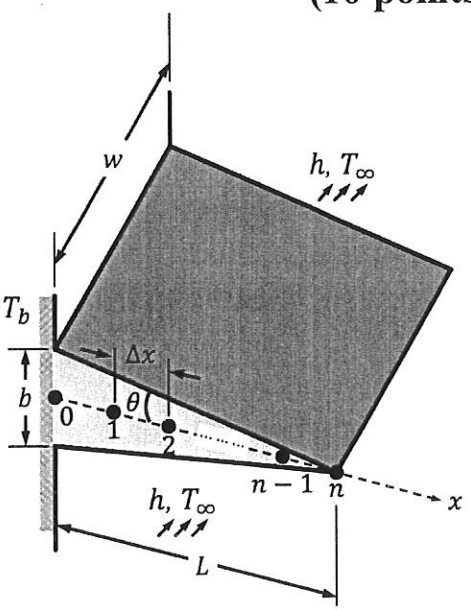
a) **Find the amount of heat transfer**, assuming the whole assembly is perfectly insulated. (10 points)

b) **Determine the area of heat transfer** in the heat exchanger. (5 points)

Question 6 **(10 points)**

Given a triangular fin with total length of L, total width *of* w and base thickness of b. The thermal conductivity is k and the base temperature is T_b. The fin is being cooled by convection in an ambient temperature of T_∞ and the convective coefficient is h. The temperature distribution along the fin is to be solved using the finite difference method. **Write down the finite difference equation for node *j***, assuming state-state condition and $w \gg L, b$.





----- *End of Examination* -----

Appendix

Selected material properties

Property	Material	Temperature	Value
Density, ρ	Water		1000 kg/m^3
	Air	268.5 K	1.2 kg/m^3
Viscosity, v	Water		1.5×10^{-6} m^2/s
	Air	268.5 K	1.298×10^{-5} m^2/s
Thermal Diffusivity, α	Air	268.5 K	1.765×10^{-5} m^2/s
Prandtl Number, Pr	Air	268.5 K	0.7355
Specific Heat, C_p	Water	Any T	4200 J/kg·K
Thermal Conductivity, k	Water		0.6 W/m·K
	Air	268.5 K	0.02328 W/m·K

Correlations for Nusselt Numbers

- Cylinder with external cross flow:

$$\overline{Nu}_D = 0.3 + \frac{0.62 \cdot Re_D^{1/2} \cdot Pr^{1/3}}{\left[1 + \left(\frac{0.4}{Pr}\right)^{2/3}\right]^{1/4}} \cdot \left[1 + \left(\frac{Re_D}{282000}\right)^{5/8}\right]^{4/5}$$

- Fully developed laminar flow with uniform surface temperature: $\overline{Nu}_D = 3.66$
- Fully developed laminar flow with uniform surface heat flux: $\overline{Nu}_D = 4.36$
- Fully developed turbulent flow,

$$\overline{Nu}_D = \frac{\frac{f}{8} \cdot (Re_D - 1000) \cdot Pr}{1 + 12.7 \cdot \left(\frac{f}{8}\right)^{1/2} \cdot (Pr^{2/3} - 1)}$$

  - where the friction factor, f, is given by,

$$\frac{1}{\sqrt{f}} = \begin{cases} -2.0 \cdot \log\left(\frac{\varepsilon / D}{3.7} + \frac{2.51}{Re_D \cdot \sqrt{f}}\right) & \text{for rough wall} \\ 0.790 \cdot \ln(Re_D) - 1.64 & \text{for smooth wall} \end{cases}$$

- Long, horizontal cylinder in quiescent ambient,

$$\overline{Nu}_D = \left\{0.6 + \frac{0.60 + 0.387 \cdot Ra_D^{1/6}}{\left[1 + \left(\frac{0.559}{Pr}\right)^{9/16}\right]^{8/27}}\right\}^2 \quad \text{for} \quad Ra_D \le 10^{12}$$

Heat Exchangers Effectiveness Correlations

- Parallel Flow:

$$\varepsilon = \frac{1 - \exp\left[-NTU \cdot \left(1 + C_r\right)\right]}{1 + C_r}$$

- Counter Flow:

$$\varepsilon = \frac{1 - \exp\left[-NTU \cdot \left(1 - C_r\right)\right]}{1 - C_r \cdot \exp\left[-NTU \cdot \left(1 - C_r\right)\right]} \quad \text{for} \quad C_r < 1$$

$$\varepsilon = \frac{NTU}{1 + NTU} \quad \text{for} \quad C_r = 1$$

Heat Exchangers NTU Correlations

- Parallel Flow:

$$NTU = -\frac{\ln\left[1 - \varepsilon \cdot \left(1 + C_r\right)\right]}{1 + C_r}$$

- Counter Flow:

$$NTU = \frac{1}{C_r - 1} \cdot \ln\left(\frac{\varepsilon - 1}{\varepsilon \cdot C_r - 1}\right) \quad \text{for} \quad C_r < 1$$

$$NTU = \frac{\varepsilon}{1 - \varepsilon} \quad \text{for} \quad C_r = 1$$

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

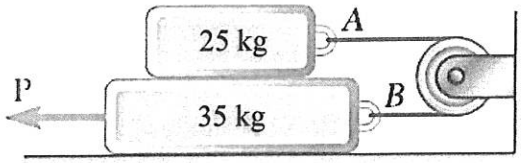
- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、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112學年度碩士班暨碩士在職專班招生考試試題

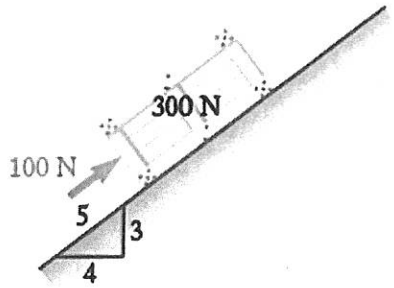
科目名稱：靜力學【機電系碩士班丁組】 **題號：438004**

※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) 共 2 頁第 1 頁

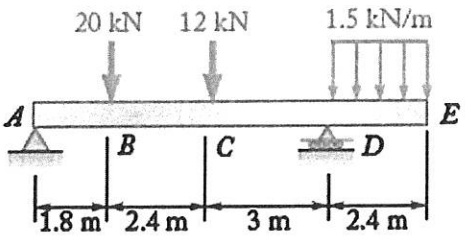
1 (15%) The coefficients of friction are $\mu_s = 0.35$ and $\mu_k = 0.25$ between all surfaces of contact. Determine the smallest force P required to start the 35-kg block moving, if cable AB is attached as shown.



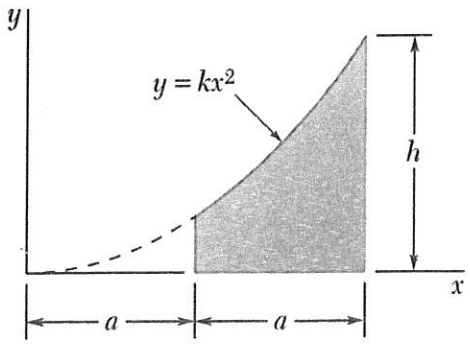
2 (15%) A 100 N force acts as shown on a 300 N block placed on an inclined plane. The coefficients of friction between the block and plane are $\mu_s = 0.25$ and $\mu_k = 0.20$. Determine whether the block is in equilibrium and find the value of the friction force.



3 (15%) Draw the shear and bending-moment diagrams for the beam and loading shown.



4 (15%) Determine by direct integration the centroid of the area shown. Express your answer in terms of a and h.



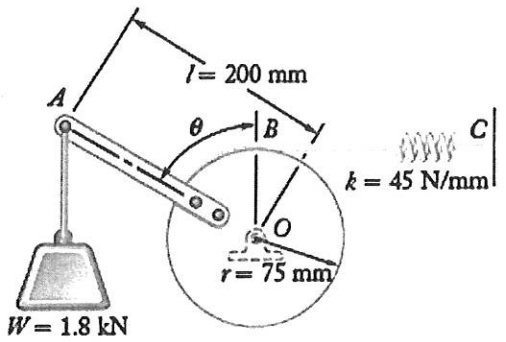
試題請隨卷繳回，請留意背面是否有題

國立中山大學112學年度碩士班暨碩士在職專班招生考試試題

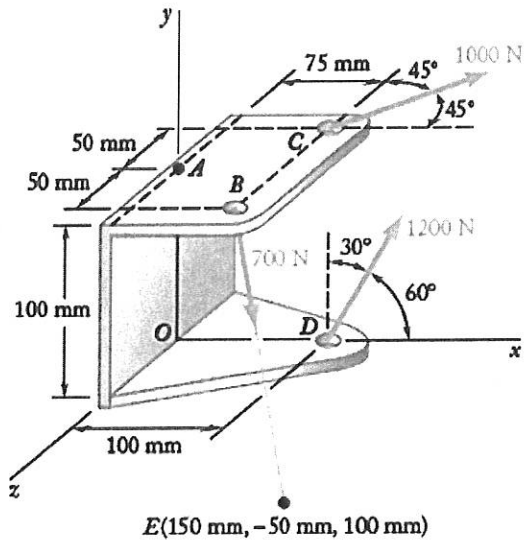
科目名稱：靜力學【機電系碩士班丁組】 **題號：438004**

※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) 共 2 頁第 2頁

5 (15%) A 1.8 kN weight is attached at A to the lever shown. The constant of the spring BC is $k = 45$ N/mm., and the spring is unstretched when $\theta = 0$. Determine the position of equilibrium.



6 (15%) Three cable are attached to a bracket as shown. Replace the force exerted by the cables with an equivalent force-couple system at A.



7 (10%) Please describe the meaning of the (a) Force-Couple System and (b) equilibrium Equations.

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

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. (20%) For the system given in Fig. 1.
   (a) (10%) Plot the root locus.
   (b) (10%) Determine the range of K for stability.

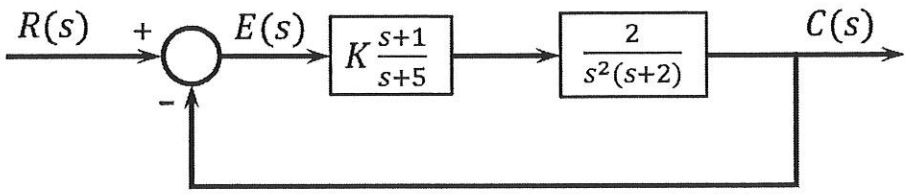


Fig. 1

2. (10%) In Fig. 2, please find the transfer function, $G(s) = X_2(s)/F(s)$, for the system if M_1=8 kg, M_2=5 kg, B_1=4 N-s/m, B_2=3 N-s/m, B_3=7 N-s/m, K_1=3 N/m, K_2=7 N/m.

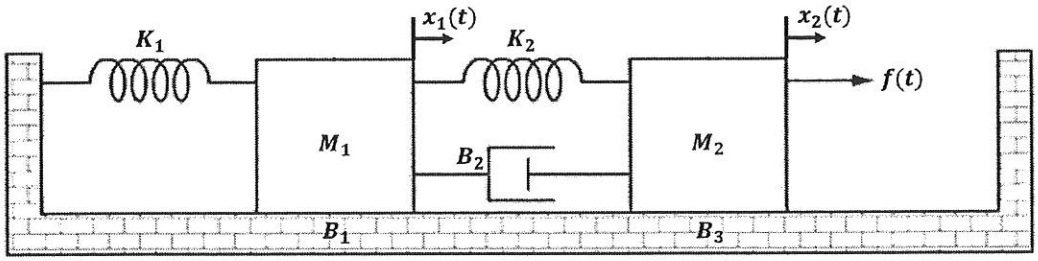


Fig. 2

3. (20%) In Fig. 3, consider the operational-amplifier circuit, where R_1=300 kΩ, R_2=200 kΩ, R_3=5 MΩ, R_4=5 MΩ, R_5=1 MΩ, R_6=3 MΩ, C_1=10 μF, and C_2=0.1 μF.
   (a) (10%) Please find the transfer function $G(s) = V_o(s)/V_i(s)$.
   (b) (10%) Please find the poles and zeros of $G(s)$.

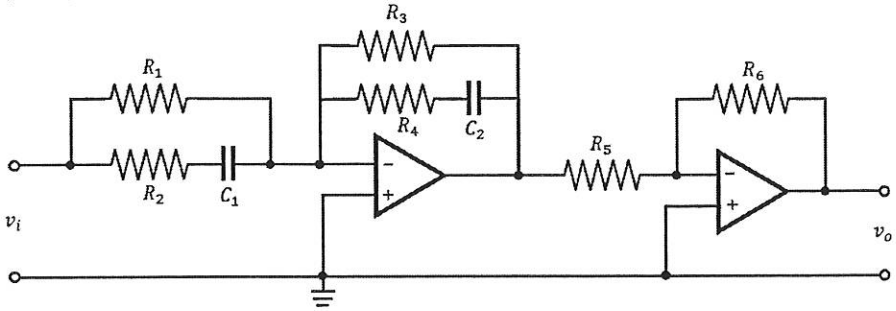


Fig. 3

以下四題(題4-題7)為簡答題(題4-題7)，簡明扼要將問題的重點回答出來即可！

4. (5%) For a second-order linear system with no zero, how does the damping ratio influence the phase margin of the system?

5. (5%) What is the major drawback of increasing the gain of the loop transfer function of a feedback system? Why?

6. (5%) This problem considers a feedback control system whose input is the desired output. In your opinion, what is the ideal amplitude spectrum of such a closed-loop system? Why?

7. (5%) What can be gained by using a phase-lead controller?

8. (30%) This problem considers a unity feedback system. With $\tau = 1$, the Bode diagram (asymptomatic approximation) of its controller G_c is given in Fig. 4. Note that in Fig. 4, $20\log|G_c(j\omega)| = 27$ dB for $\omega = 0.1$ rad/sec and $\omega = 100$ rad/sec. Also, $\angle G_c(j\omega) = -88$ degrees at $\omega = 0.1$ rad/sec and $\angle G_c(j\omega) = 88$ degrees at $\omega = 100$ rad/sec.
   (a) (5%) Is G_c a PI, a PD, or a PID controller? Explain why?
   (b) (5%) Compare to a proportional controller $G_c = 1$, can this controller improve the steady-state error of the feedback system? Why or why not?
   (c) (5%) Assuming that the input to this controller is $\cos(0.1t)$, what is the steady-state output of this controller?
   (d) (15%) The loop transfer function of this feedback system is known to be $L = G_cG$, where $20\log|G(j\omega)| = 0$ dB and $\angle G(j\omega) = -45$ degrees at $\omega = 100$ rad/sec. Determine the steady-state output of this closed-loop system when its input is $\cos(100t)$.

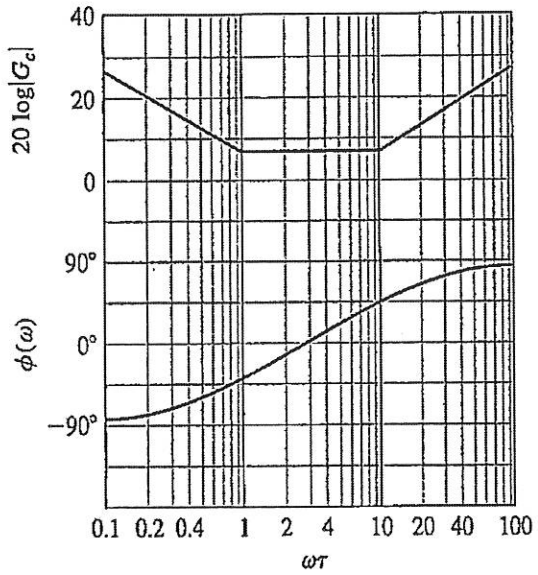


Figure 4

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

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 (25 %)

1. Consider the design of a column AB of length L to support a given centric axial load P (Fig. 1). The column is pin-connected at both ends, and A is the cross-sectional area. (a) Derive the critical load Pcr.(5%); (b) Derive the equation of the elastic curve after the column has buckled.(5%); (c) Determine the critical load for the square strut (Fig. 2).(5%); (d) Determine the radius of the round strut for which both struts have the same critical load.(5%); (e) Express the cross-sectional area of the square strut as a percentage of the cross-sectional area of the round strut. Use E=200 GPa.(5%)

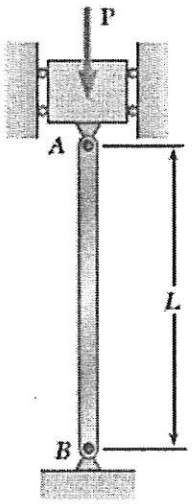


Figure 1

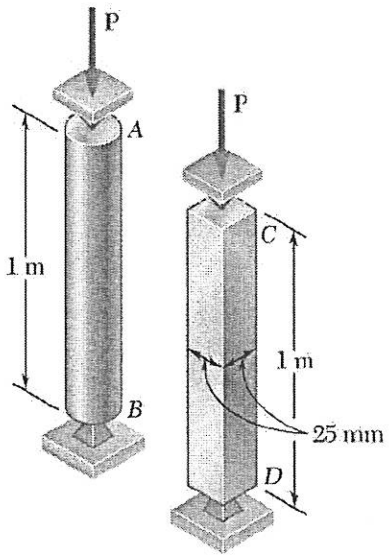


Figure 2

Prob. #2 (30 %)

(a) For a narrow rectangular beam (i.e., a beam of rectangular section of width b and depth h with b ≤ 1/4h), shows that the distribution of shearing stresses in a transverse section of a rectangular beam is parabolic (Figure 3). (10%)

(b) Determine the strain energy of the rectangular cantilever beam AB (Figure 3) with taking into account the effect of both normal and shearing stresses. (10%)

(c) Show that for any given material, the ratio *G/E* of the modulus of rigidity over the modulus of elasticity is always less than 1/2 but more than 1/3. (5%)

(d) Show the detail for beam AB (Figure 3) with a ratio h/L less than 1/10, and the percentage error of strain energy is less than 0.9%. It is therefore customary in engineering practice to neglect the effect of shear to compute the strain energy of shallow beams. (5%)

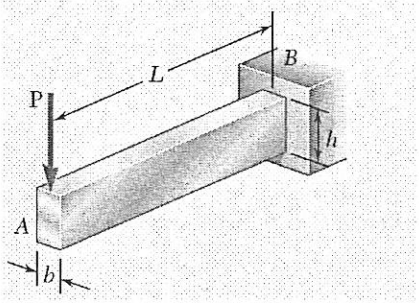


Figure 3

Prob. #3 (25 %)

The 4-kN force is parallel to the x axis, and the force Q is parallel to the z axis. The shaft AD is hollow. Knowing that the inner diameter is half the outer diameter and that τ_{all}= 60 MPa, determine the smallest permissible outer diameter of the shaft.

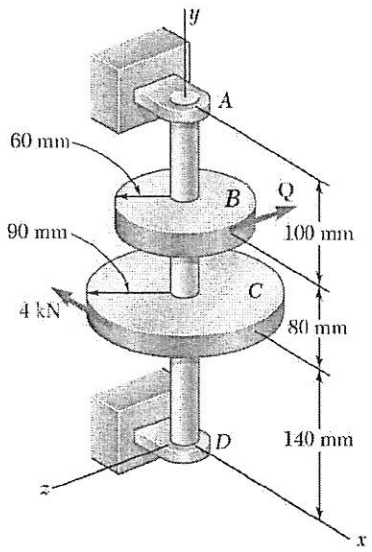


Figure 4

Prob. #4 (20 %)

(a) Determine the location and magnitude of the maximum deflection of beam AB. (b) Assuming that beam AB is a W310*143, M_0 = 80 kN·m, I=347*10^6 mm^4, and E = 200 GPa, determine the maximum allowable length L of the beam if the maximum deflection is not to exceed 1.8 mm.

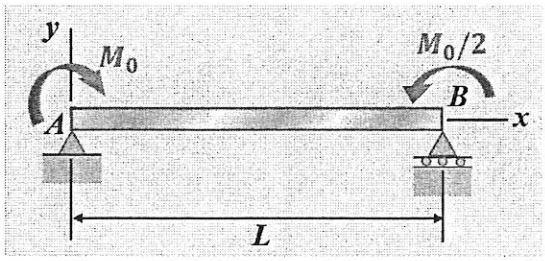


Figure 5

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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112學年度碩士班暨碩士在職專班招生考試試題

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）　　

All figures are for illustrative purposes only and not to scale.

1. As shown in Figure 1. A truck carries a gas cylinder. Suddenly the gas cylinder leaks, so it bounces up. The truck and the cylinder have an initial horizontal speed of 40 km/h, and the take-off speed of the gas cylinder is 20 m/s vertically upward. The truck stops immediately after the gas cylinder bounces up. When the cylinder travels to the highest point, a bird suddenly strikes the cylinder horizontally, making the horizontal speed of the cylinder drop by 3 m/s. **Determine the horizontal travelling distance of the gas cylinder when it drops on the road. Also, determine the total travelling time of the cylinder.** Assuming the truck's height is ignored, the gas cylinder bounces up from the road surface. The volume of the gas cylinder is also ignored. ($g = 9.8\ m/s^2$) (20%)

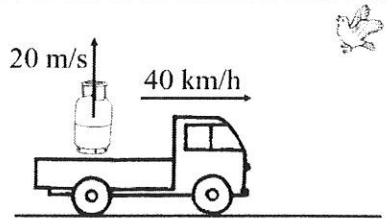


Figure 1.

2. As shown in Figure 2. A 32-kg sphere A of radius 100 mm moves with a velocity of magnitude $v_0 = 2$ m/s. There is another 2.5-kg sphere B of radius 60 mm, hanging from an inextensible cord and initially at rest. If sphere A trikes sphere B, which makes sphere B swing to a maximum height $h = 0.5$ m, **determine the coefficient of restitution between the two spheres**. Neglect air resistance when B is swinging. ($g = 9.8\ m/s^2$) (20%)

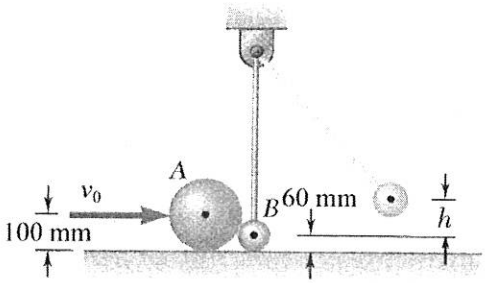


Figure 2.

3. As shown in Figure 3. The 20-kg rod AB is pin-connected at A and subjected to a couple moment of $M = 50$ N·m. If the rod is released from rest when the spring is unstretched at 20°, **determine the rod's angular velocity at the instant** 60°. As the rod rotates, the spring always remains horizontal because of the roller support at C. ($g = 9.8\ m/s^2$) (20%)

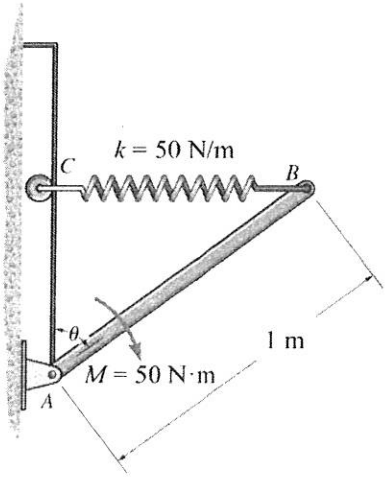


Figure 3.

4. As shown in Figure 4. The disk has a mass of 50 kg and is originally spinning at the end of the strut with an angular velocity ω = 600 rpm. Suppose it is then placed against the wall, where the coefficient of kinetic friction is μ_k = 0.5. The angle θ between the strut and horizontal plane is 45°. **Determine the time required for the motion to stop. Also, what is the force in strut BC during this time?** (g = 9.8 m/s^2) (20%)

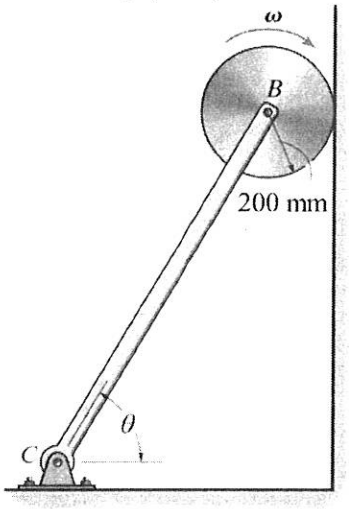


Figure 4.

5. As shown in Figure 5. Collar C is pinned to rod CD while it slides on rod AB. If rod AB has an angular velocity of 10 rad/s and an angular acceleration of 5 rad/s^2, both acting counterclockwise, **determine the angular velocity and the angular acceleration of rod CD at the instant shown**. (20%)

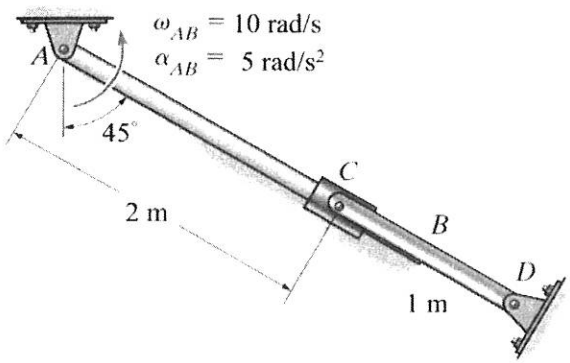


Figure 5.

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

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

- **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，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 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，後果由考生自負。
- 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 112 學年度碩士班暨碩士在職專班招生考試試題

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）　　共 3 頁第 1 頁

1. Determine the components of reaction at the ball-and-socket joint *A* and the tension in the supporting cables *DB* and *DC* as shown in Figure 1 (20%).

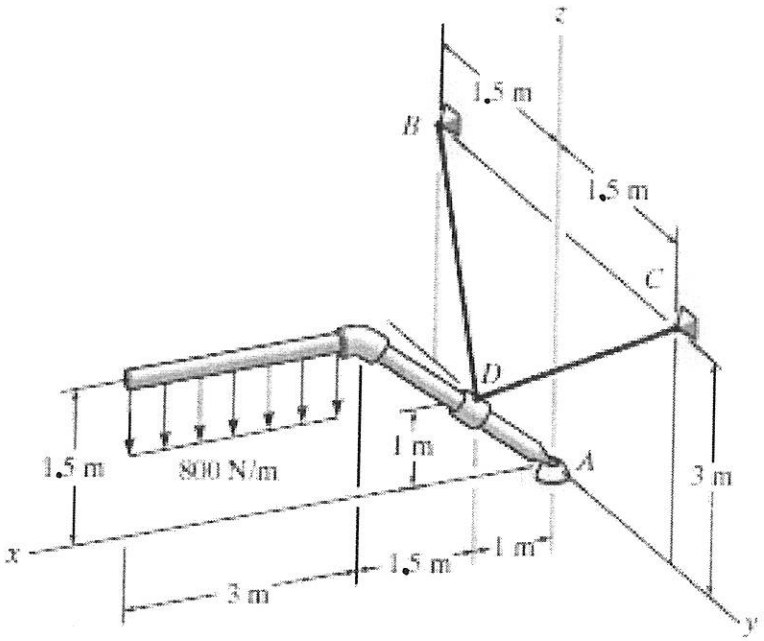


Figure 1

2. As shown in Figure 2, cable is attached to the 20-kg plate *B*, passes over a fixed peg at *C*, and is attached to the block at *A*. Using the coefficients of static friction shown, determine the smallest mass of block *A* so that it will prevent sliding motion of *B* down the plane. (20%)

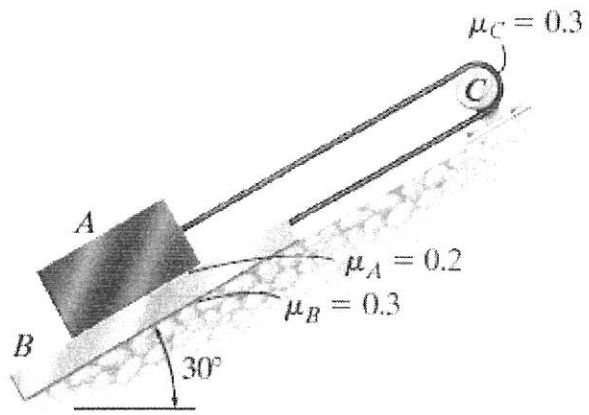


Figure 2

3. The 100-kg crate, as shown in Figure 3, is subjected to the forces shown. If it is originally at rest, determine the distance it slides in order to attain a speed of v = 8 m/s. The coefficient of kinetic friction between the crate and the surface is μ_k = 0.2. (20%)

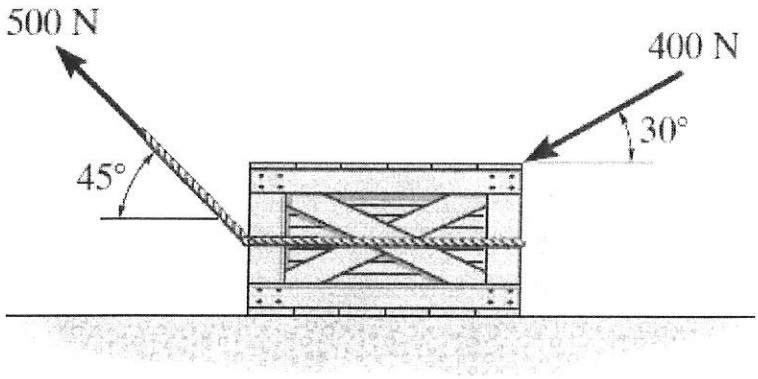


Figure 3

4. At the instant shown, u = 60°, and rod *AB*, as shown in Figure 4, is subjected to a deceleration of 16 m/s^2 when the velocity is 10 m/s. Determine the angular velocity and angular acceleration of link *CD* at this instant. (20%)

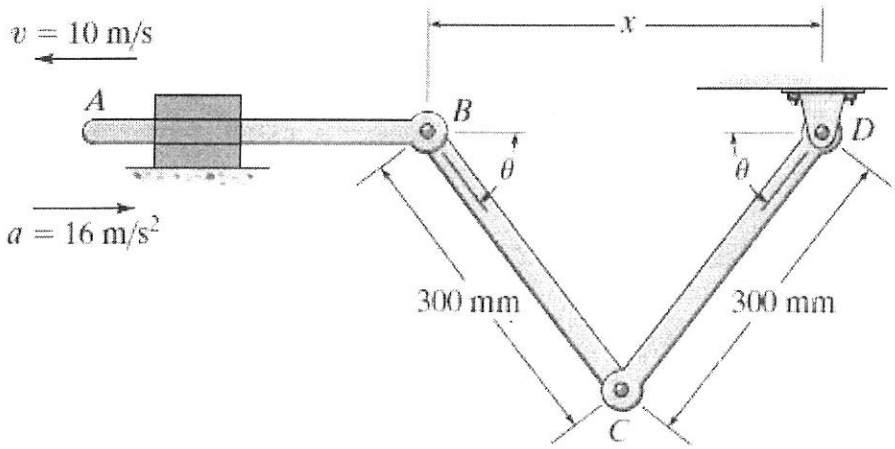


Figure 4

5. As shown in Figure 5, If P=200N and the 15-kg uniform slender rod starts from rest at $\theta = 0^{\circ}$, determine the rod's angular velocity at the instant just beforeθ= 45°. (20%)

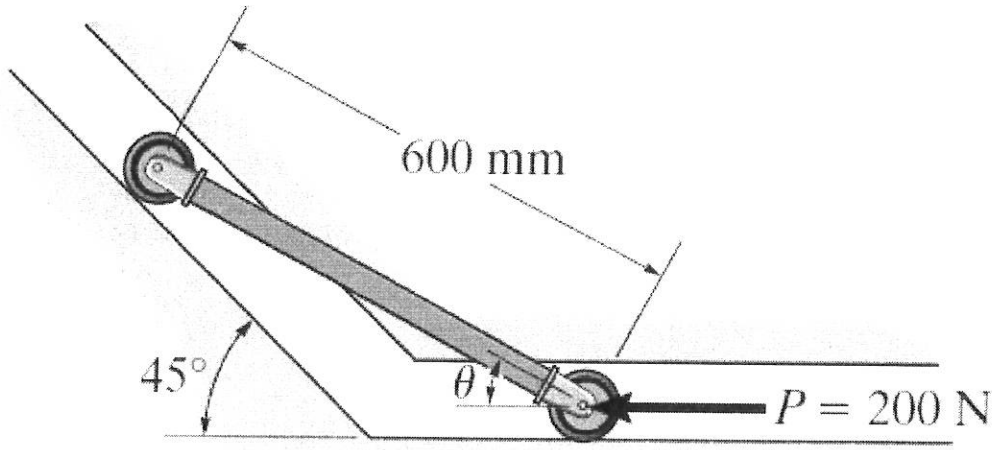


Figure 5