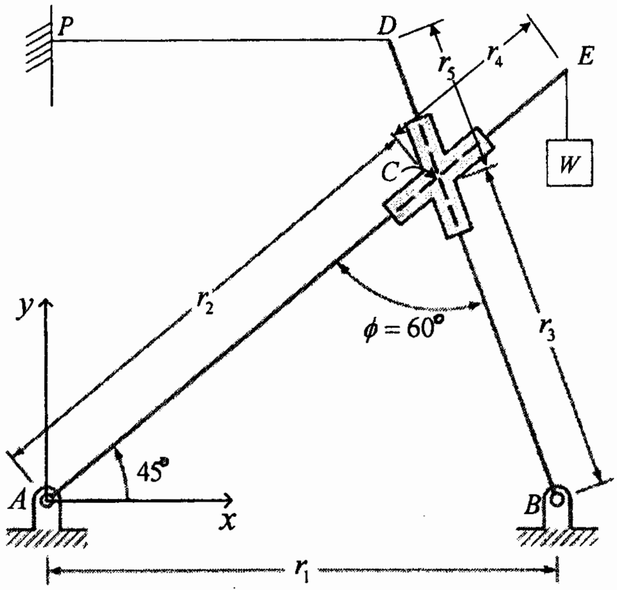
※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (25 %) The following figure shows a linkage with two pivots, A and B, and two sliding joints intersected at point C. The angle between the two sliding joints is a constant: $\phi = 60$. At the configuration shown in the figure, a load, $W = 600$ N , hangs from one end of rod AE, while a rope, PD, connects rod BD to a wall. (a) Find the tension on the rope, denoted by T, using the principle of virtual work. (b) What is the vertical component of the reaction force at pivot B? (No need to calculate the horizontal component.) Note that you must use the principle of virtual work in determining the tension on the rope in (a).

$r_1 = 2$ m; $r_2 = 2.23$ m; $r_3 = 1.63$ m; $r_4 = 0.72$ m; $r_5 = 0.64$ m



2. **(25%) In what follows we will discuss some theorems in static equilibrium. Please read carefully and follow instructions to draw a few schematic pictures.**

Consider a planar rigid body. Any system of forces and moments acting on the body can be simplified as an equivalent force, with a certain line of action. When dealing with a spatial body, we have a similar theorem, which states that any system of forces and moments in the 3-D space can be simplified to a wrench, which is composed of a force together with a parallel moment. Sometimes a wrench, consisting of a pair of coaxial force and moment, is referred to as an "equivalent screwdriver." A wrench can be identified by its axis in space and the magnitudes of the force and moment. Now draw a vector and a small circle, with the vector penetrating the circle, to represent a wrench. The vector is represented by an arrowed line segment, and the circle is near the tail of the vector. Mark your drawing as Figure 1.

Consider a body in the 3-D space. A wrench, denoted by W_1, acts on the body. In order to balance this wrench, we can apply another wrench, denoted by W_2, along the same axis but in the opposite direction of W_1. Draw this situation of two wrenches in static equilibrium in Figure 2. In the figure, you must first draw a "potato" shape to represent a spatial body, and then draw two collinear wrenches on the body. Note that you need to use the symbol shown in Fig. 1 to denote a wrench.

Let us consider another rigid body in space and two random wrenches, denoted by W_3 and W_4, that act on the body. The axes of the two wrenches are skew lines; namely, they are not collinear, intersecting, or parallel. These two wrenches do not balance each other. If you try to find the resultant of the two wrenches by using a single wrench, W_5, you will see that the resultant wrench and the two original wrenches must have a common perpendicular. In order to balance the resultant wrench W_5, according to the concept illustrated in Fig. 2, you need another wrench, denoted by W_6, which is collinear but in the opposite direction to W_5. Note that we now have a spatial body in equilibrium with three wrenches, W_3, W_4, and W_6, exerted on the body. This is the so-called three-axis theorem in statics, which states that for three wrenches in equilibrium, their axes must intersect a line perpendicularly. Draw this theorem and mark it as Figure 3. In the figure, begin by drawing a "potato" and then draw W_3 and W_4 as two skew vectors (with circles near the tails). Next, draw the common perpendicular of the axes of W_3 and W_4. You should draw perpendicular symbols at the intersections of the wrenches and their common perpendicular. Finally, draw another wrench to indicate W_6, which can reside between W_3 and W_4 and perpendicularly intersects the common perpendicular of W_3 and W_4. Remember to draw a perpendicular symbol at the intersection of W_6 and the common perpendicular too.

Now that you have completed Fig. 3, let us look at the figure from a different angle. Imagine viewing the three wrenches W_3, W_4, and W_6, from the direction of their common perpendicular. In other words, you are observing the projection of the three wrenches on a plane orthogonal to their common perpendicular. Draw the projection and mark it as Figure 4. In the drawing, ignore the circles near the tails of the wrench vectors. Does the schematic drawing look familiar? In fact, it illustrates the theorem regarding three coplanar forces in static equilibrium.

(背面仍有題目,請繼續作答)

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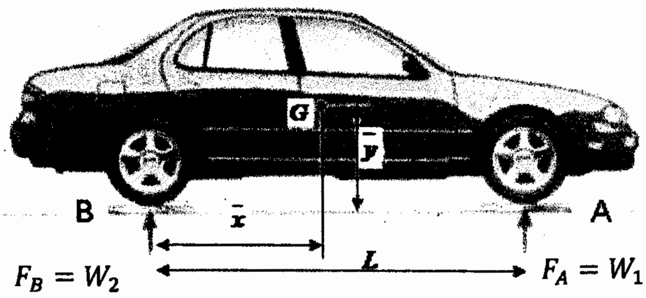
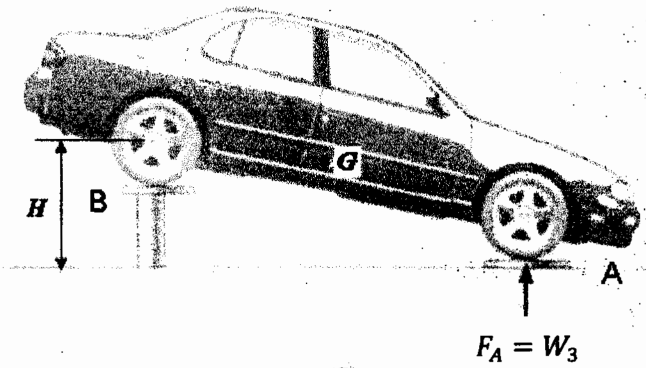
3. (25%) (a) Please define the center of gravity of a body **in English**. (b) The car rests on four scales as shown in figure (1) and in this position the scale readings of both front and rear tires are $F_A = W_1$ and $F_B = W_2$. When the rear wheels are elevated to a height of H above the front scales as shown in figure (2), the new readings of the front wheels are also recorded ($F_A = W_3$). The distance between the front and rear wheel axles is L. The tires each have a radius of R. Please estimate the location $\bar{x}$ and $\bar{y}$ to the center of gravity G of the car by using W_1, W_2, W_3, R, L, and H.



(1)



(2)

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考試日期：0222，節次：1
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4. (25%) The two-shoe external drum brake is shown in the following figure and drum rotation is clockwise. The lever force of 1000 N is applied as shown. The coefficient of friction between drum and shoe is 0.15. Although the normal force and the friction force acting between the drum and shoe are distributed continuously over the contact surface, we assume theses forces to be concentrated at the center of contact in this problem. Please (a) draw the free-body diagram for each component in this system, (b) calculate the reaction forces at joints A, B, and C, and (c) estimate the resulting braking torque.