Mid-Semester Test (AY21/22 S2)

EP0605 – Advanced Physics **Time Allowed: 1 hour 40 minutes**

Instructions to Candidates **Max Marks**: 100

1. All the Singapore Polytechnic examination rules must be strictly adhered to.
2. This paper consists of **6** questions. Take $g = 9.80$ m/s^2.
3. Answer all the questions in this question booklet. All working must be shown.
4. This paper consists of **7** pages (inclusive of the cover page).
5. Fill in the table below.

Name :			
Admission No :		S/No	
Class :		Date :	

For Official Use Only	Question	Marks
	1	
	2	
	3	
	4	
	5	
	6	
	Total	

1. a) In the below equation, the SI units of z and z_0 are in metres (m), t and t_0 are in seconds (s). The SI unit of ρ is m/s while that of λ is m/s^3. Using dimensional analysis, show whether the equation is homogenous or not.

$$(z - z_0) - \rho t_0 - \lambda(t - t_0)^3 = 0$$

b) Work done is defined as the dot product of force and displacement. A particle is under a constant force $\boldsymbol{F} = (\mathbf{i} + 4\mathbf{j} - 7\mathbf{k})$ N as it moves from a point (−2, −1, 2) m to another point (2, 0, 4) m. Find the work done on the particle.

c) What is the angle between the displacement vector and the force vector in 1(b)?

(17 marks)

2. The position of a particle of mass 0.5 kg moving along the *x*-axis is given by $x = \alpha t^4 - \beta t^2 - k$, where α, β and *k* are constants, *t* is in seconds while *x* is in metres.

   a) Find the SI units of α, β and *k*.
   b) Find the average velocity of the particle between $t = 0$ and $t = 3$ s.
   c) Find the instantaneous acceleration of the particle at $t = 3$ s.
   d) Find the net force acting on the particle at $t = 3$ s.

(17 marks)

3. A cart moves on a straight rail at a constant speed of 2.00 m/s. At t = 0 s, it launches a stone at 45.0° to the horizontal with a speed of 10.0 m/s.

   a) Calculate the initial horizontal and vertical components of the velocity of the stone.
   b) How long does the stone take to hit a wall 10.0 m away from the launch point?
   c) At what height will the stone hit the wall?

(17 marks)

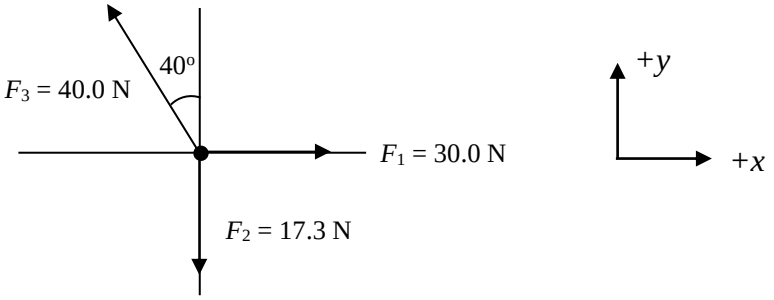
4. a) An elevator and its load have a combined mass of 1000 kg. The elevator is moving with an initial velocity of 8.00 m/s downwards. Then, it decelerates uniformly to a stop. During the deceleration, the elevator travels a distance of 20.0 m.

What is the tension T in the supporting cable while the elevator is being brought to rest?

b) A point is subjected to three forces as shown.

Find the force needed to keep the point in equilibrium. Express your answer in terms of its magnitude and direction, as well as in component form.

(17 marks)



5. (a) A particle undergoes two successive displacements $\boldsymbol{r}_1 = 2\mathbf{i} - 10\mathbf{j}$ and $\boldsymbol{r}_2 = 7\mathbf{i} - 2\mathbf{j}$. Find the unit vector in the direction of the final displacement of the particle.

(b) The torque ($\boldsymbol{\tau}$) about the origin is defined as the cross product of the position vector and the force vector.

$$\boldsymbol{\tau} = \boldsymbol{r} \times \boldsymbol{F}$$

(i) If $\boldsymbol{r} = (3\mathbf{i} - \mathbf{j} + \mathbf{k})$ m and $\boldsymbol{F} = (2\mathbf{i} - 3\mathbf{j} + \mathbf{k})$ N, find the torque, $\boldsymbol{\tau}$.
(ii) Show that the torque is perpendicular to $\boldsymbol{r}$.

(17 marks)

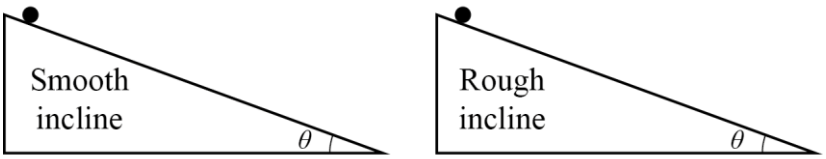
6. The diagram below shows two inclined planes of the same angle of inclination θ.

In case 1, a ball of mass *m* is released from rest at the top of the smooth inclined plane. The ball reaches the bottom with speed *v*. In case 2, the same ball is released from rest at the same height on the rough inclined plane. The ball reaches the bottom at *v*/2.

The magnitude of the acceleration due to gravity is *g*.

Find the coefficient of friction μ_k between the object and the rough inclined plane in terms of the variables given.

(15 marks)



Case 1 Case 2

Answer:

1(a)	Homogenous
1(b)	-6 J
1(c)	99.3°
2(a)	α: m/s^4; β: m/s^2; k: m
2(b)	$27\alpha - 3\beta$
2(c)	$108\alpha - 2\beta$
2(d)	$54\alpha - \beta$
3(a)	$v_x = 9.07$ m/s; $v_y = 7.07$ m/s
3(b)	1.10 s
3(c)	1.85 m
4(a)	11400 N
4(b)	$\vec{F}_4 = -4.29\hat{\imath} - 13.3\hat{\jmath}$ Magnitude = 14.0 N, direction = 252° with respect to +x-axis
5(a)	$\frac{1}{5}(3\vec{\imath} - 4\vec{\jmath})$
5(b)(i)	$\vec{\tau} = 2\hat{\imath} - \hat{\jmath} - 7\hat{k}$ Nm
6	$\mu = \frac{3}{4}\tan\theta$