Mid-Semester Test (AY20/21 S2)

EP0605 – Advanced Physics **Time Allowed: 1½ hour**

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 = 9.8 m/s^2.
3. Answer all the questions in this question booklet. All working must be shown.
4. This paper consists of **8 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) Write the dimensions for the following physical quantities:

   i) $p(V_2 - V_1)$, where p is pressure (force per unit area), V_2 and V_1 are the final and initial volume of the gas respectively.

   ii) $\frac{1}{2} kx^2$, where k is the spring constant in N/m and x is the elongation in m.

   b) Write down the SI units of the expressions in i) and ii).

   c) In dimension analysis, what does it mean when an equation is homogeneous?

   d) Explain why a homogeneous equation may be physically incorrect? Give two examples of mechanics equations that are homogeneous but physically wrong.

(17 marks)

2. A sprinter is running with a constant speed 10.4 m/s on a straight track and passes a stationary car, which immediately begins to race with constant acceleration 7.9 m/s^2.

   a) How much time does the car require to catch up with the sprinter?
   b) How far does the car travel before catching up with sprinter?
   c) Using the same set of axes, sketch the *x*-*t* graphs of the car and the sprinter from the time the car started moving until it caught up with the sprinter.

(17 marks)

3. a) A particle is under a constant force $\boldsymbol{F} = (-2\,\mathbf{i} + 4\,\mathbf{j} + \mathbf{k})$ N as it moves from $\boldsymbol{r}_1 = (5\,\mathbf{i} + \mathbf{j} + 2\,\mathbf{k})$ m to $\boldsymbol{r}_2 = (-2\,\mathbf{i} + 3\,\mathbf{j} + 4\,\mathbf{k})$ m.

   i) Find the displacement vector $\Delta\boldsymbol{r}$.
   ii) Find the dot product of the displacement and force vectors.
   iii) Find the angle between the displacement and force vectors.

   b) The position vector of a particle of mass 2.0 kg moving on the *x*-*y* plane is $\boldsymbol{r}(t) = 2t\,\mathbf{i} + 2\sin(\pi t/4)\,\mathbf{j}$, where $\boldsymbol{r}$ is in metres and t is in seconds. Calculate in component form,

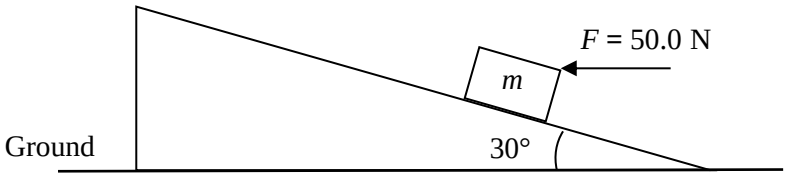
   i) the particle's instantaneous velocity at $t = 1.0$ s.
   ii) the force acting on the particle at $t = 1.0$ s.

(17 marks)

4. A block with mass m = 2.50 kg is pushed up a fixed inclined plane by a horizontal force F = 50.0 N (see the below figure). The coefficient of kinetic friction between the block and the inclined plane is 0.300.

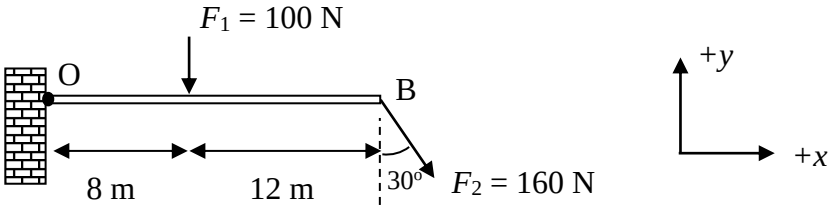
   a) Draw the free body diagram of the block.
   b) Find the magnitude of the normal force due to the incline on the block.
   c) Find the magnitude of the friction force acting on the block.
   d) Find the acceleration of the block.

(17 marks)



5. a) Express $\boldsymbol{F}_1$ and $\boldsymbol{F}_2$ in the below diagram in terms of unit vectors **i**, **j** and **k**.
   b) Determine the torque $\boldsymbol{\tau}_1$ and $\boldsymbol{\tau}_2$ about the point O (origin) due to $\boldsymbol{F}_1$ and $\boldsymbol{F}_2$ respectively as shown in the diagram.

   Note : $\boldsymbol{\tau} = \boldsymbol{r} \times \boldsymbol{F}$, where $\boldsymbol{r}$ is the radius vector. Take right as $+x$ (unit vector **i**), up as $+y$ (unit vector **j**) and out of the paper as $+z$ (unit vector **k**).



(17 marks)

6. An airplane travelling at 180.0 km/h wants to drop food packets to flood victims isolated on a patch of land 196.0 m below. You may neglect air resistance.

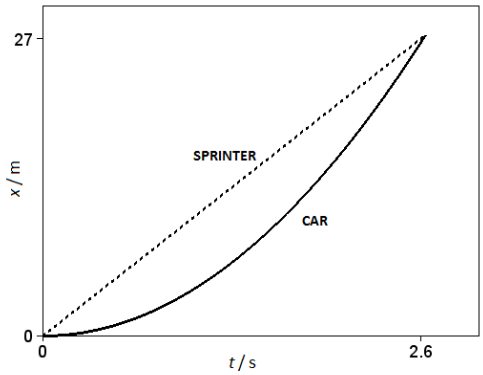
   a) How many seconds before the plane is directly overhead the patch of land should the packets be dropped?

   b) From the time when the packets are released till they reach the ground, what horizontal distance does the airplane travel?

   c) From the location of the airplane when the packets are released, to the location where the packets hit the ground, what is the magnitude of the displacement vector between these two points?

(15 marks)

Answer:

1(a)(i)	$[M][L]^2[T]^{-2}$
1(a)(ii)	$[M][L]^2[T]^{-2}$
1(b)	N m or J
1(c)	An equation is homogeneous when the dimensions on both sides of the equal sign are consistent
1(d)	There could be missing or additional dimensionless constants in the equation.
2(a)	2.6 s
2(b)	27 m
2(c)	
3(a)(i)	$\Delta\vec{r} = \left(-7\hat{\imath} + 2\hat{\jmath} + 2\hat{k}\right)$ m
3(a)(ii)	24 J
3(a)(iii)	46°
3(b)(i)	$\vec{v}(t) = \left(2\,\hat{\imath} + \frac{\pi}{2\sqrt{2}}\,\hat{\jmath}\right)$ m/s
3(b)(ii)	$-1.74\,\hat{\jmath}$ N
4(b)	46.2 N
4(c)	13.9 N
4(d)	6.86 m/s^2
5(a)	$\vec{F}_1 = -100\,\hat{\jmath}$ N, $\vec{F}_2 = 80\left(\hat{\imath} + \sqrt{3}\,\hat{\jmath}\right)$ N
5(b)	$\vec{\tau}_1 = -800\,\hat{k}$ Nm, $\vec{\tau}_2 = -2770\,\hat{k}$ Nm
6(a)	6.32 s
6(b)	316 m
6(c)	372 m