Mid-Semester Test (AY21/22 S1)

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) The acceleration of an object has the formula $a = \frac{m^x v^y}{r^z}$ where m, v and r are mass, velocity and distance, respectively. Using dimensional analysis, determine the values of x, y, and z and hence, find the formula for the acceleration.

b) A particle is under the influence of a force $\mathbf{F} = (3\mathbf{i} + 4\mathbf{j})$ N. The displacement vector of the particle is $\mathbf{s} = (7\mathbf{i} + 24\mathbf{j})$ m. Calculate the dot product of **F** and **s** and hence, find the angle between the two vectors.

(17 marks)

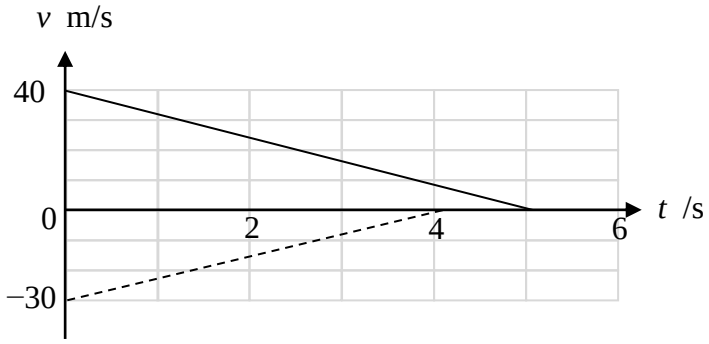
2. a) A particle moves so that its position as a function of time is given by

$$\vec{r} = \hat{i} + 4t^2\, j + tk\,.$$

i) Write the expressions for its instantaneous velocity and acceleration as functions of time.

ii) What is the average velocity and average acceleration between $t = 0$ s and $t = 2$ s?

b) Two trains are moving along a straight track when their drivers suddenly notice that they are headed towards each other. The figure below shows their velocity-vs-time graphs as the drivers slow the trains. The slowing processes begin when the trains are 200 m apart. What is their separation when both trains have stopped?

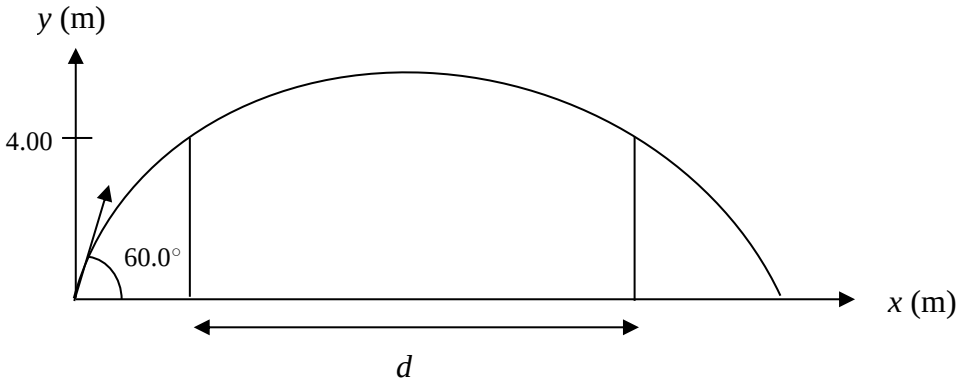


(17 marks)

3. A boy threw a stone with an initial speed of 15.0 m/s at 60.0^{o} with respect to the ground. The stone just missed the tops of two 4.00 m tall wall that are separated by distance *d*. The below figure (not drawn to scale) depicts the scenario.

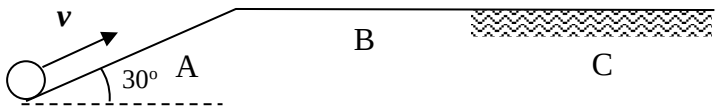
i) What is the maximum height reached by the stone?
ii) How long did the stone take to reach the maximum height?
iii) Determine the separation *d* of the two walls?

(17 marks)



4. a) State Newton's First Law of motion.

b) The diagram below shows three segments of a surface. All segments are 2.0 m long. Segment A is smooth and inclined at 30°. Segments B and C are both horizontal but B is smooth while C has a coefficient of kinetic friction of 0.25.



An object of mass 1.0 kg at the bottom of A is given an initial velocity directed along the inclined surface such that it can just reach the end of C.

i) Describe the motion of the object in the three segments (in terms of velocities and acceleration).
ii) What is the initial velocity of the object?

c) What is the initial velocity of the object if it were to just stop at the top of A?

(17 marks)

5. Angular momentum $\vec{L}$ is defined as $\vec{L} = \vec{r} \times \vec{p}$ where $\vec{r}$ is the position vector and $\vec{p} = m\vec{v}$ is the linear momentum of a particle of mass m. A particle of mass m = 1.0 kg moves with velocity v = 10 m/s from A to B as shown in the below figure. Given r_1 = 10 m, $\theta_1 = 60^o$, r_2 = 5.0 m and $\theta_2 = 30^o$.

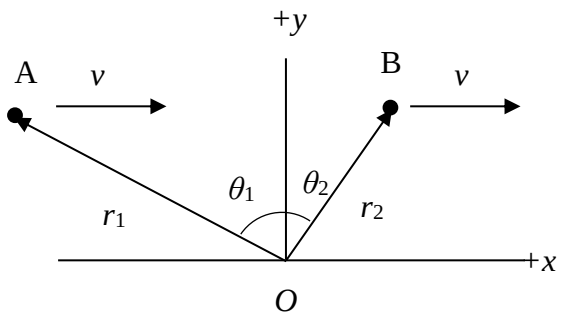
Take right as $+x$ (unit vector $\hat{i}$), up as $+y$ (unit vector j) and out of the paper as $+z$ (unit vector k).

i) Determine the angular momentum, $\vec{L}_1 = \vec{r}_1 \times \vec{p}_1$ of the particle at A.

ii) Determine the angular momentum $\vec{L}_2 = \vec{r}_2 \times \vec{p}_2$ of the particle at B.

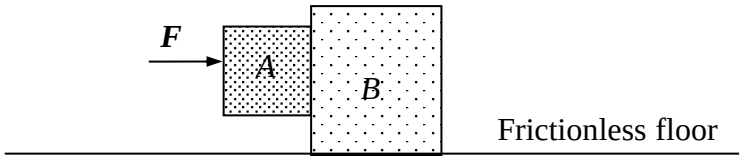
iii) Determine the change in angular momentum $\Delta\vec{L}$.

(17 marks)



6. The two blocks (A = 16 kg and B = 88 kg) in the figure below are not attached to each other. The coefficient of static friction between the two blocks is μ_s = 0.33, but the surface beneath the larger block is frictionless.

i) Draw the free-body diagram for blocks A and B if a horizontal force $\boldsymbol{F}$ acts on A as shown in the figure.
ii) What is the magnitude of the minimum force $\boldsymbol{F}$ required to keep block A from slipping down block B?
iii) If the force $\boldsymbol{F}$ acts on block B instead of block A, what is the magnitude of $\boldsymbol{F}$ so that block A does not fall off block B?



(15 marks)

Answer:

1(a)	$x = 0, y = 2, z = 1$
1(b)	20.6°
2(a)(i)	$\vec{v} = 8t\,\hat{j} + \hat{k}$, $\vec{a} = 8\,\hat{j}$
2(a)(ii)	$\vec{v}_{ave} = \left(8\,\hat{j} + \hat{k}\right)$ m/s, $\vec{a}_{ave} = 8\,\hat{j}$ m/s^2
2(b)	40 m
3(i)	8.61 m
3(ii)	1.33 s
3(iii)	14.5 m
4(a)	Every object remains stationary or moves with constant velocity unless a net force acts on it.
4(b)(i)	A: object's slows down with acceleration $-g\sin\theta$ B: object moves with constant velocity, 0 acceleration C: object slows down with constant deceleration
4(b)(ii)	5.42 m/s
4(c)	4.43 m/s
5(i)	$-50.0\,\hat{k}$ kg m^2/s
5(ii)	$-43.3\,\hat{k}$ kg m^2/s
5(iii)	$6.70\,\hat{k}$ kg m^2/s
6(ii)	562 N
6(iii)	3090 N