		Name		Type
Group Number		Surname		A
List Number		e-mail		
Student ID		Signature		

ATTENTION: Each question has only one correct answer and is worth one point. Be sure to fill in completely the circle that corresponds to your answer on the answer sheet. Use a pencil (not a pen). Only the answers on your answer sheet will be taken into account.

For all questions take $\frac{1}{4\pi\epsilon_o} = 9 \times 10^9\ N\,m^2/C^2$**.**

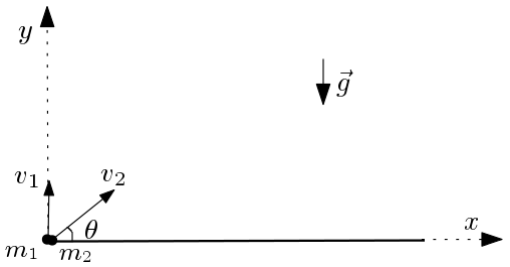
1. Which of the following is a unit vector perpendicular to both $\vec{A} = 2\hat{i} + \hat{j}$ and $\vec{B} = 3\hat{i} - 2\hat{k}$?

(a) $\frac{3\hat{i}+2\hat{j}-3\hat{k}}{\sqrt{29}}$ (b) $\frac{-3\hat{i}+4\hat{j}-2\hat{k}}{\sqrt{29}}$ (c) $\frac{3\hat{i}+4\hat{j}-3\hat{k}}{\sqrt{34}}$ (d) $\frac{-3\hat{i}+4\hat{j}+3\hat{k}}{\sqrt{34}}$ (e) $\frac{-2\hat{i}+4\hat{j}-3\hat{k}}{\sqrt{29}}$

Questions 2-4

An object of mass m_1 and another object of mass m_2 are thrown at the same instant from the ground with the same initial speeds $v_1 = v_2 = 5\ m/s$, as shown in the figure. $\theta = 53^o$ and take $g = 10\ m/s^2$.

Take $g = 10\ m/s^2$ **and** $\theta = 53^o$ **,** $\sin 53^o = 4/5$ **.**



2. What is the acceleration vector of m_1 relative to m_2?

(a) 0 (b) $\frac{1}{2}g\hat{j}$ (c) $-\frac{1}{2}g\hat{j}$ (d) $-g\hat{j}$ (e) $g\hat{j}$

3. What is the velocity of m_1 relative to m_2 when m_2 is at the heighest point of its trajectory in units of m/s?

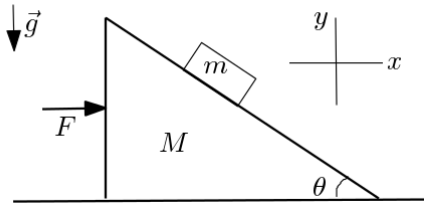
(a) $-2\hat{i} + \hat{j}$ (b) $3\hat{i} - 2\hat{j}$ (c) $\hat{i} + \hat{j}$ (d) $\hat{i} - \hat{j}$ (e) $-3\hat{i} + \hat{j}$

4. What is the distance between m_1 and m_2 at $t = 0.5\ s$?

(a) $\sqrt{2}\ m$ (b) $3/2\ m$ (c) $\sqrt{10}/2\ m$ (d) $\sqrt{3}\ m$ (e) $\sqrt{7}/2\ m$

Questions 5-8

A constant horizontal force $F = 32\ N$ is applied on $M = 4\ kg$ and the system is moving to the right, as shown in the figure. The small block $m = 2\ kg$ is at rest relative to M during the motion. There is no friction between M and the ground, the coefficient of static friction between m and M is $\mu_s = 0.5$, and the angle of inclanation is $\theta = 53^o$. (Take $g = 10\ m/s^2$ and $\sin 53 = 4/5$.)



5. What is the acceleration of the system?

(a) $16/3\ m/s^2$ (b) $3\ m/s^2$ (c) $4\ m/s^2$ (d) $5\ m/s^2$ (e) $14/3\ m/s^2$

6. What is the magnitude of the normal force applied on m by M?

(a) $20\ N$ (b) $308/15\ N$ (c) $298/15\ N$ (d) $17\ N$ (e) $21\ N$

7. What is the magnitude of the friction force between m and M?

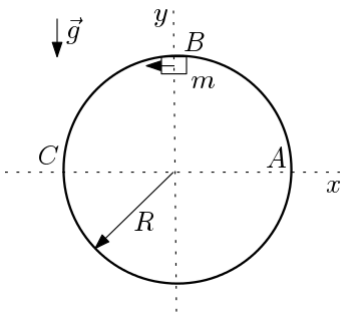
(a) $154/15\ N$ (b) $157/15\ N$ (c) $14\ N$ (d) $48/5\ N$ (e) $51/5\ N$

8. What is the minimum value of F which keeps m at rest relative to M during the motion of the system?

(a) $30\ N$ (b) $25\ N$ (c) $28\ N$ (d) $19\ N$ (e) $22\ N$

Questions 9-12

A small remote-controlled car of mass $m = 500\ g$ is moving at a constant speed $v = 6\ m/s$ in a vertical circle of radius $R = 1.5\ m$ inside a hollow metal cylinder. The object is at point A at time $t = 0$. (Take $g = 10\ m/s^2$.)



9. What is the normal force exerted on the car by the walls of the cylinder at point B?

(a) $12\ N$ (b) $11\ N$ (c) $7\ N$ (d) $5\ N$ (e) $14\ N$

10. What is the normal force exerted on the car by the walls of the cylinder at point C?

(a) $11\ N$ (b) $12\ N$ (c) $14\ N$ (d) $5\ N$ (e) $7\ N$

11. What is the average velocity of the car between $t = 0$ and $t = \pi/4\ s$ in units of m/s?

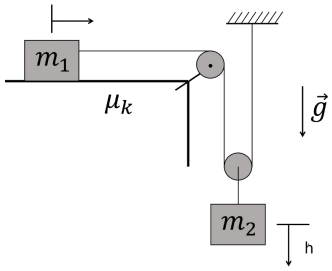
(a) $+\frac{10}{\pi}\hat{j}$ (b) $-\frac{12}{\pi}\hat{i}$ (c) $+\frac{12}{\pi}\hat{i}$ (d) $-\frac{12}{\pi}\hat{j}$ (e) $-\frac{10}{\pi}\hat{i}$

12. What is the average acceleration vector of the car between $t = 0$ and $t = \pi/4\ s$ in units of m/s^2?

(a) $-\frac{44}{\pi}\hat{j}$ (b) $+\frac{44}{\pi}\hat{i}$ (c) $+\frac{48}{\pi}\hat{i}$ (d) $-\frac{48}{\pi}\hat{j}$ (e) $-\frac{48}{\pi}\hat{i}$

Questions 13-16

The system shown in the figure starts motion from rest. The coefficient of kinetic friction between $m_1 = 1\ kg$ and the table is $\mu_k = 0.2$. Assume that the cords and the pulleys are massless. The acceleration of m_1 is a_1 and that of $m_2 = 2\ kg$ is a_2.



13. What is the relation between the accelerations of the blocks?

(a) $a_1 = 3a_2$ (b) $3a_1 = a_2$ (c) $2a_1 = a_2$ (d) $a_1 = 2a_2$ (e) $a_1 = a_2$

14. What is the tension in the rope tied to m_1?

(a) $7\ N$ (b) $22/3\ N$ (c) $21/4\ N$ (d) $21/5\ N$ (e) $8\ N$

15. What is the work done by friction when m_2 falls a distance $h = 50\ cm$?

(a) $-6\ J$ (b) $-5\ J$ (c) $-4\ J$ (d) $-2\ J$ (e) $-3\ J$

16. What is the speed of m_2 when it falls a distance $h = 50\ cm$?

(a) $\frac{3\sqrt{2}}{3}\ m/s$ (b) $\frac{5\sqrt{3}}{3}\ m/s$ (c) $\frac{4\sqrt{2}}{3}\ m/s$ (d) $\frac{2\sqrt{3}}{3}\ m/s$ (e) $\frac{2\sqrt{6}}{3}\ m/s$

Questions 17-20

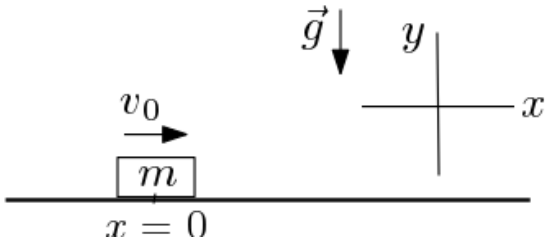
A block of mass m with initial speed v_0 enters into a region of a rough surface at $x = 0$, as shown in the figure. The coefficient of kinetic friction in this region is variable and of the form $\mu_k = bx$, where b is a constant.

17. What is the SI unit of the constant b?

(a) m (b) m/s (c) m^{-1} (d) m^{-2} (e) $m \cdot s$

18. What is the magnitude of the acceleration of the block as a function of x?

(a) $3bx$ (b) bgx (c) gx (d) $2bx$ (e) $2gx$



19. Which of the following is the work done by the friction between $x = 0$ and $x = d$?

(a) $-bmgd$ (b) $-\frac{3}{2}bmgd^2$ (c) $-\frac{3}{2}bmgd$ (d) $-\frac{1}{2}bmgd$ (e) $-\frac{1}{2}bmgd^2$

20. At which point x the block comes to rest?

(a) $\frac{3v_0}{\sqrt{g}}$ (b) $\frac{v_0}{\sqrt{bg}}$ (c) $\frac{2v_0}{\sqrt{g}}$ (d) $\frac{2v_0}{\sqrt{mg}}$ (e) $\frac{v_0}{\sqrt{b^2g}}$