MCQ Part 1

1. A block of mass m is pushed up a frictionless ramp inclined at angle θ by a horizontal force F. The block moves up the ramp at constant velocity. Which of the following expressions correctly gives F?
   (a) $F = mg\sin\theta$
   (b) $F = mg\cos\theta$
   (c) $F = mg\tan\theta$
   (d) $F = \dfrac{mg}{\cos\theta}$
   (e) $F = \dfrac{mg}{\tan\theta}$

2. A box of mass m sits on top of a larger box of mass M, which rests on a frictionless floor. A horizontal force F is applied to the lower box. The coefficient of static friction between the two boxes is μ_s. Which of the following is the maximum force F that can be applied to the lower box without the upper box sliding?
   (a) $F = \mu_s mg$
   (b) $F = \mu_s(m+M)g$
   (c) $F = \mu_s mg\left(\dfrac{m+M}{m}\right)$
   (d) $F = \mu_s mg\left(\dfrac{M}{m}\right)$
   (e) $F = \mu_s(m+M)g\left(\dfrac{M}{m+M}\right)$

3. A skydiver of mass m falls through the air and eventually reaches terminal velocity. Which of the following correctly describes the forces on the skydiver at terminal velocity and immediately after the parachute opens?

	At terminal velocity	**Immediately after chute opens**
(A)	Net force = 0, $a = 0$	Net force upward, decelerating
(B)	Net force downward, $a = g$	Net force = 0, $a = 0$
(C)	Net force = 0, $a = 0$	Net force downward, still accelerating
(D)	Net force upward, decelerating	Net force = 0, $a = 0$
(E)	Net force downward, decelerating	Net force upward, decelerating

4. A small block is placed on a rotating turntable at a distance r from the center. The turntable spins at constant angular speed. The coefficient of static friction between the block and turntable is μ_s. If the block is moved to a distance $2r$ from the center while the angular speed is unchanged, the minimum value of μ_s required to prevent sliding changes by a factor of:
   (a) $\dfrac{1}{4}$

(b) $\frac{1}{2}$

(c) 1 (unchanged)

(d) 2

(e) 4

MCQ Part 2

A block of mass $3m$ rests on a frictionless horizontal table and is connected by a light string over a frictionless pulley to a hanging block of mass m, as shown. A second hanging block of mass $2m$ is connected to the opposite side of the $3m$ block by another string over a second frictionless pulley. The system is released from rest. (Take downward as positive for each hanging block.)

5. What is the acceleration of the $3m$ block?
   (a) 0
   (b) $\frac{g}{6}$
   (c) $\frac{g}{5}$
   (d) $\frac{g}{4}$
   (e) $\frac{g}{3}$

6. What is the tension T_1 in the string connecting the $3m$ block to the m block?
   (a) $\frac{5mg}{6}$
   (b) $\frac{7mg}{6}$
   (c) mg
   (d) $\frac{7mg}{3}$
   (e) $\frac{mg}{6}$

7. If the mass of the table block is changed from $3m$ to m while the two hanging masses remain the same, the acceleration of the system will:
   (a) Remain the same.
   (b) Increase, because total mass decreased.
   (c) Remain the same, because the net driving force also changes.
   (d) Increase, because net force is unchanged but total mass is less.
   (e) Decrease, because having a lighter table block reduces friction.

Free Response

8. A 12.0-kg block is on a rough horizontal surface ($\mu_s = 0.55$, $\mu_k = 0.40$). A force F is applied at an angle $\phi = 25.0^\circ$ *below* the horizontal.
   (a) Derive an expression for the normal force on the block in terms of m, g, F, and ϕ.
   (b) Show that the threshold force needed to begin sliding is given by
   $$F_{\text{min}} = \frac{\mu_s mg}{\cos\phi - \mu_s \sin\phi}$$
   and calculate its value.
   (c) Once sliding begins, if F is kept at F_{min}, find the acceleration of the block.
   (d) Explain qualitatively why pushing downward at an angle makes it harder to slide the block compared to pushing horizontally.

9. A block of mass $m = 5.00\,\text{kg}$ rests on a frictionless ramp inclined at $\theta = 35.0^\circ$. It is connected by a massless string over a frictionless pulley to a hanging mass M. The string is parallel to the incline.
   (a) Find the value of M required for the system to remain in static equilibrium.
   (b) With $M = 8.00\,\text{kg}$, the system is released from rest. Derive expressions for the acceleration of the system and the tension in the string, and calculate each.
   (c) If the ramp now has kinetic friction $\mu_k = 0.20$ and $M = 8.00\,\text{kg}$, how does the acceleration compare to part (b)? Calculate the new acceleration and explain the direction of the friction force on m.

10. Three blocks are stacked and connected as follows: block C (mass $3M$) sits on a frictionless floor; block B (mass $2M$) rests on top of C; block A (mass M) rests on top of B. A horizontal string connects A directly to a wall on the left. A horizontal force F is applied to C to the right. The coefficient of static friction between all block surfaces is $\mu_s = 0.45$. $M = 4.00\,\text{kg}$.
   (a) Draw a free body diagram for each of the three blocks. Identify all forces and their Newton's Third Law reaction partners.
   (b) Explain why block A remains stationary while B and C may accelerate.
   (c) Find the maximum force F that can be applied to C without block B sliding on C.
   (d) Find the tension in the string connecting A to the wall when F is at this maximum value.